TMI-2 Independent Spent Fuel Storage Installation
Application for
10 CFR 72 Specific License Renewal

Special Nuclear Materials License Number SNM-2508
(Docket No. 72-20)

Prepared for:
United States Department of Energy-Idaho Office

Prepared by:
Orano Federal Services LLC
and
Spectra Tech, Inc.

Revision 3

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ACRONYM LIST

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Acronym	Definition
2-D	Two Dimensional
3-D	Three Dimensional
ABW	American Boiler Works, Inc.
AC	Acceptance Criteria
ACI	American Concrete Institute
AH	Absolute Humidity
AISC	American Institute of Steel Construction
ALARA	As Low As Reasonably Achievable
AMA	Aging Management Activity
AMID	Aging Management Institute of Nuclear Power Operations Database
AMP	Aging Management Program
AMR	Aging Management Review
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASR	Alkali-Silica Reaction
ASTM	American Society for Testing and Materials
AWS	American Welding Society Automated Welding System
B&W	Babcock and Wilcox
BEA	Battelle Energy Alliance, LLC
BOM	Bill of Material
BPVC	ASME Boiler and Pressure Vessel Code
BWR	Boiling Water Reactor
CAL	Confirmatory Action Letter
CAR	Corrective Action Report
CASTNET	Clean Air Status and Trends Network
CFR	Code of Federal Regulations
CISCC	Chloride-Induced Stress Corrosion Cracking
CMTR	Certified Material Test Report
CoC	Certificate of Compliance
DE	Design Earthquake

ACRONYM LIST

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Acronym	Definition
DEF	Delayed Ettringite Formation
DFT	Dry Film Thickness
DOE	United States Department of Energy
DOE-EM	DOE, Office of Environmental Management
DOE-ID	DOE, Idaho Operations Office
DOELAP	DOE, Laboratory Accreditation Program
DSC	Dry Shielded Canister
DSS	Dry Storage System
EDF	Engineering Design File
EPRI	Electric Power Research Institute
ER	Environmental Report
FDC	ICP Field Design Change System
FNPT	Female National Pipe Thread
FONSI	Finding of No Significant Impact
FSAR	Final Safety Analysis Report
FSC	Fuel Storage Container
FSD	Fuel Storage Device
FSV	Fort St. Vrain
ft	foot
GALL	General Aging Lessons Learned
GPU	General Public Utilities Nuclear Corporation
GR	Grade
GTCC	Greater than Class C
HAZ	Heat Affected Zone
HEPA	High Efficiency Particulate Air
HIC	Hydrogen-Induced Cracking
HRS	Hydraulic Ram System
HSM	Horizontal Storage Module
HTGR	High Temperature Gas Cooled Reactor
IBR	Incorporated By Reference

ACRONYM LIST

(5 pages)

Acronym	Definition
ICP	Idaho Cleanup Project
ID	Inner Diameter
IFSF	Irradiated Fuel Storage Facility
in.	inches
IN	Information Notice
INTEC	Idaho Nuclear Technology and Engineering Center
ISFSI	Independent Spent Fuel Storage Installation
ISG	Interim Staff Guidance
ITG	Idaho Treatment Group, LLC
ITS	Important-to-Safety
kW	kiloWatt
LAR	License Amendment Request
LCO	Limiting Condition for Operation
LRA	License Renewal Application
MCNP	Monte Carlo N-Particle
MNPT	Male National Pipe Thread
mpy	Mils Per Year
MSB	Multi-assembly Sealed Basket
MT	Magnetic Particle Examination
MTI	Materials Technology Institute of the Chemical Process Industries, Inc.
MWd/MTU	MegaWatt day per Metric Ton of Uranium
N/A	Not Applicable
NACE	National Association of Corrosion Engineers
NCR	Non-Conformance Report
NDE	Non-Destructive Examination
NEI	Nuclear Energy Institute
NITS	Not Important-to-Safety
NLF	NRC Licensed Facilities
NOAA	National Oceanic and Atmospheric Administration
NPT	National Pipe Thread

ACRONYM LIST

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Acronym	Definition
NRC	Nuclear Regulatory Commission
NUHOMS®	Nutech Horizontal Modular Storage System
NUREG	NRC Technical Report
NUREG/CR	NUREG Contractor Report
NVLAP	National Voluntary Laboratory Accreditation Program
OD	Outer Diameter
OE	Operating Experience
pcf	Pounds Per Cubic Foot
PCI	Precast/Pre-stressed Concrete Institute
PEO	Period of Extended Operation
pg.	page
PGA	Peak Ground Acceleration
PLN	Plan
PMF	Predicted Maximum Flood
ppm	Parts Per Million
psi	Pounds Per Square Inch
PT	Liquid Penetrant Inspection
PTZ	Pan-Tilt-Zoom
PWR	Pressurized Water Reactor
QA	Quality Assurance
RAI	NRC Request for Additional Information
rem	roentgen equivalent man
S/N	Serial Number
SAR	Safety Analysis Report
SCC	Stress Corrosion Cracking
SEI/ASCE	Structural Engineering Institute/American Society of Civil Engineers
SER	NRC Safety Evaluation Report
SGI	Safeguards Information
SMUD	Sacramento Municipal Utility District
SNC	Sierra Nuclear Corporation

ACRONYM LIST

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Acronym	Definition
SNF	Spent Nuclear Fuel
SNM	Special Nuclear Materials
SOW	Statement of Work
SPS	Skid Positioning System
SR	Surveillance Requirement
SSC	Structure, System, and Component
SSE	Safe Shutdown Earthquake
SSW	Standby Storage Wells
STI	Spectra Tech, Inc.
TAN	Test Area North
TC	Transfer Cask
TLAA	Time-Limited Aging Analysis
TMI-2	Three Mile Island, Unit 2
TN	Transnuclear Inc.
TPR	Technical Procedure
TS	Technical Specifications
TT	Transfer Trailer
UFSAR	Updated Final Safety Analysis Report
UNC	Unified National Coarse Thread
UT	Ultrasonic Testing
UV	Ultraviolet
VCC	Ventilated Concrete Cask
VDS	Vacuum Drying System
VSC	Ventilated Storage Cask
WJE	Wiss, Janney, Elstner Associates
WO	Work Order

CHAPTER 1:
GENERAL INFORMATION

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1.1 INTRODUCTION

(NUREG-1927, Section 1.4.3 and Section 1.4.5)

The United States Department of Energy Idaho Operations Office (DOE-ID) has prepared this License Renewal Application (LRA) for the Three Mile Island Unit 2 (TMI-2) Independent Spent Fuel Storage Installation (ISFSI). As outlined in Section 1.2.1, DOE-ID has prepared this LRA in accordance with the applicable requirements in title 10 of the U.S. Code of Federal Regulations (CFR),10 CFR 72 [1.4.2] and the guidance contained in Nuclear Regulatory Commission (NRC) Technical Report (NUREG-1927) [1.4.4] and Nuclear Energy Institute (NEI) guidance document (NEI 14-03) [1.4.5]. This application supports license renewal for an additional 20-year period beyond the end of the current license term of Special Nuclear Materials (SNM) License Number SNM-2508, (Docket No. 72-20) [1.4.1]. The original 20-year license will expire on March 19, 2019 and, in accordance with 10 CFR 72.42(b), this LRA is being submitted at least 2 years prior to this date. This LRA includes the general and technical supporting information required for license renewal pursuant to 10 CFR 72.42. Also, in conjunction with this LRA and pursuant to 10 CFR 72.34 and 10 CFR 51.60(a) [1.4.3], DOE-ID has prepared and is submitting a separate supplemental Environmental Report (ER).

The TMI-2 ISFSI is authorized to receive, acquire, possess, and store TMI-2 core and core handling debris. The TMI-2 ISFSI is located at the Idaho National Laboratory (INL) Site[1] within the perimeter of the Idaho Nuclear Technology and Engineering Center (INTEC) in Scoville, Idaho. The original ISFSI license application was submitted by DOE-ID, including a Safety Analysis Report (SAR) on October 31, 1996 [1.4.33], with the original SNM-2508 license being issued on March 19, 1999 [1.4.19]. A Final Safety Analysis Report (FSAR) [1.4.6] was issued shortly thereafter and has been maintained in accordance with 10 CFR 72.70 since. The TMI-2 ISFSI license has been amended five times since initial issuance.

1.1.1 Name/Address of Applicant

(NUREG-1927, Section 1.4.1)

Department of Energy
Idaho Operations Office
1955 Fremont Avenue
Idaho Falls, ID 83415

1.1.2 Description of Applicant

(NUREG-1927, Section 1.4.1)

DOE-ID is the organization responsible for TMI-2 ISFSI activities authorized by License SNM-2508 [1.4.1]. In support of the DOE-ID Idaho Cleanup Project (ICP), DOE-ID retains overall responsibility for managing Spent Nuclear Fuel (SNF) storage facilities and licenses under NRC regulations and is the licensee for the TMI-2 ISFSI. During the license renewal term or Period of Extended Operation (PEO), DOE-ID will continue to retain overall responsibility for ISFSI activities to ensure the overall protection of the health and safety of the public, the workers, and the environment.

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[1] The INL Site was formerly referred to as the Idaho National Engineering Laboratory (INEL) Site and the Idaho National Environmental and Engineering Laboratory (INEEL) Site.

1.1.3 Delegations of Authority and Assignment of Responsibilities

(NUREG-1927, Section 1.4.1)

Upon issuance of Amendment 5 to the TMI-2 ISFSI license SNM-2508 [1.4.1], the *D*eputy Manager for Idaho Cleanup Project (ICP), Office of Environmental Management (EM) became the DOE representative with overall responsibility for compliance with the TMI-2 ISFSI license. The DOE-ID (EM) TMI-2 Facility Director is responsible for compliance oversight of TMI-2 ISFSI operations. Ultimately, DOE retains responsibility for the safe operation of the TMI-2 ISFSI and compliance with all license conditions.

DOE-ID has several prime contractors that support ongoing activities at the INL Site. As of April 01, 2016, the NRC Licensed Facilities (NLF) contractor and its associated subcontractors carry out the management, operation, and oversight of the TMI-2 ISFSI facility. The NLF contractor is Spectra Tech, Inc. (STI) [1.4.45]. Other DOE-ID prime contractors include, but are not limited to, Fluor-Idaho and Battelle Energy Alliance LLC (BEA). The NLF contractor interfaces with these other site contractors through interface agreements.

The NLF contractor is the contractually delegated authority for management and operation of the TMI-2 ISFSI. In addition, the NLF contractor is contractually assigned responsibility for compliance with license requirements and applicable regulations. The NLF contractor is provided with management and staff for routine operations and maintenance. The NLF contractor responsibilities include, but are not limited to: operations, physical security, general infrastructure (including utilities and communication services), maintenance and execution of key programs, emergency management, Quality Assurance (QA), radiation protection, waste management, safeguards and security, information management, records management, property management, training, radiological environmental monitoring, aging management, and support for information requests.

1.2 APPLICATION FORMAT AND CONTENT

Information contained in Chapter 1 includes:

- Summary of the application, including Applicant Name, Address, and Description of Responsibilities (Section 1.1)
- Formatting and content of the application along with a regulatory compliance matrix (Section 1.2)
- A general background description of the TMI-2 ISFSI site, facility, licensing history, financial assurances and granted licensing exemptions (Section 1.3)
- A list of the references for Chapter 1 (Section 1.4)

Note: Throughout this LRA, references are cited within brackets to circumvent any confusion between referenced materials and other information.

1.2.1 Regulations and Regulatory Guidance

The format and content of the application are based on:

- 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" [1.4.2]
- NUREG-1927, Revision 1, "Standard Review Plan for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance *(CoC)*" [1.4.4]
- NEI 14-03, Revision 2, "Format, Content and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management" [1.4.5]
- 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions" [1.4.3]

A regulatory compliance matrix for the LRA is included in Table 1-1.

1.2.2 Design Bases

(NUREG-1927, Section 1.4.4)

As required by 10 CFR 72.70, this LRA includes design bases information as documented in the most recently Updated FSAR (UFSAR) as defined and described in Section 1.2.2.1. Consistent with NUREG-1927 [1.4.4], this LRA is based "on the continuation of the approved design bases throughout the period of extended operation". The existing design bases consist primarily of the following:

- TMI-2 License Number SNM-2508, Amendment 5 and Technical Specifications (TS), [1.4.1], along with the license exemptions indicated in Condition 12 of the Materials License
- United States Department of Energy, "Safety Analysis Report for INEEL Three Mile Island Unit 2 Independent Spent Fuel Storage Installation," Docket No. 72-20, 3/31/1999, as updated [1.4.6]
- Note: Approved exemptions from the regulations are discussed in context of license renewal in Section 1.3.4
- Docketed Licensing Correspondence, as referenced in context of LRA

1.2.2.1 UFSAR Description

The ISFSI UFSAR is the approved design bases as retained by DOE-ID, and is identified in License Condition 9 of the Amendment 5 approval letter dated June 6, 2017 [1.4.1]. The TMI-2 ISFSI UFSAR is updated on a biennial basis in accordance with 10 CFR 72.70(c)(6), and incorporates any amendments or other administrative updates that were approved and became effective during the previous 24 months. The SAR identified in Condition 9 of Amendment 5 builds upon the initial approved application (Amendment 0 FSAR) [1.4.16], four subsequently approved amendment updates to the FSAR (Amendment 1 through Amendment 4) and biennial updates to the FSAR [1.4.7]-[1.4.14]. A summary description of the contents of each amendment is provided in Section 1.3.3. Of note, the UFSAR incorporates any conditions of approved amendments as may be contained in the applicable Safety Evaluation Reports (SERs) [1.4.17] through [1.4.19]. The 2011 biennial update to the FSAR is the *"most recently updated FSAR"* [1.4.12]. Attached to that 2011 biennial update were some updates to Chapter 9 of the FSAR. Therefore, throughout this LRA, the 2011 biennial update letter is referred to as the UFSAR reference.

1.2.2.2 Unique Features of the TMI-2 ISFSI

The TMI-2 ISFSI is unique compared to other ISFSIs in several ways that are germane to the renewal of the license in general, and aging management in particular. The TMI-2 ISFSI features listed below are important to understand while reviewing this LRA. This list is qualitative in nature, with specific details identified either in the UFSAR [1.4.12] or within the body of this LRA.

1. The TMI-2 reactor achieved initial criticality approximately one year before the March 1979 accident (Page 7 of [1.4.23]). On December 30, 1978, three months before the accident, the TMI-2 reactor went into commercial operation. Therefore, the burnup of the TMI-2 core debris is very low (approximately an order of magnitude below typical SNF).
2. The material stored at the TMI-2 ISFSI is limited to the TMI-2 core debris materials from the TMI-2 accident, as specified by conditions in the TMI-2 ISFSI License. This material was transferred to the ISFSI in a single campaign that concluded in 2001. Without an amendment to the license, no additional material is authorized for addition to the ISFSI. There are no plans for such an amendment.
3. Based on the 1979 accident timeframe, the cooling time on the TMI-2 core debris material will be approximately 40 years at the start of the PEO. Given the very low burnup and very long cooling time, the result is a very low radiation source term and decay heat at the start of the PEO, which will continue to decrease during the PEO.
4. The TMI-2 ISFSI is located in a high elevation, arid, non-marine environment that is isolated from industrial pollution sources, thus lending itself as a location with very low potential for customary degradative and corrosive effects.
5. The original design life of the TMI-2 ISFSI, including the Dry Storage System (DSS) is 50 years. This 50-year design basis period bounds the requested 20-year license term extension and the original 20-year initial licensing timeframe. Thus, the Structures, Systems, and Components (SSCs) at the TMI-2 ISFSI have already been designed and analyzed to perform their intended functions throughout the PEO, with an additional 10 years of design margin.
6. The TMI-2 core debris is stored in stainless steel, ¼-in. thick shell cylindrical TMI-2 Canisters which are a much more rigid structural boundary than typical SNF cladding, lending itself to the robustness of the DSS design for all intended functions.

7. The TMI-2 Canisters in turn are stored in Dry Shielded Canisters (DSCs) in like fashion to other Nutech Horizontal Modular Storage (NUHOMS®) System DSCs. However, the DSCs used at the TMI-2 ISFSI have two unique design features compared with other NUHOMS® DSCs: 1) the TMI-2 DSCs are fabricated from coated carbon steel, and 2) are vented to the inside space of the Horizontal Storage Module (HSM) via High Efficiency Particulate Air (HEPA) filters. As such, the carbon steel design is primarily susceptible to non-catastrophic general corrosion that is routinely monitored, eliminating any prospect for Chloride-Induced Stress Corrosion Cracking (CISCC) that is a potential concern for stainless steel DSCs used in the commercial industry.

8. The TMI-2 ISFSI is located in the central portion of the INL Site, access to which is controlled by DOE-ID. The INL Site is a very large tract of land, providing a large controlled area boundary, far removed from the public (including even small population centers), thus providing large margins on regulatory dose limits. In addition, the TMI-2 ISFSI is located in a fenced, controlled access pad, which itself is located in a controlled access area of the INL Site (i.e., the INTEC facility). Most of the surrounding buildings within INTEC have been decommissioned and removed, leaving a very small work force. The isolation, combined with 40-year-old, low burn up TMI-2 core debris with, heavily shielded HSMs, keeps the radiation risks exceptionally low.

1.2.3 Material Incorporated by Reference

(NUREG-1927, Section 1.4.4)

This LRA references several other documents related to renewal of the TMI-2 ISFSI, including other applicable ISFSI LRAs. Two references are considered material "incorporated by reference" (IBR) as defined by 10 CFR 72.42(b) [1.4.2]. Other non-IBR documented references are clearly cited in this LRA. The two specific IBR references are for the OS197 TC (Standardized NUHOMS® UFSAR [1.4.41] and Standardized NUHOMS® LRA [1.4.27]) and consist of a review of corresponding SSCs included for the scoping evaluation, corresponding Aging Management Reviews (AMRs) and corresponding Aging Management Activities (AMAs). Where used, the Standardized NUHOMS® UFSAR and LRA are identified by the specific IBR location (e.g., section or appendix number) referenced within those documents. For completeness, the specific IBR sections of the Standardized NUHOMS® CoC 1004 docket are as follows:

- Standardized NUHOMS® UFSAR [1.4.41] Sections 12.1, 12.2, and 12.3 pertaining to the OS197 TC; Section 12.2.2; Table 12.2-1; and Table 12.3-5
- Standardized NUHOMS® LRA [1.4.27] Sections 1.2.2.3, 3.3.3, 3.4, 3.4.1, 3.4.2, 3.4.3, 3.7 and Appendices 1A-1K, 2C (pertaining to the OS197 TC); Appendix 2E (Table 2E-3 only); Appendix 3B (pertaining to the OS197 TC); and Appendix 6A (Section 6A.7 only)

1.2.4 LRA Content Summary

(NUREG-1927, Section 1.3, Section 1.4.4 and Section 2.3)

Information contained in the remaining chapters and attachments includes:

Scoping Evaluation: Section 2.2 of Chapter 2 provides a description of the methodology used to identify the SSCs of the TMI-2 ISFSI that are within the scope of the renewal. This methodology is based on the two-step process described in NUREG-1927 [1.4.4]. Section 2.3 also provides a summary of the results of the scoping evaluation.

Aging Management Review (AMR): Section 3.3 of Chapter 3 provides the methodology used for the AMR of the TMI-2 ISFSI, based on the guidance provided in NUREG-1927 [1.4.4]. The AMR documented in Section 3.3.1 identifies the materials and environments for those SSCs and associated subcomponents determined to be within the renewal scope of Chapter 2. This is accomplished by reviewing the drawings and the design bases included in the FSAR, [1.4.6] as updated. Once the SSC material/environment combinations are determined, potential aging effects and associated aging mechanisms requiring management are identified and evaluated based on engineering literature, related industry research information, and existing Operating Experience (OE).

Section 3.2 of Chapter 3 provides a summary of this OE for the TMI-2 ISFSI. This portion of the LRA describes the pre-application inspections verifying the condition of the ISFSI components and related subcomponent SSCs. As summarized in Section 3.3.2, the information gleaned from this OE is used in part to identify potential aging effects and associated aging mechanisms that require management. After potential aging effects are identified, it is determined whether they can be addressed by a Time-Limited Aging Analysis (TLAA) or other aging evaluation, or will require an Aging Management Program (AMP). If a TLAA does not adequately manage the identified aging effect on an in-scope SSC for the PEO, the affected SSC is included in an AMP. The AMP is designed to ensure that no identified aging effect results in a loss of intended design function of the in-scope SSCs for the PEO. In addition, per the guidance in NUREG-1927, Section 3.5, other supplemental evaluations may be included as part of the TLAA appendices or aging effects discussions in the AMR either to justify the proposed attributes of an AMP or to justify the exclusion of an aging mechanism/effect or SSC subcomponent from the scope of an AMP [1.4.4]. Section 3.3.3 of Chapter 3 summarizes the AMAs implemented to handle the applicable aging effects and mechanisms identified.

Tollgate Assessments: In addition, consistent with Appendix A of the NEI 14-03 supplemental guidance [1.4.5], Section 3.9 of Chapter 3 regarding "Tollgates" is included with this LRA and describes the proposed tollgates for the TMI-2 ISFSI. As described in [1.4.5], tollgates may be included in the renewed site-specific license and associated UFSAR for performance by DOE-ID. Tollgates document an assessment of the aggregate impact of aging-related OE, research, monitoring, and inspections at specific points in time during the PEO.

Appendices:

- Appendix A: Aging Management Programs (AMPs)
    - Appendix A1: Dry Shielded Canister AMP
    - Appendix A2: Horizontal Storage Module AMP
    - Appendix A3: Transfer Cask Aging Management
    - Appendix A4: TMI-2 Canister Aging Management
- Appendix B: Time-Limited Aging Analyses (TLAAs)

Subsequent to approval of the LRA, the FSAR will be updated to add any aging management and renewal-related changes.

The recommended FSAR changes for the TMI-2 ISFSI renewal are shown in:

- Appendix C: FSAR Supplement and Changes

The recommended TS changes for the TMI-2 ISFSI renewal are shown in:

- Appendix D: Proposed License/Technical Specification Changes

Table 1-1: Regulatory Compliance Cross-Reference Matrix

Renewal Application Section Number and Heading		NUREG-1927 Section Number and Heading	10 CFR 72 Requirement
CHAPTER 1. GENERAL INFORMATION		---	---
1.1	INTRODUCTION	1.4.3 Environmental Report, 1.4.5 Timely Renewal	§72.2, 72.34, 72.42
1.1.1	Name/Address of Applicant	1.4.1 General Information	§72.22(a),(b)
1.1.2	Description of Applicant	1.4.1 General Information	§72.22(c),(d)
1.1.3	Delegations of Authority and Assignment of Responsibilities	1.4.1 General Information	§72.22(d)(5)
1.2	APPLICATION FORMAT AND CONTENT	---	---
1.2.1	Regulations and Regulatory Guidance	---	---
1.2.2	Design Bases & 1.2.2.1 UFSAR Description	1.4.4 Application Content	§72.2, 72.48(d), 72.70(c)(6)
1.2.3	Material Incorporated by Reference	1.4.4 Application Content	---
1.2.4	LRA Content Summary	1.3 Regulatory Requirements, 1.4.4 Application Content, 2.3 Regulatory Requirements	---
1.3	FACILITY DESCRIPTION/BACKGROUND	---	§72.24(b)
1.3.1	Facility Design Summary	---	§72.24(b)
1.3.2	Financial Assurances	1.4.2 Financial Information	§72.22(e), 72.30(c)
1.3.3	License Amendment History and Aging Management Implications	1.4.4 Application Content	---
1.3.4	Granted License Exemptions and Aging Management Implications	1.4.4 Application Content	---
1.3.5	10 CFR 72.48 Evaluations and Aging Management Implications	1.4.4 Application Content	---
CHAPTER 2. SCOPING EVALUATION		---	---
2.1	SCOPING INTRODUCTION	2.1 Review Objective	---
2.2	SCOPING EVALUATION PROCESS AND METHODOLOGY	2.2 Areas of Review, 2.4.1 Scoping Process	§72.24(g), 72.42(b)
2.2.1	Scoping Methodology	2.4.1 Scoping Process	§72.24(g), 72.42(b)
2.3	RESULTS OF SCOPING EVALUATION	2.4.2 SSCs Within the Scope of License Renewal, 2.4.2.1 Scoping of Fuel Assemblies, 2.4.2.2 Scoping of SSCs Depending on Individual Design Bases, 2.4.3 SSCs Not Within the Scope of License Renewal	§72.3, 72.24(b),(c),(d),(g), 72.120, 72.122, 72.124, 72.126, 72.128

Table 1-1: Regulatory Compliance Cross-Reference Matrix

Renewal Application Section Number and Heading	NUREG-1927 Section Number and Heading	10 CFR 72 Requirement
2.3.1 Description of TMI-2 ISFSI SSCs	2.4.1 Scoping Process	§72.24(g), 72.42(b)
2.3.2 SSCs within Scope of License Renewal	2.2 Areas of Review, 2.4.1 Scoping Process, 2.4.2 SSCs Within the Scope of License Renewal, 2.4.2.1 Scoping of Fuel Assemblies	§72.3, 72.42(b), 72.24(b),(c),(d),(g), 72.120, 72.122, 72.124, 72.126, 72.128
2.3.3 SSCs not within the Scope of License Renewal	2.2 Areas of Review, 2.4.1 Scoping Process, 2.4.3 SSCs Not Within the Scope of License Renewal, 2.4.2.1 Scoping of Fuel Assemblies	§72.42(b), 72.24(b),(c),(d),(g), 72.120, 72.122, 72.124, 72.126, 72.128
CHAPTER 3. AGING MANAGEMENT REVIEW	---	---
3.1 INTRODUCTION	3.2 Areas of Review	---
3.2 OPERATING EXPERIENCE REVIEW	3.4.1.1 Identification of Materials and Environments, 3.4.1.2 Identification of Aging Mechanisms and Effects	---
3.2.1 Operating Experience Review Process	3.6.1.10 Operating Experience	---
3.2.2 TMI-2 ISFSI Operating Experience	3.6.1.10 Operating Experience	---
3.2.3 Pre-Application Inspections	3.4.1.1 Identification of Materials and Environments, 3.4.1.2 Identification of Aging Mechanisms and Effects 3.6.1.10 Operating Experience/Pre-Application Inspections	---
3.2.4 Generic Industry Experience	3.6.1.10 Operating Experience	---
3.3 AGING MANAGEMENT REVIEW METHODOLOGY	---	---
3.3.1 Identification of Materials and Environments	3.2 Areas of Review, 3.4.1.1 Identification of Materials and Environments	---
3.3.2 Identification of Aging Effects Requiring Management	3.2 Areas of Review, 3.4.1.2 Identification of Aging Mechanisms and Effects	§72.24(d), 72.104(a), 72.106(b), 72.124, 72.120(a)(d), 72.158, 72.122(a),(b),(c),(h)(1),(h)(5),(l), 72.126, 72.162, 72.164
3.3.3 Identification of the Activities Required to Manage the Effects of Aging	3.2 Areas of Review, 3.4.1.3 Aging Management Activities, 3.5 Time-Limited Aging Analyses, 3.6 Aging Management Program	§72.3,72.42(a)
3.4 AMR RESULTS — DSC	---	---
3.4.1 Description of DSC	----	---
3.4.2 DSC Materials Evaluated	3.2 Areas of Review, 3.4.1.1 Identification of Materials and Environments	---

Table 1-1: Regulatory Compliance Cross-Reference Matrix

Renewal Application Section Number and Heading		NUREG-1927 Section Number and Heading	10 CFR 72 Requirement
3.4.3	Environments for the DSC	3.2 Areas of Review, 3.4.1.1 Identification of Materials and Environments	---
3.4.4	DSC Aging Effects	3.2 Areas of Review, 3.4.1.2 Identification of Aging Mechanisms and Effects	§72.24(d), 72.104(a), 72.106(b), 72.124, 72.120(a)(d), 72.158, 72.122(a),(b),(c),(h)(1),(h)(5),(l), 72.126, 72.162, 72.164
3.4.5	Aging Management Activities for DSCs	3.2 Areas of Review, 3.4.1.3 Aging Management Activities	§72.3,72.42(a)
3.5	AMR RESULTS — HSM	---	---
3.5.1	Description of HSM	---	---
3.5.2	HSM Materials Evaluated	3.2 Areas of Review, 3.4.1.1 Identification of Materials and Environments	---
3.5.3	Environments for the HSM	3.2 Areas of Review, 3.4.1.1 Identification of Materials and Environments	---
3.5.4	HSM Aging Effects	3.2 Areas of Review, 3.4.1.2 Identification of Aging Mechanisms and Effects	§72.24(d), 72.104(a), 72.106(b), 72.124, 72.120(a)(d), 72.158, 72.122(a),(b),(c),(h)(1),(h)(5),(l), 72.126, 72.162, 72.164
3.5.5	Aging Management Activities for HSMs	3.2 Areas of Review, 3.4.1.3 Aging Management Activities	§72.3,72.42(a)
3.6	AMR RESULTS — TRANSFER CASK	---	---
3.7	AMR RESULTS — BASEMAT AND APPROACH SLAB	---	---
3.7.1	Description of Basemat and Approach Slab	---	---
3.7.2	Basemat and Approach Slab Materials Evaluated	3.2 Areas of Review, 3.4.1.1 Identification of Materials and Environments	---
3.7.3	Environments for the Basemat and Approach Slab	3.2 Areas of Review, 3.4.1.1 Identification of Materials and Environments	---
3.7.4	Basemat and Approach Slab Aging Effects	3.2 Areas of Review, 3.4.1.2 Identification of Aging Mechanisms and Effects	§72.24(d), 72.104(a), 72.106(b), 72.124, 72.120(a)(d), 72.158, 72.122(a),(b),(c),(h)(1),(h)(5),(l), 72.126, 72.162,72.164
3.7.5	Aging Management Activities for Basemat and Approach Slab	3.2 Areas of Review, 3.4.1.3 Aging Management Activities	§72.3,72.42(a)
3.8	AMR RESULTS — TMI-2 CANISTER	---	---
3.8.1	Description of TMI-2 Canister	---	---

Table 1-1: Regulatory Compliance Cross-Reference Matrix

Renewal Application Section Number and Heading	NUREG-1927 Section Number and Heading	10 CFR 72 Requirement
3.8.2 TMI-2 Canister Materials Evaluated	3.2 Areas of Review, 3.4.1.1 Identification of Materials and Environments	---
3.8.3 Environments for TMI-2 Canisters	3.2 Areas of Review, 3.4.1.1 Identification of Materials and Environments	---
3.8.4 TMI-2 Canister Aging Effects	3.2 Areas of Review, 3.4.1.2 Identification of Aging Mechanisms and Effects	§72.24(d), 72.104(a), 72.106(b), 72.124, 72.120(a)(d), 72.158, 72.122(a),(b),(c),(h)(1),(h)(5),(l), 72.126, 72.162, 72.164
3.8.5 Aging Management Activities for TMI-2 Canisters	3.2 Areas of Review, 3.4.1.3 Aging Management Activities	§72.3,72.42(a)
3.9 PERIODIC TOLLGATE ASSESSMENTS	3.6.1.10 Operating Experience/Learning AMPs	---
Appendix A: Aging Management Programs (AMPs)	3.6 Aging Management Program, 3.6.1 Review Guidance, 3.6.3 Implementation of AMP(s)	§72.82(d), 72.126, 72.122(f),(h)(4),(i), 72.128(a), 72.158, 72.162, 72.164, 72.170, 72.168(a), 72.172
Appendix A1: Dry Shielded Canister AMPs		
Appendix A2: Horizontal Storage Module AMPs		
Appendix A3: Transfer Cask AMPs		
Appendix A4: TMI-2 Canister AMPs		
Appendix B: Time-Limited Aging Analyses (TLAAs)	3.5 Time-Limited Aging Analyses	§72.24(d), 72.104(a), 72.106(b), 72.120(a)(d), 72.122(a),(b),(c),(f), (h)(1),(h)(4),(h)(5),(i),(l), 72.124, 72.126, 72.128(a), 72.170
Appendix C: FSAR Supplement and Changes	Figure 3-1, 3.6.1.9 Administrative Controls, 1.4.4 Application Content, 1.4.7 Terms, Conditions, and Specifications for Specific Licenses and CoCs in the Period of Extended Operation	---
Appendix D: Proposed License/Technical Specification Changes	1.4.4 Application Content, 1.4.7 Terms, Conditions, and Specifications for Specific Licenses and CoCs in the Period of Extended Operation	---

1.3 FACILITY DESCRIPTION/BACKGROUND

Subsequent to the March 1979 accident at the TMI-2 Nuclear Power Station, in March 1982, Congress mandated that the DOE accept the entire TMI-2 damaged core for research, development, and storage at a DOE facility [1.4.26]. DOE selected INL to perform the TMI-2 core debris investigations. Defueling of the TMI-2 reactor began in October 1985 and was completed in January 1990. The TMI-2 core and associated core handling debris were shipped from the TMI-2 Nuclear Power Station to the INL Site from the period July 1986 until April 1990 and received, examined, and stored at the Test Area North (TAN) TAN-607 hot shop and fuel storage pool. Since the TAN Hot Shop was scheduled for decommissioning, DOE selected dry storage of the TMI-2 Canisters as the interim storage approach.

It should be noted that of the estimated 306,653 pounds of damaged fuel materials shipped from TMI-2 to the INL Site, an estimated 7,936 pounds was from "non-core material" (i.e., core-handling debris) [1.4.42]. According to a summary of shipments from TMI-2, this non-core material consisted of core baskets and casings (4,260 pounds), drill strings, debris buckets and diatomaceous earth [1.4.42]. Therefore, the term "core debris" as used in the LRA is considered synonymous with any of the contents of the TMI-2 Canisters, including "core handling debris."

In March of 1999, the NRC licensed the TMI-2 ISFSI pursuant to 10 CFR 72 for authorization to receive, possess, store, and transfer the TMI-2 SNF core debris, resulting from the 1979 TMI-2 accident, for a 20-year term. The first TMI-2 core debris transfer from TAN to the ISFSI was completed in March 1999. Nine additional transfers were completed during 2000. The remaining 19 transfers were completed during 2001, with the last one completed in April 2001 (See Table 1-2) [1.4.43].

The TMI-2 ISFSI uses a modified NUHOMS® SNF storage system, designated NUHOMS®-12T, for storage of the TMI-2 core debris within TMI-2 Canisters. The TMI-2 ISFSI design is largely based on the Standardized NUHOMS® dry storage HSMs, including for the DSCs, the NUHOMS®-24P DSC. The Standardized NUHOMS® spent fuel storage system has an extensive licensing and technical basis. On November 4, 2014, the Standardized NUHOMS® CoC was submitted for renewal for a period of 40 years [1.4.28].

The foundation of the Standardized NUHOMS® design began with the original NUHOMS® Topical Report in 1985 for storage of seven spent pressurized water reactor (PWR) fuel assemblies [1.4.22]. The NUHOMS® Topical Report was revised in 1988 to provide the generic design criteria and safety analysis for the larger 24 spent PWR fuel assembly design designated as the NUHOMS®-24P [1.4.24]. In 1995, the NRC issued CoC 72-1004 for the Standardized NUHOMS® design, expanding to include the NUHOMS®-52B [1.4.21]. From this CoC, the June 1996 SAR for the Standardized NUHOMS® design formed the historical foundation from which the NUHOMS®-12T spent fuel storage system originated [1.4.24]. In particular, the NUHOMS®-12T spent fuel storage system was adapted for TMI-2 Canister use. Instead of the 24 PWR SNF assemblies stored in the NUHOMS®-24P DSC basket, the NUHOMS®-12T design was revised to accommodate an internal basket to hold 12 TMI-2 Canisters. Other NUHOMS®-12T key design distinctions from the Standardized NUHOMS® include the use of zinc-rich primer-coated carbon steel SSCs, the lack of HSM ventilation inlets/outlets, and the use of a vented and filtered DSC. These design details are described in the TMI-2 UFSAR, and will be discussed in context of license renewal throughout the remainder of this LRA.

Table 1-2: Storage Systems Loaded at the TMI-2 ISFSI

LOAD SEQUENCE	DATE LOADED INTO HSM	DSC # DSCs DESIGNATED AS DOE12T-001 THROUGH DOE12T-029	HSM #* HSMs DESIGNATED AS HSM-1 THROUGH HSM-30
1	3/31/99	2	16
2	7/10/00	3	17
3	10/14/00	4	20
4	10/27/00	5	22
5	11/6/00	11	24
6	11/19/00	8	27
7	11/29/00	10	28
8	12/7/00	9	21
9	12/16/00	7	26
10	12/21/00	13	25
11	1/4/01	16	23
12	1/11/01	18	19
13	1/19/01	14	30
14	1/26/01	17	14
15	2/2/01	15	13
16	2/10/01	19	12
17	2/15/01	12	11
18	2/20/01	6	10
19	2/26/01	25	9
20	3/5/01	20	18
21	3/12/01	21	8
22	3/20/01	22	7
23	3/27/01	23	6
24	3/31/01	24	5
25	4/06/01	1	4
26	4/09/01	26	3
27	4/13/01	27	29
28	4/16/01	28	2
29	4/20/01	29	1

*Note: HSM-15 is not loaded with radioactive material and is considered a spare with an empty DSC overpack housed inside.

1.3.1 Facility Design Summary

The UFSAR describes the design bases for the TMI-2 ISFSI [1.4.6]. The following consolidated summary is provided as background material to the LRA, and is meant as reference information only.

The dry storage technology for the TMI-2 containerized core debris utilizes an adaptation of the Standardized NUHOMS® system. There are notable differences between the TMI-2 core debris contents of the DSS and commercial spent fuel assemblies stored in other Standardized NUHOMS® DSSs. As shown in Figures 3.1-1, 3.1-2 and 3.1-3 of the UFSAR, TMI-2 core debris is canisterized in "TMI-2 Canisters," whereas commercial fuel is clad only, without any additional enclosure in addition to the DSC itself. The cladding in typical SNF assemblies provides structural support to ensure that the SNF pellets are maintained in a known geometric configuration. For the TMI-2 ISFSI, the TMI-2 Canisters provide this function, not the SNF cladding. As stated in Section 1.1.1 of the UFSAR, the TMI-2 Canisters provide a much stronger structural element within the DSC basket, as compared to commercial SNF assemblies [1.4.12].

The NUHOMS®-12T system provides for the horizontal, dry storage of canisterized TMI-2 core debris in an HSM. The storage system SSCs for the NUHOMS®-12T consist of a reinforced concrete HSM and a carbon steel DSC with an internal basket assembly which holds up to 12 stainless steel TMI-2 Canisters. As stated in Section 3.1 of the UFSAR, the design life of the DSC and HSMs is 50 years, which can be extended to all TMI-2 ISFSI SSCs [1.4.6].

As shown in Figures 4.2-1 and 4.2-2 of the UFSAR, The HSM is a prefabricated, reinforced concrete vault that is 10-ft 3-in. wide by 18-ft 2-in. long by 14-ft 6-in. high (nominal dimensions). The HSM serves to provide shielding for the DSC to minimize the radiation dose rate from the ISFSI and to transfer decay heat from the contents inside the DSC. The HSM is a low-profile structure designed to withstand all normal and off-normal loads as well as loads potentially created by earthquakes, tornado missiles, and other adverse natural phenomena. The HSM includes a steel lined door that is removed for insertion and retrieval of the DSC and a rear door that provides access to the DSC vent and purge ports (described further below). Unlike the Standardized NUHOMS® design, the TMI-2 HSMs do not rely on internal natural convection cooling and are not ventilated.

As shown in Figures 1.2-4 and 4.2-4 of the UFSAR, the NUHOMS®-12T DSC is a 67.19-in. diameter, 163.5-in. long cylindrical carbon steel vessel used for the storage of up to 12 TMI-2 Canisters. The DSC is diametrically similar to the standard NUHOMS® system DSC, but is 23.5 inches shorter in length. The DSC shell is 5/8-in. thick with closure end plates forming a high integrity steel welded pressure vessel, which provides confinement for the TMI-2 Canisters. The principal material of construction for the NUHOMS®-12T DSC is carbon steel, primed and coated with an inorganic, zinc-rich coating. All structural components of the DSC are fabricated from this material.

UFSAR, Section 1.1.1 states the heat load for the TMI-2 Canister is considerably lower than that for a commercial SNF assembly [1.4.12]. The decay heat of the TMI-2 core debris is rejected from the TMI-2 Canisters to the DSC shell and to the HSM walls by radiant heat transfer. The heat is conducted through the HSM walls and removed from the HSM outer surfaces by natural convection and by radiant heat transfer to the ambient air. Under worst-case, extreme summer ambient conditions, thermal calculations show that, unlike the commercially-used NUHOMS® Systems, no convection cooling via HSM cooling air vents is required to remove the decay heat generated from the TMI-2 core debris.

The TMI-2 core debris inside the TMI-2 Canisters was originally treated as having the potential for hydrogen gas generation due to radiolysis. Based on these considerations, the Standardized NUHOMS® system was modified to accommodate such conditions. Specifically, the NUHOMS®-12T DSC was modified to include venting of the DSC through HEPA grade filters during storage. The vent system (using four, 2-in. diameter filters located in the vent port housing and one, 2-in. diameter filter located in the purge port housing) allows for release of the hydrogen gas and allows for monitoring, purging or both of the system during operation. The vent and purge ports may be accessed via the HSM rear wall through a vented steel door.

The TMI-2 ISFSI design includes an extra HSM with a pre-installed DSC overpack in case a challenged DSC needs to be moved for an unexpected (beyond design basis) reason.

The NUHOMS®-12T system used transfer equipment to move each DSC from the TAN facility (where they were loaded with TMI-2 Canisters and readied for storage) to the HSMs where they are stored. The transfer system included the Transfer Cask (TC), lifting slings, Hydraulic Ram System (HRS), Transfer Trailer (TT), tractor for towing, cask transportation skid, and a Skid Positioning System (SPS). Other than the lifting slings, the intention of the TC and other transfer equipment is to allow retrieval of the DSCs. The NUHOMS®-12T DSCs can be moved using any NRC Part 72-approved TC or an NRC 10 CFR 71 certified transportation system, however, as described below only two TCs are certified in accordance with the UFSAR (See Section 1.3.2.1 of [1.4.6]).

At TAN, the transfer equipment SSCs interfaced with the TAN Hot Shop cask-handling crane. Auxiliary equipment such as a Vacuum Drying System (VDS) and an Automated Welding System (AWS) were also used to facilitate DSC loading, purging, and sealing operations at TAN.

The TMI-2 UFSAR provides the information necessary for moving DSCs using the transport-certified MP187 as a TC. In addition, Appendix E of the UFSAR provides the detailed information necessary for moving DSCs using the 10 CFR 72 approved OS197 TC. The major difference between usage of the two TCs is that the 10 CFR 72 approved OS197 TC cannot be used for transportation on public roadways and, therefore, does not require impact limiters, evacuation and helium backfill of the DSC, leak testing of the DSC closure weld, nor installation of the vent/filter housing transportation covers. Figure 1.3-1 and Figure E1.3-1 of the UFSAR shows a sketch for the MP187 and OS197 TCs, respectively.

The HSM is installed on a load-bearing foundation, which consists of a reinforced concrete pad on a subgrade suitable to support the loads (i.e., basemat). The approach slab is a reinforced concrete slab that provides access and support to the DSC transfer system.

1.3.2 Financial Information

(NUREG-1927, Section 1.4.2)

Consistent with NUREG-1927, Section 1.4.2 [1.4.4]:

> *"The renewal application for a specific license contains the necessary documentation regarding financial data, pursuant to 10 CFR 72.22(e), which shows that the specific licensee can carry out the proposed activities for the requested duration....*
>
> *In addition, the application should include a decommissioning funding plan that identifies any changes in decommissioning costs and the extent of contamination, pursuant to 10 CFR 72.30(c)."*

As set forth in 10 CFR 72.22(e), DOE is not required to provide detailed financial information to demonstrate its financial qualifications [1.4.2]. DOE requests, through the federal budget appropriations process, the necessary funding for the operation and decommissioning of the TMI-2 ISFSI. License Condition No. 15 for the TMI-2 ISFSI license (SNM-2508) addresses funding [1.4.1].

Section 9.6.2 of the UFSAR discusses the cost of decommissioning as was outlined in the "Conceptual Plan for Decommissioning," Revision 0, included as an enclosure to the original TMI-2 ISFSI License Application [1.4.33]. Table 1 of the decommissioning plan contains cost estimates for decommissioning the TMI-2 ISFSI. The DOE Office of Environmental Management has included the TMI-2 ISFSI decommissioning program in its overall cost estimate for the Environmental Management Program at the INL Site. With respect to decommissioning cost variances from the original ISFSI planning, DOE-ID transmitted a letter in response to changes to 10 CFR 72.30, in which the regulatory changes were published on June 7, 2011 [1.4.32]. In the letter, DOE-ID indicated that the proposed TMI-2 decommissioning plan in the original TMI-2 license application contains sufficient information on proposed future actions for the DOE to account for the life cycle liability, including future decontamination and decommissioning costs for the TMI-2 ISFSI in the federal budget planning process.

1.3.3 License History and Aging Management Implications
(NUREG-1927, Section 1.4.4)

Consistent with Section 1.4.4 of NUREG-1927 [1.4.4], changes to 10 CFR 72 specific licenses are to be addressed in the LRA. Table 1-3 summarizes the original SNM-2508 license [1.4.39] history and its relationship to the design bases. This table also includes the five approved license amendments. The remaining paragraphs in this section describe each amendment, with a discussion of any impacts on license renewal, including aging management information.

Table 1-3: TMI-2 ISFSI License History Summary

SNM-2508 License Revision Number	Approval Date	Description	Location of Supporting Design Bases within the FSAR
0	3/19/1999	Initial approval to store spent fuel at the TMI-2 ISFSI.	Main FSAR Body and Appendices A through E, Technical Specifications and Bases.
1	4/4/2001	Changes to License Condition 6.B	Materials License SNM-2508.
2	6/14/2001	Changes in the areas of Safeguards Contingency (TS 5.5.4).	Technical Specifications.
3	7/12/2001	Changes in the areas of Safeguards Contingency (TS 5.5.4), DSC Loading Requirements (TS 2.1.1 and TS 4.3), American Society of Mechanical Engineers (ASME) Code Exceptions (TS Table 4-1), TS Section 5.5 changes to conform to 10 CFR 72.48 and 72.70 rule changes, and for Radiation Protection (TS 3.2.1 and 3.2.2).	Technical Specifications.
4	6/30/2005	Changes ISFSI TS corrective actions if the 5-year leak test of the DSCs fails.	Chapter 4, "Installation Design," Chapter 7, "Radiation Protection," Chapter 8, "Analysis of Design Events," Technical Specifications.
5	6/6/2017	Modified TMI-2 license delegation of authority and other organizational structure administrative changes (currently under NRC review).	Chapter 9, "Conduct of Operations," Chapter 11, "Quality Assurance," Technical Specifications.

Amendment 1

Description [1.4.17]:

Condition 6.B of original (Amendment 0) ISFSI materials license SNM-2508 identified the numbers and types of TMI-2 Canisters containing the TMI-2 core debris, 265 TMI-2 Fuel Canisters, 12 TMI-2 Knockout Canisters, and 67 TMI-2 Filter Canisters [1.4.39]. DOE-ID performed a review of key project and design bases documentation including the UFSAR and determined the combined quantity of 344 TMI-2 Canisters was correct with the exception that three of the TMI-2 Fuel Canisters were not loaded into the ISFSI and it was determined that the numbers of two of the types of TMI-2 Canisters were incorrect [1.4.40]. Specifically, (a) the number of TMI-2 Filter Canisters allowed in the ISFSI is five TMI-2 Canisters greater than the actual number of TMI-2 Filter Canisters, and (b) the number of TMI-2 Fuel Canisters allowed in the ISFSI is five TMI-2 Canisters less than the actual number of TMI-2 Fuel Canisters.

The total number of TMI-2 Canisters loaded with core debris was 344, which includes 270 TMI-2 Fuel Canisters, 62 TMI-2 Filter Canisters, and 12 TMI-2 Knockout Canisters. However, three of the TMI-2 Fuel Canisters contain TMI-2 core debris that is mounted in epoxy metallurgical material. These three TMI-2 Fuel Canisters were not shipped to or stored at the TMI-2 ISFSI, but were placed in temporary dry storage at the TAN site pending evaluation for future disposition. This resulted in a total TMI-2 ISFSI facility loading of 341 TMI-2 Canisters containing 267 TMI-2 Fuel Canisters, 62 TMI-2 Filter Canisters, and 12 TMI-2 Knockout Canisters. This amendment of License Condition 6.B with the corrected numbers of TMI-2 Canister types stored in the ISFSI allowed DOE-ID to finalize loading operations.

Aging Implication:

This change to license condition 6.B has no resulting impact on the aging activities or the assurance of safety for the term of license renewal since it does not change the materials or environments of the TMI-2 Canisters, but simply refers to a question regarding the quantity of TMI-2 Canisters. Of note, in accordance with license condition 6.A and this license condition 6.B, DOE-ID is not authorized to load any additional material at the ISFSI.

Amendment 2

Description [1.4.18]:

This amendment addressed TS changes to Section 5.5.4, "Physical Protection Plan." In addition, this amendment issued a new Safeguards Information (SGI) plan [1.4.38]. According to the SER for Amendment #2:

> *"Technical Specification 5.5.4.a has been changed to reflect the date of May 24, 2001, that submitted the final SGI plan in its entirety. Technical Specification 5.5.4 has also been corrected to properly reference 10 CFR 72.186(b) instead of 10 CFR 72.186 when referring to provisions under which the security plan may be amended without prior Commission approval, and the paragraph numbering has also been corrected."*

Aging Implication:

This TS change entirely pertains to security-related matters. As such, it is specifically excluded from the renewal review per Section 1.2 of NUREG-1927 [1.4.4].

Amendment 3

Description [1.4.19]:

This amendment addressed TS changes. The five changes approved in this amendment are described below and any aging implications outlined. Change number 5 was described in an April 2, 2001 LAR [1.4.36] , while the other four were described in an October 4, 2000 LAR [1.4.34], with Change number 1 being revised by a May 11, 2001 and May 24, 2001 revision to the LAR [1.4.35],[1.4.38] and Change number 2 being revised by a March 27, 2001 response to an Request for Additional Information (RAI) [1.4.37].

1. Safeguards Contingency (Change requests A and B)

   TS 5.5.4.b was issued to deal specifically with the safeguards contingency plan submitted pursuant to 10 CFR 72.184, Safeguards Contingency Plan. DOE-ID requested NRC approval of a revised Safeguards Contingency Plan. DOE-ID had prepared a specific Safeguards Contingency Plan for the TMI-2 ISFSI based on the requirements of 10 CFR 72.184 and 10 CFR 73, Appendix C. It was intended that the revised plan would replace the existing plan from a March 9, 1999 submittal and be separate from the INTEC site-wide contingency plan.

A conforming change request to update the language of TS 5.5.4 was initiated in response to a DOE-ID event report [1.4.34]. Per the original LAR language:

> *"Specifically, TS 5.5.4.b was issued to deal specifically with the safeguards contingency plan submitted pursuant to 10 CFR 72.184, Safeguards Contingency Plan. The DOE-ID staff did not realize that the contingency plan referenced in the technical specification was not the same contingency plan attached to the TMI-2 ISFSI Physical Protection Plan approved in paragraph (a) of TS 5.5.4. Instead, paragraph (b) refers to a DOE-ID letter and several attachments used to demonstrate the contingency planning performed for the Idaho National Engineering and Environmental Laboratory (INEEL), upon which the TMI-2 ISFSI is sited."*

The safety analysis, included with a modified LAR, indicated [1.4.35]:

> *"DOE has prepared a specific Safeguards Contingency Plan for NRC approval that meets the requirements of 10 CFR 72.184 and 10 CFR Part 73, Appendix C. No decrease in safety or security is presented by this change."*

Aging Implication:

This TS change entirely pertains to security-related matters. As such, it is specifically excluded from the renewal review per Section 1.2 of NUREG-1927 [1.4.4]. Separately, this TS change and related SGI plan issuance have no resulting impact on the aging activities or the assurance of the SSCs intended functions for the PEO.

2. DSC Loading Requirements (Change requests C and D)

   The change involved the wording of TS 2.1.1. Specifically, the phrasing of TS 2.1.1 "...the DSC sealing and testing operations have been performed in accordance with detailed operating procedures..." allowed the interpretation that notification and reporting pursuant to TS 2.2.2 and TS 2.2.3 could be required for any deviation from the DSC sealing procedure. The third paragraph from TS 2.1.1 where this language resided was removed in Amendment 3.

   Related to this issue was the concern that the design requirements in the third paragraph in TS 2.1.1 are not *"Functional and Operating Limits"* (the title of Section 2 of the TS). Because TS 2.1.1 was revised to reflect standardized ISFSI TS, the design requirements found in the version of TS 2.1.1 needed to be retained in a section of the TS appropriate for the content of the third paragraph. As a result, a new TS 4.3, "TMI-2 Canister and DSC Preparation" paragraph was added.

   Of note, the initially proposed TS 2.1.1 amendment language would have allowed changes to the contents under 10 CFR 72.48 [1.4.2], which would not have required prior NRC review. This was the subject of an RAI issued by the NRC [1.4.15], which was resolved as part of DOE-ID response to the RAI [1.4.37], correcting the problematic wording.

Aging Implication:

The new specification added to Section 4, Design Features, captured the intent of the third paragraph requested for removal from TS 2.1.1. This new specification recognized the design requirements for drying the TMI-2 Canisters, the design requirements for sealing, welding and inspecting the DSC, and the design requirements for testing the DSC vent housing seals. The traceability requirements for identifying which TMI-2 Canisters are located within each DSC and HSM were also provided. None of the SSC design requirements were revised because of this change. As a result, this TS change has no resulting impact on the aging activities or the assurance of DSS safety for the PEO.

3. ASME Code Exceptions (Change request E)

   A clarification was requested to TS Table 4-1, ASME Code Exceptions. The request was an editorial change to an existing exception desired to avoid confusion. The existing exception to ASME Section NB-6000 previously stated in part:

   > *"The DSC containment boundary is not pressure tested in accordance with NB-6000 since the upper cover plate to shell, purge port and vent to top shield plug welds are fabricated after fuel is loaded…."*

   The use of the word "fabricated" in the first sentence required clarification that the helium leak tests by the fabricator could be interpreted to mean both the DSC supplier (responsible for fabrication) and the INL Site contractor responsible for final closure. Therefore, the NRC approved the change of the word *"*fabricated*"* to *"*performed*"* because there was no helium leak testing performed after DSC closure.

   UFSAR, Chapter 5, describes helium leak testing for use of the MP187 because it was anticipated that the MP187 CoC would require helium leak testing for loading operations. The description of operation with the OS197 TC in UFSAR, Appendix E, excludes mention of the helium leak testing because there was no intention to rely on helium leak testing for on-site transfers and storage. Rather, the DSC has a series of barriers to ensure the confinement of radioactive materials as discussed in Section 3.3.2.1 of the UFSAR. In addition, the DSC confinement boundary welds were examined in accordance with TS Section 4.2.1.3 requirements. All of the TMI-2 DSCs were loaded using the OS197 TC, which excluded the helium leak testing as described above. In accordance with Section 5.1.2.3 of the UFSAR, no other Part 72 Helium leak testing would be required for future DSC retrieval operations.

Aging Implication:

Since the change was an editorial change in operational procedures and execution, there is no resulting impact on the aging activities or the assurance of DSS safety of in-scope SSCs for the PEO.

4. Rule Changes to 72.48 and 72.70 (Change requests F and G)

   Two changes were requested to conform to 1999 revised rule changes in Sections 10 CFR 72.48 and 10 CFR 72.70, including for FSAR update reporting frequency from 12 months to 24 months. The changes were editorial changes to TS 5.5.1.d and 5.5.2.6 to correct outdated paragraph and subparagraph references.

Aging Implication:

The changes were editorial in nature and have no impact on aging activities or the assurance of DSS safety during the PEO.

5. Radiation Protection (Change request H)

   A change to Limiting Condition for Operation (LCO) TS 3.2.1 and 3.2.2 [1.4.1] was requested to allow for the inclusion of a neutron dose component within the limits provided. A change to the limits was not requested, only that the "gamma" designator for the dose contributor be removed. During loading of the ISFSI in December 2000, a DSC was placed in an HSM with a previously unknown neutron source contained in one of the TMI-2 Canisters. DOE-ID evaluated the neutron source in a 10 CFR 72.48 review and determined that the source was two Am-Be-Cm capsules and that NRC review and approval was not required for the change. Although these LCOs only placed limits on "gamma" contributions, internally, DOE-ID, as a conservative measure, had stipulated that the LCO limits applied to all contributions of dose (both gamma and neutron). Since the neutron sources contribute a portion of the doses observed, DOE-ID requested that the word "gamma" be removed from LCOs 3.2.1 and 3.2.2.

Aging Implication:

Although these specific changes were editorial in nature and have no impact on aging activities or the assurance of DSS safety during the PEO, the localized neutron source's radiation effects over the PEO is evaluated in Section 3.3.1.2.2.

Amendment 4

Description [1.4.20]:

The DSCs are vented through HEPA filters in the top covers that provide a diffusion path for hydrogen potentially created by the TMI-2 core debris. The interfaces between the filter housing and the DSC top cover plate are dual, concentric, metallic seals situated between polished surfaces on the two SSCs. The vent housing seals are subject to LCO 3.1.1 [1.4.1], which specifies a maximum allowable leak rate of 1×10^{-2} standard cm^3/sec. Verification that the LCO is met by the seals is determined by the performance of a leak test conducted every 5 years, in accordance with Surveillance Requirement (SR) 3.1.1.1. If the leak test failed the SR, the previous TS required reseating or replacing the seals to restore compliance with the LCO leak rate or removing the affected DSC from the HSM and transporting the affected DSC to TAN or other appropriate facility for corrective actions.

Amendment 4 modified the LCO "Conditions" and "Required Actions" to remove the requirement to transport the affected DSC to TAN or another facility if the seals could not be adequately repaired or replaced to meet the LCO leakage limit. Required Action B was added to perform a monthly contamination survey and submit a report to the NRC if the housing seal leak rate was not restored within 7 days. Required Action C was also added to allow replacement of the dual, metallic seals with dual, elastomeric seals. To date, no metallic seals have been replaced with elastomeric seals.

In support of the TS change justifications, Chapter 7 of the FSAR was updated in Section 7.4.1, "Operational Dose Assessment" to compare the estimated collective occupational exposure between reseating or replacing the seals and removing the DSC from the HSM and then placing it in overpack HSM-15. In addition, the confinement safety consequences of leaking vent or purge port seals were supported by an evaluation in FSAR Section 7.6.3, "Estimated Dose Equivalents" and Section 8.1.4, "Storage with Leakage of Vent or Purge Port Seals."

Aging Implication:

The Amendment 4 license request [1.4.29] discussed the safety consequence if the vent or purge sealing surfaces failed to meet the leak rate specification. Section 8.1.4.2, "Confinement Analysis" was added to the UFSAR indicating that for leaking or even missing double seals, "…the gaps between the vent and purge filter housings and the DSC lid are so small that it would be difficult for particulate radioactive material to pass through without significant motive force. The worst case would be all the particulate radioactive material that could potentially be released from the DSC during normal operation is released unfiltered through the leaking double metallic seals."

A radiological evaluation of a complete radioactive particulate release was conducted as part of the amendment, with no confinement credit taken for the seals. The total dose at the INL Site boundary was calculated and incorporated into FSAR Section 8.1.4.3. The resulting accident dose at the INL Site boundary was less than the10 CFR 72.106 [1.4.2] accident regulatory limit of 5 roentgen equivalent man (rem) and found to be acceptable by the NRC. Neither the vent/purge sealing grooves, nor the seals themselves (whether metallic or elastomeric) perform a confinement intended function. As a result, any postulated aging effects on those SSCs does not prevent fulfillment of the DSC's confinement function. However, LCO 3.1.1, SRs 3.1.1.1, and 3.1.1.2 [1.4.1] require periodic leak testing of the dual metallic DSC vent/purge housing seals on a 5-year basis and annually for the elastomeric seals. This aging monitoring activity already assures conformance with a defense-in-depth confinement function provided by the seals. The aging implications related to the UFSAR Section 8.1.4.2, "Confinement Analysis" also extends to other DSC SSCs that perform an exclusive confinement function during the PEO. This is elaborated on in Section 3.4.4.4. Based on the FSAR and TS changes resulting from this amendment, there are no other aging implications of this license amendment.

Amendment 5

Description [1.4.44]:

Condition 11 of the TMI-2 ISFSI license [1.4.1] specifies that the Secretary of Energy has delegated the Manager, Department of Energy, Idaho Operations Office as the authorized representative to the Secretary in all matters regarding this license. On September 8, 2016, DOE-ID submitted a LAR to change the TMI-2 ISFSI license authorized DOE representative to the Deputy Manager for Idaho Cleanup Project (ICP), Office of Environmental Management (EM) (Section 9.1.1 of [1.4.44]). Conforming changes were also requested to TS 5.1.1 and 5.2.1.2. This amendment request was approved by the NRC on June 6, 2017 [1.4.1].

Aging Implication:

This is an administrative change and there are no aging implications associated with this license amendment.

1.3.4 Granted License Exemptions and Aging Management Implications

(NUREG-1927, Section 1.4.4)

Section 1.4.4 of NUREG-1927 indicates that information pertaining to granted exemptions and their implication to aging management are contained in the LRA [1.4.4]. The four exemptions listed below are part of Condition 12 of the TMI-2 ISFSI License [1.4.1]. They are reviewed for any aging implications on the LRA.

Exemption Condition 12a)

"Requirements of 10 CFR 72.102(f)(1) related to the specified seismic design criteria of 10 CFR Part 100, Appendix A."

As stated in the NRC's Finding of No Significant Impact (FONSI) [1.4.30]:

> *"On September 15, 1997, DOE-ID requested an exemption from the requirement of 10 CFR 72.102(f)(1) which stated: "For sites that have been evaluated under the criteria of Appendix A of 10 CFR Part 100, the design earthquake (DE) must be Equivalent to the safe shutdown earthquake (SSE) for a nuclear power plant." In this context, "DE" and "SSE" refer to the design peak ground acceleration (PGA), with an appropriate response spectrum, caused by the largest credible earthquake."*

This deterministic analysis for the seismic hazard yielded a DE of 0.56g PGA. However, DOE-ID requested to use a PGA of 0.36g, which was calculated using a risk-based model (probabilistic) for seismic design of the ISFSI. DOE-ID was "concerned with designing low risk facilities, such as an ISFSI, to the requirements of 10 CFR Part 100, Appendix A, as it would set a precedent that appears to be unnecessary, technically inappropriate, and potentially unattainable throughout the DOE complex."

The current text of 72.102(f) is unchanged from that in the 1999 FONSI.

Aging Implication:

The lower seismic acceleration loads will need to be maintained as part of the license, as they are integrated into the design bases in the original seismic structural evaluations of the SSCs. Therefore, this exemption is still required and has no impact on the aging analysis.

Exemption Condition 12b)

"Requirements of 10 CFR 20.1501(c) to use NVLAP accredited dosimetry and instead is authorized to use DOELAP dosimetry."

As stated in the NRC's FONSI [1.4.30]:

> *"On December 18, 1998, DOE-ID requested an exemption from the requirements of 10 CFR 20.1501(c) which state in part that "All personnel dosimeters ... that require processing .... must be processed and evaluated by a dosimetry processor ... (1) Holding current personnel dosimetry accreditation from the National Voluntary Laboratory Accreditation Program (NVLAP) of the National Institute of Standards and Technology ... Specifically, the applicant proposes allowing the DOE Laboratory Accreditation Program (DOELAP) as an approved alternative."*

Aging Implication:

The version of this regulation at the time the exemption was granted originated from 10 CFR 20.1501(c) [1.4.31]. NRC rulemaking in June 2011 added a new Section 1501(b) to 10 CFR 20, requiring licensees to maintain records from surveys. As such, 10 CFR 20.1501(b) was re-designated as 10 CFR 20.1501(c) and 10 CFR 20.1501(c) was re-designated as 10 CFR 20.1501(d). DOE-ID, hence TMI-2 ISFSI, uses a DOELAP accredited processor. Thus, the exemption is still required, but now applies to 10 CFR 20.1501(d), and an administrative change to this effect is requested as part of this LRA. The exemption has no impact on the LRA activities.

Exemption Condition 12c)

"Requirement of 10 CFR 72.124(b) that the design of the ISFSI shall provide for positive means to verify the continued efficacy of solid neutron absorbing materials. "

As stated in the NRC's FONSI [1.4.30]:

> *"On its own initiative, the staff is also considering issuance of an exemption from the requirement of 10 CFR 72.124(b) which states: "When practicable the design of an ISFSI or MRS must be based on favorable geometry, permanently fixed neutron absorbing materials (poisons), or both. Where solid neutron absorbing materials are used, the design shall provide for positive means to verify their continued efficacy." Specifically, the staff is considering granting an exemption from the requirement to provide positive means of verifying the continued efficacy of neutron absorbing materials....*
>
> *The exemption from 10 CFR 72.124(b) is necessary because, while this requirement is appropriate for wet spent fuel storage systems, it is not appropriate for dry spent fuel storage systems such as the one DOE-ID plans to use for storage of the TMI-2 fuel debris. Periodic verification of neutron poison effectiveness is neither necessary nor practical for these casks....*
>
> *The neutron absorbing material (poison) is in a form that exposure to the ambient atmosphere of the DSC interior will not cause a significant deterioration of the structural properties of the material over the expected life of the facility."*

Current text of 10 CFR 72.124(b) reads as follows [1.4.2]:

> *"Methods of criticality control. When practicable, the design of an ISFSI or MRS must be based on favorable geometry, permanently fixed neutron absorbing materials (poisons), or both. Where solid neutron absorbing materials are used, the design must provide for positive means of verifying their continued efficacy. For dry spent fuel storage systems, the continued efficacy may be confirmed by a demonstration or analysis before use, showing that significant degradation of the neutron absorbing materials cannot occur over the life of the facility."*

The version of this regulation at the time the exemption was issued did not include the last sentence regarding "continued efficacy" of the neutron absorbing materials. The revised rule addressed the need for such exemptions and added no new requirements.

Aging Implication:

As discussed in Section 2.3.2.3, the boron in the TMI-2 Canisters is credited as part of criticality control safety. As this exemption was written per NRC's initiative and is included in NRC's SER for the solid neutron absorbing materials efficacy, the exemption remains germane [1.4.16]. The NRC's FONSI supporting approval of the exemption refers to FSAR text (Section 3.3.4) [1.4.6] that states only 75% credit for neutron absorber was taken, and the FONSI goes on to state the neutron flux is low enough to *"deplete only a small percentage of neutron absorbing material during several thousand years of exposure."* The SER goes on to state in Section 8.5.2, "Stored Material Specifications":

> *"The stored material specifications satisfy the requirements of 10 CFR 72.124(b) because the criticality safety of the facility is based on canister geometry and fixed neutron absorbers. Because of the low neutron flux within the DSC, burnup of the neutron absorbing material will be negligible over the design life of the facility; in addition, the neutron absorbing material is in such a form that structural deterioration, although not expected, will not cause a decrease in the effectiveness of the poisons. Therefore, the licensee has been granted an exemption to the requirements of 10 CFR 72.124(b) that require the licensee to provide a positive means to verify the continued efficiency of the neutron absorbing materials."*

As a result, the exemption will need to be maintained due to the previous NRC evaluations conducted assessing the long-term efficacy of the BORAL® sheets used in the TMI-2 Fuel Canister and B_4C rods used in the TMI-2 Filter and Knockout Canisters. Therefore, the bases for this exemption previously conducted are pertinent to discounting aging effects on the TMI-2 Canister neutron poisons within the Internal TMI-2 Canister Environment for the PEO.

Exemption Condition 12d)

"Requirements of 10 CFR 72.82(e) that a report of the preoperational test acceptance criteria and test results be submitted at least 30 days prior to loading the ISFSI."

As stated in the NRC's FONSI [1.4.30]:

> *"On February 12, 1999, DOE-ID requested an exemption from the requirement of 10 CFR 72.82 (e) to submit a report of the preoperational test acceptance criteria and test results at least 30 days prior to the receipt of spent fuel or high-level radioactive waste."*

10 CFR 72.82(e) has been removed from the Part 72 regulations and would no longer be applicable because the HSM is fully loaded and will not receive additional SNF or high-level radioactive waste [1.4.2].

Aging Implication:

The exemption is no longer required or applicable and has no impact on aging. Therefore, as an administrative change, this exemption is proposed for removal from the license. See Appendix D for proposed changes to the TMI-2 ISFSI license, including any recommended TS updates.

1.3.5 10 CFR 72.48 Evaluations and Aging Management Implications

(NUREG-1927, Section 1.4.4)

In accordance with Section 1.4.4 of NUREG-1927, changes, tests, and experiments authorized under 10 CFR 72.48 since the last biennial UFSAR update are to be addressed in the LRA [1.4.4]. The most recent biennial 72.48 report for the TMI-2 license was submitted on March 11, 2015 [1.4.14]. There have been no changes, tests or experiments implemented pursuant to 10 CFR 72.48 at the TMI-2 ISFSI since the biennial report submitted on March 11, 2015.

1.4 REFERENCES (CHAPTER 1)

1.4.1 U.S. Nuclear Regulatory Commission, "License for Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste and Revised Technical Specifications," License No. SNM-2508, Amendment No. 5, June 6, 2017, Docket No. 72-20, NRC Accession Number ML17151A325 and ML17151A326.

1.4.2 U.S. Nuclear Regulatory Commission, 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," Code of Federal Regulations.

1.4.3 U.S. Nuclear Regulatory Commission, 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions," Code of Federal Regulations.

1.4.4 U.S. Nuclear Regulatory Commission, NUREG-1927, Revision 1, "Standard Review Plan for Renewal of Specific Licenses and Certificates of Compliance for Dry Storage of Spent Nuclear Fuel," June, 2016, NRC Accession Number ML16179A148.

1.4.5 Nuclear Energy Institute, NEI 14-03, Revision 2, "Format, Content and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management," December 2016, Washington D.C.

1.4.6 U.S. Department of Energy, "Safety Analysis Report for INEEL Three Mile Island Unit 2 Independent Spent Fuel Storage Installation, Revision 1," March 31, 1999, NRC Accession Number 9903260243.

1.4.7 U.S. Department of Energy, 2001 Update Report, "Submittal of TMI-2 ISFSI Update Reports (Docket 72-20) (INTEC-NRC-01-012)," March 16, 2001.

1.4.8 U.S. Department of Energy, 2003 Update Report, "Submittal of TMI-2 ISFSI Update Reports (Docket 72-20) (INTEC-NRC-03-013)," March 18, 2003.

1.4.9 U.S. Department of Energy, 2005 Update Report, "Submittal of TMI-2 ISFSI Update Reports (Docket 72-20) (EM-FMDP-05-009)," March 09, 2005.

1.4.10 U.S. Department of Energy, 2007 Update Report, "Submittal of TMI-2 ISFSI Update Reports (Docket 72-20) (EM-FMDP-07-008)," March 15, 2007, NRC Accession Number ML070820547.

1.4.11 U.S. Department of Energy, 2009 Update Report, "Submittal of TMI-2 ISFSI Update Reports (Docket 72-20) (EM-FMDP-09-016)," March 18, 2009.

1.4.12 U.S. Department of Energy, 2011 Update Report, "Submittal of TMI-2 ISFSI Update Reports (Docket 72-20) (EM-FMDP-11-024)," March 02, 2011.

1.4.13 U.S. Department of Energy, 2013 Update Report, "Submittal of TMI-2 ISFSI Update Reports (Docket 72-20) (EM-FMDP-13-018)," March 14, 2013, NRC Accession Number ML13074A799.

1.4.14 U.S. Department of Energy, 2015 Update Report, "Submittal of TMI-2 ISFSI Update Reports (Docket 72-20) (EM-FMDP-15-015)," March 11, 2015, NRC Accession Number ML15084A135.

1.4.15 U.S. Nuclear Regulatory Commission, "Request for Additional Information for Amendment to SNM-2508 - Technical Specifications and Exemption for TMI-2 (TAC NO. L23218)," March 9, 2001, Docket No. 72-20.

1.4.16 U.S. Nuclear Regulatory Commission, "Safety Evaluation Report, Docket No. 72-20, Department of Energy, Three Mile Island 2 Independent Spent Fuel Storage Installation, License No. SNM-2508, Amendment No. 0," March 19, 1999, Docket No. 72-20, NRC Accession Number ML060970085.

1.4.17 U.S. Nuclear Regulatory Commission, "Safety Evaluation Report: Amendment No. 1 to SNM-2508," April 4, 2001, Docket No. 72-20.

1.4.18 U.S. Nuclear Regulatory Commission, "Safety Evaluation Report: Amendment No. 2 to SNM-2508, Safeguards Information Protection Plan," June 14, 2001, Docket No. 72-20.

1.4.19 U.S. Nuclear Regulatory Commission, "Safety Evaluation Report: Amendment No. 3 to SNM-2508, Safeguards Contingency Plan and Miscellaneous Administrative Technical Specifications Changes," July 12, 2001, Docket No. 72-20.

1.4.20 U.S. Nuclear Regulatory Commission, "Safety Evaluation Report, Docket No. 72-20, Department of Energy, Three Mile Island 2 Independent Spent Fuel Storage Installation, License No. SNM-2508, Amendment No. 4," June 30, 2005, Docket No. 72-20, NRC Accession Number ML051810422.

1.4.21 U.S. Nuclear Regulatory Commission, Office of Nuclear Materials Safety and Safeguards, "Certificate of Compliance for Dry Spent Fuel Storage Casks, Certificate No. 1004, Docket No. 72-1004, Revision 0," January 23, 1995.

1.4.22 NUTECH, Inc., NUH-001, Revision 1, "Topical Report for the Nutech Horizontal Modular Storage System for Irradiated Nuclear Fuel," November, 1985, San Jose, CA.

1.4.23 Rogovin, M., Frampton Jr., G.T., "Three Mile Island: Volume I: A Report to the Commissioners and to the Public," NUREG/CR-1250, NRC Contractor Technical Report, January 1, 1980.

1.4.24 Letter from J. P. Roberts, NMSS, to W. J. McConaghy, NUTECH Engineers, Inc., "Subject: Acceptance as a Reference of "Topical Report for the NUTECH Horizontal Modular Storage System for Irradiated Nuclear Fuel, NUHOMS®-24" (NUH-002) Revision I," April 21, 1989, NRC Accession Number ML053410443.

1.4.25 VECTRA, "Safety Analysis Report for the Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel, NUH-003, Revision 4A, File No. NUH003.0103, NRC Docket No. 72-1004," VECTRA Technologies, Inc., June, 1996, NRC Accession Number 9607150237.

1.4.26 U.S. Department of Energy Idaho Field Office, DOE/ID-10400, "Historical Summary of the Three Mile Island Unit 2 Core Debris Transportation Campaign," March, 1993.

1.4.27 AREVA TN Americas, "Renewal Application for the Standardized NUHOMS® System, Certificate of Compliance No. 1004, Revision 3," September 29, 2016, NRC Accession Number 16279A371 (Submittal Enclosure 3, Proprietary Version) and ML16279A372 (Submittal Enclosure 4, Public Version).

1.4.28 AREVA TN Americas, "Certificate of Compliance Renewal Application for the Standardized NUHOMS® System - CoC 1004," November 4, 2014, NRC Accession Number ML14309A344.

1.4.29 U.S. Department of Energy, "License Amendment Request for the Three Mile Island Unit 2 (TMI-2) Independent Spent Fuel Storage Installation (ISFSI) (Docket 72-20) (INTEC-NRC-05-001)," January 31, 2005, NRC Accession Number ML050380446.

1.4.30 U.S. Nuclear Regulatory Commission, "Federal Register Notices Publishing Environmental Assessments and Findings of No Significant Impacts for Requests for Exemptions from Requirements of 10 CFR Parts 20 and 72," March 13, 1999, Docket No. 72-20, NRC Accession Number 9903230211.

1.4.31 U.S. Nuclear Regulatory Commission, 10 CFR Part 20, "Standards for Protection Against Radiation," Code of Federal Regulations.

1.4.32 U.S. Department of Energy, "10 CFR Part 72.30 Financial Assurance and Recordkeeping for Decommissioning, per 10 CFR 72.30 for Dockets 72-09, Fort Saint Vrain, 72-20, Three Mile Island and 72-25, Idaho Spent Fuel Facility (EM-FMDP-12-086)," December 14, 2012, NRC Accession Number ML13002A076.

1.4.33 U.S. Department of Energy, "License Application for The Idaho National Engineering Laboratory Three Mile Island Unit Two Independent Spent Fuel Storage Installation, Enclosure, Revision 0," October 31, 1996, NRC Accession Number 9611080065.

1.4.34 U.S. Department of Energy, "Request for License Amendment for Material License SNM-2508 (Docket 72-20) (INTEC-NRC-00-069)," October 04, 2000.

1.4.35 U.S. Department of Energy, "Revision to Request for License Amendment for Material License SNM-2508 (Docket 72-20) (INTEC-NRC-01-032)," May 11, 2001.

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1.4.37 U.S. Department of Energy, "Response to Request for Additional Information for Amendment to SNM-2508 - Technical Specifications and Exemption for TMI-2 (TAC No. L23218) (Docket 72-20) (INTEC-NRC-01-017)," March 27, 2001.

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1.4.39 U.S. Nuclear Regulatory Commission, "Issuance of Materials License SNM-2508 for the Three Mile Island, Unit 2, Independent Spent Fuel Storage Installation (TAC NOS. L22283 AND L22800," License No. SNM-2508, Amendment No. 0, March 19, 1999, Docket No. 72-20, NRC Accession Number ML060970079.

1.4.40 U.S. Department of Energy, "Request for Amendment to Materials License SNM-2508 Section 6.8 to Correct Number of Fuel Debris and Filter Canisters to be placed in the Three Mile Island Unit 2 Independent Spent Fuel Storage Installation (Docket 72-20) (INTEC-NRC-01-018)," March 26, 2001.

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1.4.42 General Public Utilities Nuclear, TMI-2 Technical Bulletin TB 86-33, Revisions 0-20, "Dewatering Canisters in Preparation for Offsite Shipment," May 30, 1990 (Revision 20).

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1.4.44 DOE-ID Letter to U.S. Nuclear Regulatory Commission EM-NRC-16-022, "License Amendment Request to Update the Licensee Delegation of Authority for Three Mile Island-2 Spent Fuel Storage Installation," dated September 8, 2016, NRC Accession Number ML16258A191.

1.4.45 DOE-ID Letter to U.S. Nuclear Regulatory Commission EM-FMDP-16-024, "Completion of License Condition 14 for Materials Licenses SNM-2504 and 2508 (Docket 72-09 and 72-20) and License Condition 17 of Material License 2512 (Docket 72-25) (EM-NRC-16-024)," dated September 27, 2016, NRC Accession Number ML16287A428.

CHAPTER 2:
SCOPING EVALUATION

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2.1 SCOPING INTRODUCTION

(NUREG-1927, Section 2.1)

Chapter 2 describes the evaluation process, methodology, and results of the scoping evaluations, identifying SSCs of the TMI-2 ISFSI that are within and not within the scope of license renewal.

Consistent with the guidance contained in NUREG-1927, "Standard Review Plan for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance" [2.4.1], the first step of the renewal process is the performance of a scoping evaluation. The objective of the scoping evaluation is to identify the SSCs of the TMI-2 ISFSI that are within the scope of renewal. The second step is the AMR, whereby the in-scope SSCs are evaluated for potential degradation due to aging effects. This second step is described in Chapter 3, "Aging Management Review."

A description of the scoping process and methodology is provided in Section 2.2. The design documents used for identifying the component-specific SSCs are located in Section 2.3.1. The results of the scoping evaluation are provided in Sections 2.3.2 and 2.3.3.

2.2 SCOPING EVALUATION PROCESS AND METHODOLOGY

(NUREG-1927, Section 2.2 and Section 2.4.1)

This section describes the scoping evaluation process and methodology used to determine the SSCs and associated subcomponents and subcomponent parts that are within the scope of renewal. The scoping evaluation is performed based on the two-step process described in NUREG-1927 [2.4.1].

The first step is a screening evaluation to determine which primary SSCs are within scope of renewal. Consistent with the NUREG-1927 [2.4.1] guidance, SSCs are considered to be within the scope of renewal if they satisfy any of the three functions indicated below under Scoping Criterion 1. Of note, the second function is to prevent damage to the SNF during handling or storage. The statement in particular considers undamaged SNF assemblies. Since the TMI-2 core debris is already damaged SNF, this second function does not apply. Nonetheless, the TMI-2 Canister does provide geometric confinement to the TMI-2 core debris, as discussed in Section 2.3.2.3.

The second step involves further review of the primary SSCs that are determined to be within scope of renewal to identify and describe the subcomponent SSCs that support the intended function or functions of the primary SSCs. The intended functions of the subcomponents may include providing:

- Criticality control of the SNF TMI-2 core debris
- Decay heat removal
- Radioactive particulate confinement
- Radiation shielding
- Structural support, functional support, or both, to SSCs that are important-to-safety (ITS)
- A retrievability function

Scoping Criterion 1

The SSC is classified as ITS if it is relied on for one of the following functions:

1. Maintain the conditions required by the regulations or the TMI-2 ISFSI license [2.4.21] to store the TMI-2 core debris safely;
2. Prevent damage to the SNF during handling and storage; or
3. Provide reasonable assurance that SNF can be received, handled, packaged, stored, and retrieved without undue risk to the health and safety of the public.

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

Scoping Criterion 2

The SSC is classified as Not Important-to-Safety (NITS), but according to the design bases, their failure could prevent fulfillment of a function that is ITS.

Scoping Criterion 3

The scoping of storage contents (i.e., fuel assemblies) is suggested via paragraph 2.4.2.1 of NUREG-1927 [2.4.1], which discusses demonstrating *"that the analyzed fuel configuration is maintained during the period of extended operation... "*. As such, this criterion is only applied to payload contents, which may include the TMI-2 core debris or TMI-2 Canisters. Of note, Criterion 3 is not specifically called for in NUREG-1927, and therefore, this designation is specific to the TMI-2 ISFSI in order to simplify the discussion.

2.2.1 Scoping Methodology

(NUREG-1927, Section 2.4.1)

Consistent with NUREG-1927 [2.4.1], the renewal is based *"on the continuation of the approved design bases throughout the period of extended operation"*. Accordingly, the sources of information reviewed in the scoping evaluation are those that describe the design bases and the intended functions of the ITS SSCs. For the TMI-2 ISFSI, this encompasses the design bases identified in Section 1.2.2. The UFSAR is the approved design bases and is identified by the 2011 biennial update to the FSAR, as being the *"most recently updated FSAR"* [2.4.2]. The UFSAR provides the design bases of the SSCs of the DSS and documents the safety analysis of the ISFSI. As such, the UFSAR is the primary source used for the scoping evaluation. In addition, a review of the TMI-2 ISFSI license [2.4.21], TS and the NRC SERs for the original license and the five approved amendments helps determine the basis for the in-scope and out-of-scope SSC status. As necessary, an evaluation of other NRC docketed commitments or regulatory correspondence aided in a determination of the SSCs scoping status. Finally, a review of some of the original design calculations, analyses, and reports that the UFSAR referred to, either directly or indirectly in its development, assisted in a determination of SSCs scoping status. Of note, any source used is referenced directly in the text where it is used.

The scoping evaluation process described above identifies both the SSCs within and those excluded from the scope of renewal. As applicable, the scoping evaluation identifies the SSCs called out in the UFSAR by the design bases (FSAR) drawings. Collectively, the FSAR drawings, the supporting design/fabrication drawing, and associated bill of material (BOM) item numbers convey the SSC subcomponents. Therefore, these drawings in conjunction with any relevant fabrication specifications, technical procedures or engineering change notices wholly identify the subcomponent SSCs for the scoping evaluations. Table 2-2 lists the upper level FSAR and design drawings for the primary in-scope SSCs.

First, based on their intended function, a high-level component scoping review identifies each SSCs scoping status. Table 2-1 shows a summary of these high-level determinations (whether in or out of scope for each primary SSC). Section 2.3.2 identifies any SSCs that perform or support an ITS function and are therefore scoped-in for the AMR review. Any SSCs that do not perform or support an ITS function are excluded from further evaluation in the AMR by being scoped out. Section 2.3.3 identifies these out-of-scope SSCs.

Secondly, for the primary SSCs that are in-scope, a more detailed SSC scoping review evaluates each primary SSC on an item-by-item subcomponent SSC basis. Each of these SSC subcomponents scoping status is based on its scoping criterion and the six intended functions: confinement, radiation shielding, sub-criticality control, heat-removal capability, structural integrity, and retrievability. If applicable, information provided in NRC Contractor Report (NUREG/CR-6407) was used as a reference for classification of SSCs as ITS to accurately complete the scoping evaluation [2.4.3]. Section 2.3.2 and Table 2-3 identifies those in-scope subcomponent SSCs that perform or support any of the intended functions, along with the scoping criterion. In addition, Section 2.3.3 and Table 2-4 identifies any primary in-scope SSCs with out-of-scope subcomponents.

2.3 RESULTS OF SCOPING EVALUATION

(NUREG-1927, Section 2.4.2, Section 2.4.2.1, Section 2.4.2.2 and Section 2.4.3)

Table 2-1 summarizes the overall results of the scoping evaluation, listing the high-level SSCs that are identified within the scope of renewal and the criterion upon which they are determined to be within the scope of renewal. In Table 2-2 of Section 2.3.1, the design reference drawings used in outlining the detailed Scoping Evaluation SSCs are identified. Also identified in Table 2-2 is the revision of the drawings used for the scoping analyses.

The detailed scoping results for each SSC, evaluated to the subcomponent and subcomponent part level, including the determination of their associated intended function, are provided in Table 2-3 and Table 2-4. The SSC subcomponents within scope of renewal are described in Section 2.3.2 and listed in Table 2-3. The SSCs not within scope of renewal are provided in Section 2.3.3 and listed in Table 2-4. The subcomponents in the tables are identified by reference drawing, item number and a description.

Table 2-1: Scoping Evaluation of TMI-2 ISFSI SSCs/Contents

TMI-2 ISFSI SSC/Contents	Criterion 1	Criterion 2	Criterion 3	In-Scope
Dry Shielded Canister(1)	Yes	N/A	N/A	Yes
Horizontal Storage Module (except HSM-15)(2)	Yes	N/A	N/A	Yes
Overpack HSM (HSM-15)(3)	No	No	N/A	No
Transfer Cask	Yes	N/A	N/A	Yes
Dry Film Lubricant	No	No	N/A	No
Handling and Transfer Equipment(4)	No	No	N/A	No
ISFSI Basemat and Approach Slab	No	Yes	N/A	Yes
Other Transfer Equipment(5)	No	No	N/A	No
Auxiliary Equipment(6)	No	No	N/A	No
Miscellaneous Equipment(7)	No	No	N/A	No
TMI-2 Core Debris	N/A	N/A	No	No
TMI-2 Canisters(8)	N/A	N/A	Yes	Yes

Notes:

(1) DSC includes (but is not limited to) the DSC shell, top/bottom cover plates, purge and vent block, grapple ring and HEPA filters (See Section 2.3.2.1).

(2) HSM includes HSM-1 through HSM-30, excluding HSM-15. Subcomponents include (but are not limited to) the HSM reinforced concrete walls, roof, and end shield walls; DSC steel structure support assembly; HSM accessories (DSC seismic retainer, shielded door assemblies and door supports); and associated attachment/installation hardware (tie rods, bolts, nuts, washers, embedment assemblies, mechanical splices) (See Section 2.3.2.2).

(3) Overpack HSM includes all of HSM-15 and its internal DSC overpack liner (See Section 2.3.3.1).

(4) Handling and Transfer equipment includes (but is not limited to) cask rigging, cask bottom/top spacers, and TC lifting yoke (See Section 2.3.3.2).

(5) Other Transfer Equipment includes (but is not limited to) a HRS, a Transfer Trailer, a prime mover for Transfer Trailer towing, cask support skid, auxiliary equipment mounted on the skid and SPS (See Section 2.3.3.3).

(6) Auxiliary Equipment includes, but is not limited to, a VDS and an AWS (See Section 2.3.3.4).

(7) Miscellaneous Equipment includes (but is not limited to) ISFSI security fence and gate(s), lighting, lightning protection, communications, monitoring, and alarm systems (See Section 2.3.3.5).

(8) The three TMI-2 Canister types include the TMI-2 Fuel Canister, TMI-2 Filter Canister, and TMI-2 Knockout Canister (See Section 2.3.2.3).

2.3.1 Description of TMI-2 ISFSI SSCs

(NUREG-1927, Section 2.4.1)

Per NUREG-1927, Section 2.4.1, the drawings listed in Table 2-2 are the key scoping documents referenced in the itemized scoping of the SSC subcomponents.

Table 2-2: Summary of Drawings used in Scoping Evaluations for Primary In-Scope SSCs

Design Drawing/Revision	FSAR Drawing/Revision	Design Drawing Title
HSM (HSM-01 through HSM-30, excludes HSM-15)		
219-02-5100/Rev. 1	219-02-6000/Rev. 1	Horizontal Storage Module ISFSI General Arrangement
219-02-5101/Rev. 1	219-02-6000/Rev. 1	Standard Module Main Assembly
219-02-5103/Rev. 1	219-02-6000/Rev. 1	Horizontal Storage Module Standard Module Base Unit
219-02-5104/Rev. 2	219-02-6000/Rev. 1	Horizontal Storage Module Roof Slab
219-02-5105/Rev. 1	219-02-6000/Rev. 1	Horizontal Storage Module DSC Support Structure
219-02-5107/Rev. 1	219-02-6000/Rev. 1	Horizontal Storage Module Erection Hardware and Misc. Steel Doors & Fabricated Fasteners
219-02-5108/Rev. 0	219-02-6000/Rev. 1	Horizontal Storage Module End Module Shield Wall
ISFSI Basemat and Approach Slab		
219-02-5200, Sht. 1/Rev. 3	219-02-6000/Rev. 1	Horizontal Storage Module Basemat
219-02-5200, Sht. 2/Rev. 2	219-02-6000/Rev. 1	Horizontal Storage Module Basemat
DSC (DOE12T-001 DSC through DOE12T-029 DSC)		
219-02-1000/Rev. 1	219-02-2000/Rev. 2	DSC Basket Assembly
219-02-1001/Rev. 1	219-02-2001/Rev. 2	DSC Shell Assembly
219-02-1002/Rev. 1	219-02-2002/Rev. 2	DSC Basket-Shell Assembly
219-02-1003/Rev. 1	219-02-2003/Rev. 2	DSC Main Assembly
219-02-1010/Rev. 2	219-02-2010/Rev. 2	DSC Purge Port Filter Assembly
219-02-1011/Rev. 2	219-02-2011/Rev. 3	DSC Vent Port Filter Assembly
TMI-2 Canister (Fuel)		
1154070-F/Rev. 3	1161300-D/Rev. B1	Fuel Canister Assembly
TMI-2 Canister (Knockout)		
1154041-F/Rev. 3	1161301-D/Rev. 1	Knockout Canister Assembly
TMI-2 Canister (Filter)		
1154018-F/Rev. 5	1161299-D/Rev. 1	Filter Canister Assembly

2.3.2 SSCs within Scope of License Renewal

(NUREG-1927, Section 2.2, Section 2.4.1, Section 2.4.2 and Section 2.4.2.1)

In general, the SSCs determined to be within the scope of renewal are the DSC, HSM, TC, TMI-2 Canisters, and Basemat and Approach Slab. The following sub-sections outline the scoping determinations for each.

2.3.2.1 DSC

Table 2-3 lists the DSC SSC subcomponents that are within scope of the AMR. Table 2-4 lists the DSC items excluded from the AMR. In-scope SSCs with ITS functions may include: (1) confinement, (2) radiation shielding, (3) sub-criticality control, (4) heat-removal capability, (5) structural integrity, and (6) retrievability.

The following discussion describes the attributes and examples for SSCs included in each of the remaining sub-categories for those subcomponents scoped in under Criterion 1. The ITS designation for these Criterion 1 SSCs is listed in Table 3.4-1 of the UFSAR or on the FSAR drawings themselves.

(1) Confinement – From Section 3.3.2.1 of the UFSAR [2.4.2]: *"The DSC has a series of barriers to ensure the confinement of radioactive materials. The DSC cylindrical shell is fabricated from rolled steel plate which is joined with full penetration 100% radiographed welds. All top and bottom end closure welds are multiple-pass welds. This effectively eliminates pinhole leaks which might occur in a single pass weld, since the chance of pinholes being in alignment on successive weld passes is not credible. Furthermore, the DSC cover plates are sealed by separate, redundant closure welds."* As indicated in Section 4.2.3 and Table 3.3-1 of the UFSAR, the primary SSCs in this sub-category include the: 1) DSC shell, 2) Inner and Outer Bottom Cover Plates, 3) Top Shield Plug – Plate 3, 4) Top Cover Plate 5) The DSC HEPA filters, and 6) Confinement Boundary welds.

(2) Radiation Shielding – The SSCs included in this sub-category provide gamma shielding and are comprised of steel subcomponents located between the DSC and the exterior of the HSMs. Primary SSCs included in this sub-category include: 1) DSC shell, 2) Inner and Outer Bottom Cover Plates, 3) Top and Bottom Shield Plugs, and 4) Top Cover Plate. In addition, for license renewal the NITS basket assembly and purge port block SSCs are considered in-scope, as they are considered to indirectly perform a shielding function due to the TMI-2 Canister locational support they impart.

(3) Sub-criticality control – Many of the SSCs provide more than one ITS function; however, none of the SSCs of the DSC or DSC basket provide sub-criticality control. During accident conditions, the DSC basket is assumed to fail and therefore is not included in the criticality model. The TMI-2 Canisters perform this function exclusively. Section 2.3.2.3 discusses sub-criticality control provided by the TMI-2 Canisters.

(4) Heat-removal capability – The SSCs included in this category are those evaluated to be necessary to transfer the decay heat from the TMI-2 Canister core debris to the exterior environment. The SSCs in this sub-category are limited to the DSC shell.

The following discussion provides reasoning about the DSC shell being in-scope for heat-removal capability, while other DSC subcomponents are scoped out. The thermal model used for the DSC evaluation is described in Section 8.1.3.2 of the UFSAR. The results of the thermal analyses are reported in Table 8.1-10 of the UFSAR. The thermal analysis of the DSC is performed using a radial two-dimensional (2-D) cross-sectioned model and conservatively assumes all heat transfer is by conduction and radiation only. The DSC shell is included in the radial cross section model as shown in Figure 8.1-4 of the UFSAR. The radial cross section model conservatively excludes axial heat transfer as well as conduction through the basket spacer discs. The conservatisms used in this thermal analysis minimize the rate of heat transfer from the payload and therefore provide a conservatively higher temperature of the payload. The highest predicted payload (TMI-2 core debris) temperature is 219°F during the accident case analysis. This is safely bounded by the normal operating condition storage temperature of 724°F (UFSAR, Section 3.3.7.1.1) for the payload (the acceptance criterion is the fuel cladding limit for intact fuel) [2.4.10].

In Section 8.1.3.1 of the UFSAR, for the thermal analysis of the DSC in the HSM, the DSC is approximated by equivalent rectangular sections in a half-symmetric three-dimensional (3-D) model of the HSM. The modelling of the DSC in the HSM thermal analysis minimizes internal thermal resistance and thus maximizes the predicted temperature. The maximum resultant DSC surface temperature from this 3-D model is applied as a constant boundary temperature constraint in the 2-D DSC model, as described in UFSAR, Section 8.1.3.2. The higher fixed shell temperature boundary condition for the DSC in the HSM analysis also maximizes the internal temperature of the TMI-2 core debris. While not necessary for heat-removal capability, the DSC in the HSM thermal analysis model is used to predict the thermal stresses on the primary DSC SSCs. A discussion of this is found in Section 8.1.1.2.C of the UFSAR. In summary, given the thermal analysis of the NUHOMS®-12T HSM and DSC discussed in Section 8.1.3 of the UFSAR, only the DSC shell is considered for heat removal capability.

(5) Structural Integrity – The SSCs included in this sub-category are largely steel subcomponents, which comprise the confinement boundary and facilitate retrievability. Components included in this sub-category include: 1) DSC Shell, 2) Inner and Outer Bottom Cover Plates, 3) Top Shield Plate, and 4) Top Cover Plate.

(6) Retrievability – The SSCs included in this sub-category are largely steel subcomponents which comprise the outer structural boundary and include: 1) DSC Shell, 2) Outer Bottom Cover Plate, 3) Grapple Ring, and 4) Grapple Ring Support Plate.

As mentioned above, several SSCs provide more than one function. The prime example is the DSC shell. The DSC shell is included in all sub-categories with the exception of sub-criticality.

In addition to the Criterion 1 SSCs, Criterion 2 SSCs are included in the LRA scope. These are SSCs defined as NITS; however, their failure could limit the ability of one or more Criterion 1 SSCs to fulfill their ITS function. The inorganic zinc coating is a NITS item that is considered to provide protection of the carbon steel surfaces of the DSC SSCs and is considered in-scope under Criterion 2. This is the only Criterion 2 SSC for the DSC.

2.3.2.2 HSM

Detailed scoping of the HSM SSC subcomponents that are within the scope of the AMR are shown in Table 2-3. For each subcomponent, the scoping criterion and ITS functions of each are identified. As noted, failure of any of these items could prevent an SSC or SSC subcomponent from performing its ITS function.

HSM items excluded from the AMR are listed in Table 2-4. Failure of these items will not result in the failure of an ITS function or fulfillment of an ITS function for any SSC or SSC subcomponent.

As was the case for the DSC inorganic zinc coating, the HSM inorganic zinc coating on the steel SSC subcomponents of the HSM is a NITS item that is considered to provide protection of the underlying carbon steel surfaces and is considered in-scope under Criterion 2.

In addition, there are cementitious and chemical grout materials used to fill voids in the concrete and provide sealants for repairs made to the concrete matrix. Other than the grout between the end shield wall panels, these are considered NITS items, but like the inorganic zinc steel coating provide underlying structural protection of the HSM SSCs, and therefore, are considered in-scope under Criterion 2.

Other ITS functions are identified for each in-scope SSC and include: confinement, radiation shielding, sub-criticality control, heat-removal capability, structural integrity, and retrievability. A brief description of each intended function is provided below.

(1) Confinement – The confinement ITS function focuses on maintaining the radioactive material within the confinement boundary as defined in the design basis documents. In the case of the TMI-2 ISFSI, confinement is limited to the boundary provided by the DSC. There are no HSM SSCs or subcomponents identified with this function.

(2) Radiation Shielding – Radiation shielding is provided to maintain on- and off-site doses, of both gamma and neutron radiation, As Low As Reasonably Achievable (ALARA) during transfer and on-site operations. Radiation shielding, for both gamma and neutron radiation is provided by the storage module SSCs and includes the end shield walls, including the grout between the shield walls. It is primarily provided by the concrete (to include grout) of the HSM. The steel-lined, concrete-filled shielded door assembly provides additional gamma and neutron shielding at the front of the HSM.

(3) Sub-criticality control – As discussed in Section 2.3.2.1, sub-criticality control is provided by the TMI-2 Canisters as outlined in Section 2.3.2.3. No HSM SSCs provide sub-criticality control.

(4) Heat-removal capability – The HSM structures are directly involved in the heat-removal function. The thermal mass of the monolithic concrete SSCs (base unit, roof slab, and end shield walls) resist daily fluctuations of temperature and dissipates the thermal heat load within, to the external environment by natural convection. Each HSM provides cooling of the DSC and its contents by radiation, natural convection, and heat conduction through its ceiling and walls. Adjacent HSMs are spaced 6 inches apart, allowing natural convective airflow along the sidewalls of each HSM. Heat transfer between the outer surfaces of the DSC shell and the interior surfaces of the HSM walls are modeled using radiative heat transfer; any closed-cavity convection occurring in the HSM cavity air surrounding the DSC shell is conservatively neglected. In addition, the heat transfer through the DSC HEPA filter housings due to inflow of air is conservatively ignored in the thermal analysis.

(5) Structural Integrity – The structural integrity function ensures that the ISFSI array remains intact and that all SSCs maintain adequate position and alignment to perform their ITS functions. Structural integrity is a primary function of the HSM SSCs. The structural integrity is provided by the HSM concrete and DSC support structure within the HSM.

(6) Retrievability – The retrievability function pertains to retrieval of the DSC interred within the HSMs. The method of retrieval of the DSC is governed by the procedures in Section 5.1.2.3 (and alternately Appendix E, Section 5.1.2.3) of the UFSAR [2.4.2]. The HSM SSCs important to retrievability are those that provide access to the DSC and support the DSC during retrieval.

2.3.2.3 TMI-2 Canister

Detailed scoping of the TMI-2 Canister SSC subcomponents are shown in Table 2-3. The TMI-2 Canisters consist of three types: TMI-2 Fuel Canister, TMI-2 Filter Canister, and TMI-2 Knockout Canister, as described and detailed in the UFSAR [2.4.2]. The following headings describe the application of the ITS functions as discussed in the UFSAR, with respect to the TMI-2 Canisters and its subcomponents.

(1) Confinement – The confinement boundary for the TMI-2 ISFSI is the DSC. The TMI-2 Canisters are confined by the DSC shell and by multiple barriers at each end of the DSC. No credited confinement function is provided by the TMI-2 Canisters since the DSC leakage accident analyzed in Section 8.2.7 of the UFSAR takes no credit for the TMI-2 Canisters for a confinement function. Rather, the TMI-2 Canisters limit dispersion and provide geometric control of the TMI-2 core debris. The TMI-2 Canisters have two small penetrations, a purge port, and a fill port, which are left open during storage. The path that TMI-2 core debris must travel to get out of the TMI-2 Canisters is not direct, even with the penetrations left open. Furthermore, there is no motive force for transporting radioactive debris from the TMI-2 Canisters into the DSC interior. Of note, the TMI-2 Canisters confinement was evaluated in the 2001 biennial update report [2.4.7], discussed in Section 3.13 of an August, 2000 NRC Inspection Report [2.4.8] and summarized in Section 3.3.2.1 of the UFSAR [2.4.2].

(2) Radiation Shielding – TMI-2 Canister shielding provisions were included as part of the HSM dose rate modelling and the DSC top end dose rate modelling. According to Section 7.3.2.2.B of the UFSAR Shielding Analyses, "The ¼-inch thick debris canister shell has been added to the DSC shell thickness." A total 3/8-in. and 1-in. thickness was included for the bottom and top ends of the TMI-2 Canister, respectively (Section 2.3 of 219-02.0401) [2.4.5]. Therefore, the shell, and the bottom and top TMI-2 Canister heads are included for shielding protection from gamma radiation. In addition, dose rates due to gamma contributions, only at several locations at the top end of the TMI-2 Fuel Canister were calculated and summarized in UFSAR, Section 7.3.2.2.D. The model included the BORAL® neutron poison, inner/outer shroud, the Licon lightweight concrete, and shell [2.4.6].

(3) Sub-criticality control – The TMI-2 Canister shell boundary maintains the geometric separation of the canisterized TMI-2 core debris between adjacent TMI-2 Canisters. Geometric spacing of the 12 TMI-2 Canisters in the DSC is an assumption of the criticality analysis ("*The 12 TMI-2 Canisters are triangular pitch, close packed*" – UFSAR Section 3.3.4.2.C) with the outer TMI-2 Canister structure maintaining this configuration. Concurrently, the boron carbide pellets of the TMI-2 Filter/Knockout Canisters and BORAL® shroud of the TMI-2 Fuel Canister maintain a critically safe configuration internal to each of the TMI-2 Canister types. The poison tube assemblies in the TMI-2 Knockout Canister are modelled as part of the criticality evaluation as indicated in Appendix D (Page D.4) of the UFSAR. Both the central poison tube and outer poison tubes are displaced one inch bounding the original TMI-2 Canister certified drop test results, and therefore is relevant to limiting poison displacement (UFSAR, Section 3.3.4.2.C). For the TMI-2 Filter Canister, *"The poison tube and internals of the filter canister are compressed and pushed to one side of the canister shell. The filter elements are assumed to disappear from the model"* (UFSAR, Section 3.3.4.2.A). For the TMI-2 Fuel Canister (Page D.3 of UFSAR), the modelled fuel region is maximized within the shell by using minimum thicknesses on the inner and outer skin and the BORAL®.

(4) Heat-removal capability – The design bases heat load of 860 Watts per DSC is applied as a volumetric heat density of 9.60×10^{-5} Btu/min-in^3 over the fueled portion of the TMI-2 Canisters. This allows for heat rejection through the TMI-2 Canister ends as well as their sides. This includes the TMI-2 Canister heads, shell, and lower plate assemblies of the TMI-2 Fuel and Knockout Canisters (Section 8.1.3.1 C of UFSAR). Of note, the TMI-2 Filter Canister decay heat loads are bounded by the greater TMI-2 Fuel and Knockout Canister decay heat loads. Nonetheless, the upper and lower head assemblies of the TMI-2 Filter Canister are scoped-in for their possible heat removal capability. In addition, the TMI-2 Canisters are also included in the DSC thermal model in determination of the maximum fuel cladding temperature (UFSAR Section 3.3.7.1.1 with results in UFSAR Table 8.1-10). The TMI-2 Fuel Canister was modelled which included the shell, the Licon concrete, BORAL® and surrounding shroud in this DSC thermal analysis (UFSAR, Figure 8.1-4).

(5) Structural Integrity – The structural integrity of the TMI-2 Canisters is important in maintaining the geometric spacing between TMI-2 Canisters for the close-packed configuration of the criticality evaluation. In addition, the TMI-2 Canister structural integrity is necessary for maintaining the boron neutron absorbers in the as-modelled configuration for the criticality analyses. To a lesser extent, but still scoped-in, the TMI-2 Canister shell structural integrity is relied on in the TC drop analyses (oblique corner drop and horizontal side drop from 80 inches, UFSAR Section 8.2.5.1.B) since the DSC basket may yield in those accident scenarios. As stated in UFSAR Section 8.2.5.2.A, *"the TMI-2 canisters could bear on the DSC shell"*. As such, the primary main structural elements of the TMI-2 Canisters are considered in-scope, including the heads and shell.

(6) Retrievability – For both recovery and decommissioning activities, retrieval of the TMI-2 Canisters occurs by retrieving the DSCs from the HSMs using the TC and removing the DSCs from the TMI-2 ISFSI. Any retrieval of the TMI-2 Canisters directly shall only occur outside of the TMI-2 ISFSI at other federal facilities. This would consist of moving the TMI-2 Canisters to another facility at the INL Site for further processing (e.g., re-packaging the TMI-2 canisters into a transportation package) and ultimate shipment to a federal facility for long-term interim or final storage. This process is described in UFSAR, Section 9.6.3 [2.4.2]. "Interim Staff Guidance", ISG-2, Revision 2 [2.4.4] recognizes three options for licensees to comply with the regulatory requirements for fuel retrievability, including one for DSC-based retrievability (Option B). Retrieval of the DSCs exclusively is consistent with ISG-2, Rev. 2, allowing for this operational mode of the TMI-2 ISFSI. The TMI-2 ISFSI license was issued in March 1999, prior to the publication of the original version (i.e., Revision 0) of ISG-2 in May 1999. Therefore, the licensing basis for retrievability of the TMI-2 core debris via the DSCs, as described in the TMI-2 ISFSI FSAR is not predicated on any version of ISG-2. However, the DSC-based retrievability strategy is consistent with the guidance described in ISG-2, Revision 0 and ISG-2, Revision 2.

2.3.2.4 Transfer Cask

The TMI-2 TC is scoped in because it is classified as ITS and is required to provide retrievability of the DSC for recovery and decommissioning operations. While outside the HSM and still within the ISFSI limits, the TC is also necessary as it provides protection, including radiological shielding for the DSC during such operations. The TC is scoped in under Criterion 1, as an ITS item in accordance with Table 3.4-1 of the UFSAR [2.4.2]. In accordance with the UFSAR and as described in Section 1.3.1, the two TC types permitted are the OS197 and MP187. TC scoping evaluations are already included for the OS197 TC in the Standardized NUHOMS® CoC 1004 renewal application [2.4.9] and for the MP187 TC in the Rancho Seco ISFSI license renewal application [2.4.12].

Although the Rancho Seco licensee has completed subcomponent SSC scoping evaluations for the MP187 TC, scoping evaluations for the MP187 TC in context of the TMI-2 ISFSI are deemed unnecessary. This is because DOE-ID has proposed a new license condition 20 that states an MP187 TC aged greater than 20 years is prohibited from use.

For an OS197 TC aged greater than 20 years, the scoping evaluation completed from the relevant sections of the Standardized NUHOMS® CoC 1004 renewal application [2.4.9] are IBR herein. The CoC 1004 renewal application identifies the OS197 TC SSCs within the scope of renewal, as well as the SSCs excluded from the scope of renewal. In addition, pertinent to the OS197 TC, Appendix 2C of the Standardized NUHOMS® 1004 CoC is IBR herein. Appendix 2C lists the detailed TC scoping results. IBR of any proposed OS197 aged at least 20 years is considered appropriate because any safety-significant variations on applicability will be bounded by conditions already contained within the CoC 1004 renewal application (i.e., stronger radioactive source terms, higher decay heat loads, ability to add more contents to the ISFSI, high burn-up fuel, longer PEO, etc.). Any other TMI-2 ISFSI specific distinctions, which need to be addressed with respect to the TC, are covered in Appendix A3 to this LRA.

2.3.2.5 ISFSI Basemat and Approach Slab

The TMI-2 ISFSI Basemat and Approach Slab SSCs are classified as NITS, because the HSM is not anchored to the basemat (Section 3.4.3 of [2.4.2]). The basemat provides a level and stable surface for placement and storage of HSMs with reinforcement on the top and bottom of the slab. The approach slab is an asphalt slab providing access and support for the Transfer Trailer while transitioning onto the basemat. The soil supporting the slab is excavated and backfilled to provide adequate bearing pressure for all postulated loads and to ensure adequate drainage. The slab is designed to preclude the effects of frost heave. However, differential settlement of the storage pad and approach slab could affect retrievability, could lower the elevation of the pad below the Predicted Maximum Flood (PMF) level, and in the unlikely event that large settlements of the ISFSI foundation occur, the resultant shifting of adjacent HSMs may cause the HSMs to separate, reducing HSM self-shielding. There are no other credible failure modes of the basemat and approach slab that could prevent the ISFSI intended functions from being fulfilled. Therefore, the basemat and approach slab are within scope of renewal with respect to assessing for differential settlement on retrievability.

Table 2-3: Tabulation of all In-Scope ISFSI Subcomponents

IN-SCOPE SUBCOMPONENT IDENTIFICATION						INTENDED FUNCTION					
Drawing Number	Drawing Revision	Component	Item Num.	Item Description	Scoping Criterion	Confinement	Radiation Shielding	Sub-Criticality	Heat-Removal Capability	Structural Integrity	Retrievability
DRY-SHIELDED CANISTER (DSC)											
219-02-1000	1	DSC BASKET ASSEMBLY	1	SPACER DISC, 1 1/4" PLATE	2	NO	YES	NO	NO	NO	NO
219-02-1000	1	DSC BASKET ASSEMBLY	2	TOP SPACER DISC, 1 1/4" PLATE	2	NO	YES	NO	NO	NO	NO
219-02-1000	1	DSC BASKET ASSEMBLY	3	SUPPORT ROD, Ø 1-1/2" ROD	2	NO	YES	NO	NO	NO	NO
219-02-1000	1	DSC BASKET ASSEMBLY	4	PIPE SLEEVE – LONG, 2.00 NPS SCHEDULE 80	2	NO	YES	NO	NO	NO	NO
219-02-1000	1	DSC BASKET ASSEMBLY	5	PIPE SLEEVE – SHORT, 2.00 NPS SCHEDULE 80	2	NO	YES	NO	NO	NO	NO
219-02-1000	1	DSC BASKET ASSEMBLY	6	END SLEEVE	2	NO	YES	NO	NO	NO	NO
219-02-1001	1	DSC SHELL ASSEMBLY	1	CYLINDRICAL SHELL, 5/8" PLATE	1	YES	YES	NO	YES	YES	YES
219-02-1001	1	DSC SHELL ASSEMBLY	2	OUTER BOTTOM COVER	1	NO	YES	NO	NO	YES	YES
219-02-1001	1	DSC SHELL ASSEMBLY	3	BOTTOM SHIELD PLUG	1	NO	YES	NO	NO	NO	NO
219-02-1001	1	DSC SHELL ASSEMBLY	4	GRAPPLE RING, 1" PLATE	1	NO	NO	NO	NO	NO	YES
219-02-1001	1	DSC SHELL ASSEMBLY	5	GRAPPLE RING SUPPORT, 3/4" PLATE	1	NO	NO	NO	NO	NO	YES
219-02-1001	1	DSC SHELL ASSEMBLY	6	INNER BOTTOM COVER 3/4" PLATE	1	YES	YES	NO	NO	YES	NO
219-02-1002	1	DSC BASKET-SHELL ASSEMBLY	5	SUPPORT RING 3/4" PLATE	1	YES	NO	NO	NO	NO	NO
219-02-1002	1	DSC BASKET-SHELL ASSEMBLY	6	VENT PORT SHIELD BLOCK, 1-3/4" PLATE	1	NO	YES	NO	NO	NO	NO
219-02-1003	1	DSC MAIN ASSEMBLY	2	TOP SHIELD PLUG, PLATE 3 1-1/4" THICK PLATE	1	YES	YES	NO	NO	YES	NO
219-02-1003	1	DSC MAIN ASSEMBLY	3	TOP COVER PLATE	1	YES	YES	NO	NO	YES	NO
219-02-1003	1	DSC MAIN ASSEMBLY	4	PURGE PORT BLOCK	2	NO	YES	NO	NO	NO	NO
219-02-1003	1	DSC MAIN ASSEMBLY	9	TOP SHIELD PLUG PLATE 1 & 2	1	NO	YES	NO	NO	NO	NO
219-02-1010	2	DSC PURGE PORT FILTER ASSEMBLY	1	FILTER HOUSING	1	YES	YES	NO	NO	NO	NO
219-02-1010	2	DSC PURGE PORT FILTER ASSEMBLY	5	HEPA TYPE FILTER W/GASKET	1	YES	NO	NO	NO	NO	NO
219-02-1010	2	DSC PURGE PORT FILTER ASSEMBLY	10	DUAL C-SEALS, EG & G PRESSURE SCIENCE (FILTER HOUSING)	1	YES	NO	NO	NO	NO	NO
219-02-1010	2	DSC PURGE PORT FILTER ASSEMBLY	14	SCREW, CAP SOCKET HD, 1/2 - 13 UNC - 2A X 0.75" LONG	1	YES	NO	NO	NO	NO	NO
219-02-1010	2	DSC PURGE PORT FILTER ASSEMBLY	16	SCREW, CAP SOCKET HD, 1 – 8 UNC – 2A X 3.00" LONG	1	YES	NO	NO	NO	NO	NO
219-02-1010	2	DSC PURGE PORT FILTER ASSEMBLY	20	DUAL C-SEALS, EG&G PRESSURE SCIENCE	1	YES	NO	NO	NO	NO	NO
219-02-1010	2	DSC PURGE PORT FILTER ASSEMBLY	22	LOCK WASHER	1	YES	NO	NO	NO	NO	NO
219-02-1011	2	DSC VENT PORT FILTER ASSEMBLY	1	FILTER HOUSING	1	YES	YES	NO	NO	NO	NO
219-02-1011	2	DSC VENT PORT FILTER ASSEMBLY	5	HEPA TYPE FILTER W/GASKET	1	YES	NO	NO	NO	NO	NO
219-02-1011	2	DSC VENT PORT FILTER ASSEMBLY	10	DUAL C-SEALS, EG & G PRESSURE SCIENCE (FILTER HOUSING)	1	YES	NO	NO	NO	NO	NO
219-02-1011	2	DSC VENT PORT FILTER ASSEMBLY	14	SCREW, CAP SOCKET HD, 1/2 - 13 UNC - 2A X 0.75" LONG	1	YES	NO	NO	NO	NO	NO
219-02-1011	2	DSC VENT PORT FILTER ASSEMBLY	16	SCREW, CAP SOCKET HD, 1 – 8 UNC – 2A X 3.00" LONG	1	YES	NO	NO	NO	NO	NO
219-02-1011	2	DSC VENT PORT FILTER ASSEMBLY	20	DUAL C-SEALS, EG&G PRESSURE SCIENCE	1	YES	NO	NO	NO	NO	NO
219-02-1011	2	DSC VENT PORT FILTER ASSEMBLY	22	LOCK WASHER	1	YES	NO	NO	NO	NO	NO

Table 2-3: Tabulation of all In-Scope ISFSI Subcomponents

IN-SCOPE SUBCOMPONENT IDENTIFICATION						INTENDED FUNCTION					
Drawing Number	**Drawing Revision**	**Component**	**Item Num.**	**Item Description**	**Scoping Criterion**	**Confinement**	**Radiation Shielding**	**Sub-Criticality**	**Heat-Removal Capability**	**Structural Integrity**	**Retrievability**
Fabrication Specification 219-02-107 [2.4.14]	1	DSC ASSEMBLY	N/A	WELD FILLER METAL	1	YES	NO	NO	NO	YES	YES
Fabrication Specification 219-02-107 [2.4.14]	1	DSC ASSEMBLY	N/A	INORGANIC ZINC-RICH COATING	2	NO	NO	NO	NO	YES	NO
HORIZONTAL STORAGE MODULE (HSM)											
219-02-5100	1	HSM ISFSI GENERAL ARRANGEMENT	5100-203	BOLT, 3/4-10 UNC-2A X 2" LONG	1	NO	NO	NO	NO	YES	NO
219-02-5100	1	HSM ISFSI GENERAL ARRANGEMENT	5100-301	NUT, 1 1/8-7 UNC-2B	1	NO	NO	NO	NO	YES	NO
219-02-5100	1	HSM ISFSI GENERAL ARRANGEMENT	5100-305	NUT, 1 1/2-6 UNC-2B	1	NO	NO	NO	NO	YES	NO
219-02-5100	1	HSM ISFSI GENERAL ARRANGEMENT	NOTE 10	GROUT - SHIELD WALL PANELS	1	NO	YES	NO	NO	NO	NO
219-02-5100/ WORK ORDER (WO) 642973 [2.4.17]	1	HSM ISFSI GENERAL ARRANGEMENT	NOTE 8	LIFTING STRAND LOOP POCKET FILL	2	NO	NO	NO	NO	YES	NO
219-02-5101	1	STANDARD MODULE MAIN ASSEMBLY	5101-204	BOLT, 3/4 – 10 UNC – 2A X 2-3/4" LONG	1	NO	NO	NO	NO	YES	YES
219-02-5101	1	STANDARD MODULE MAIN ASSEMBLY	5101-206	BOLT, 3/4 – 10 UNC – 2A X 3-1/4" LONG	1	NO	NO	NO	NO	YES	YES
219-02-5101	1	STANDARD MODULE MAIN ASSEMBLY	5101-208	BOLT, 1 1/4 – 7 UNC – 2A X 3-1/2" LONG	1	NO	NO	NO	NO	YES	NO
219-02-5101	1	STANDARD MODULE MAIN ASSEMBLY	5101-210	BOLT, 1-1/4 – 7 UNC – 2A X 4-1/4" LONG	1	NO	NO	NO	NO	YES	NO
219-02-5101	1	STANDARD MODULE MAIN ASSEMBLY	5101-307	NUT, 1-5/8 –5 ½ UNC–2B	2	NO	NO	NO	NO	YES	NO
219-02-5101	1	STANDARD MODULE MAIN ASSEMBLY	5101-311	NUT, 1-1/4 –7 UNC – 2B	1	NO	NO	NO	NO	YES	NO
219-02-5101	1	STANDARD MODULE MAIN ASSEMBLY	NOTE 16	GROUT - LIFTING STRAND LOOP POCKET FILL	2	NO	NO	NO	NO	YES	NO
219-02-5101	1	STANDARD MODULE MAIN ASSEMBLY	NOTE 2B	WELD FILLER MATERIAL (CATEGORY B COMPONENTS)	1	NO	NO	NO	NO	YES	YES
219-02-5101/ WO 635917 [2.4.18]	1	STANDARD MODULE MAIN ASSEMBLY	Field Design Changes: FDC 7682, FDC 7715	TMI-2 ISFSI HSM ROOF BOLT PROTECTIVE COVER	2	NO	NO	NO	NO	YES	NO
219-02-5103	1	HSM STANDARD MODULE BASE UNIT	NOTE 5	REINFORCEMENT BARS, OTHER THAN #4	1	NO	NO	NO	NO	YES	NO
219-02-5103	1	HSM STANDARD MODULE BASE UNIT	NOTES 1&14	CONCRETE	1	NO	YES	NO	YES	YES	NO
219-02-5103	1	HSM STANDARD MODULE BASE UNIT	NOTES 8&18	GROUT – MOUNTING HOLES & EMBEDMENT VOIDS	2	NO	NO	NO	NO	YES	NO
219-02-5104	2	HSM ROOF SLAB	NOTE 15	SLOW-RISE POLYURETHANE FOAM FORMULA SPRAY FOAM	2	NO	NO	NO	NO	YES	NO
219-02-5104	2	HSM ROOF SLAB	NOTE 15 / FDC 7715	WATER RESISTANT POLYURETHANE FOAM MATERIAL, 6-1/2" X 6-1/2" X 1/8" THICK (NOT ADHESIVE)	2	NO	NO	NO	NO	YES	NO
219-02-5104	2	HSM ROOF SLAB	NOTE 5	REINFORCEMENT BARS, OTHER THAN #4	1	NO	NO	NO	NO	YES	NO

Table 2-3: Tabulation of all In-Scope ISFSI Subcomponents

IN-SCOPE SUBCOMPONENT IDENTIFICATION						INTENDED FUNCTION					
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219-02-5104	2	HSM ROOF SLAB	NOTES 1&11	CONCRETE	1	NO	YES	NO	YES	YES	NO
219-02-5105	1	HSM DSC SUPPORT STRUCTURE	5105-101	FRONT MOUNTING PLATE, 1" THICK	1	NO	NO	NO	NO	YES	YES
219-02-5105	1	HSM DSC SUPPORT STRUCTURE	5105-102	REAR MOUNTING PLATE, 1" THICK	1	NO	NO	NO	NO	YES	YES
219-02-5105	1	HSM DSC SUPPORT STRUCTURE	5105-103	STIFFENER PLATE, 1/2" THICK	1	NO	NO	NO	NO	YES	YES
219-02-5105	1	HSM DSC SUPPORT STRUCTURE	5105-104	STIFFENER PLATE, 1/2" THICK	1	NO	NO	NO	NO	YES	YES
219-02-5105	1	HSM DSC SUPPORT STRUCTURE	5105-105	SUPPORT PLATE, 1-1/2" THICK X 7" LONG	1	NO	NO	NO	NO	YES	YES
219-02-5105	1	HSM DSC SUPPORT STRUCTURE	5105-106	CANISTER STOP PLATE, 1-1/8" THICK	1	NO	NO	NO	NO	YES	YES
219-02-5105	1	HSM DSC SUPPORT STRUCTURE	5105-107	SUPPORT RAIL, W12 X 96	1	NO	NO	NO	NO	YES	YES
219-02-5105	1	HSM DSC SUPPORT STRUCTURE	5105-109	STIFFENER PLATE, 1/2" THICK	1	NO	NO	NO	NO	YES	YES
219-02-5105	1	HSM DSC SUPPORT STRUCTURE	5105-110	RAIL EXTENSION PLATE, 3/4" THICK	1	NO	NO	NO	NO	YES	YES
219-02-5105	1	HSM DSC SUPPORT STRUCTURE	5105-111	CROSS BEAM, W6 X 25	1	NO	NO	NO	NO	YES	YES
219-02-5105	1	HSM DSC SUPPORT STRUCTURE	NOTE 2	WELD FILLER MATERIAL	1	NO	NO	NO	NO	YES	YES
219-02-5105/ Fabrication Specification 219-02-115 [2.4.19]	1	HSM DSC SUPPORT STRUCTURE	NOTE 5	COATING	2	NO	NO	NO	NO	YES	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-101	PLATE ½” THICK	1	NO	YES	NO	NO	YES	YES
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-102	ROLLED PLATE 3/8” THICK	1	NO	YES	NO	NO	YES	YES
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-103	PLATE 1-½” THICK	1	NO	YES	NO	NO	YES	YES
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-105	MOUNTING PLATE 1” THICK	1	NO	YES	NO	NO	YES	YES
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-118	PLATE ¾” THICK	1	NO	NO	NO	NO	YES	YES
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-120	PLATE ½” THICK	2	NO	NO	NO	NO	YES	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-121	PLATE ½” THICK	2	NO	NO	NO	NO	YES	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-125	DOOR, PLATE 1-1/2” THICK	1	NO	NO	NO	NO	YES	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-126	SPACER, PLATE 1-1/2” THICK	1	NO	NO	NO	NO	YES	NO

Table 2-3: Tabulation of all In-Scope ISFSI Subcomponents

IN-SCOPE SUBCOMPONENT IDENTIFICATION						INTENDED FUNCTION					
Drawing Number	Drawing Revision	Component	Item Num.	Item Description	Scoping Criterion	Confinement	Radiation Shielding	Sub-Criticality	Heat-Removal Capability	Structural Integrity	Retrievability
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-127	HEAVY DUTY HINGE (REAR ACCESS DOOR)	1	NO	NO	NO	NO	YES	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-130	ANGLE, L8" X 8" X 1" THICK	1	NO	NO	NO	NO	YES	YES
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-131	STIFFENER PLATE, ½" THICK	1	NO	NO	NO	NO	YES	YES
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-135	PLATE, ¾" THICK	2	NO	NO	NO	NO	NO	YES
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-137	PLATE, ¾" THICK	1	NO	NO	NO	NO	YES	YES
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-139	TUBE STEEL, 5" X 5" X 3/8" THICK	2	NO	NO	NO	NO	NO	YES
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-140	PLATE, 4-½" SQUARE X 1/4" THICK	2	NO	NO	NO	NO	NO	YES
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-141	SEISMIC RETAINER, TUBE STEEL, 4" X 4" X ½" THICK X 1'-0" LONG	1	NO	NO	NO	NO	YES	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-148	REAR DSC SUPPORT STRUCTURE LUG PLATE, 2" X 4" X 1" THICK	1	NO	NO	NO	NO	YES	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-149	SHIELD WALL TIE PLATE, 3/4" THICK	1	NO	NO	NO	NO	YES	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-154	RICHMOND DOWEL BAR SPLICER (DB-SAE) WITH 1-9/16–8 UN THREAD AND #11 BAR	2	NO	NO	NO	NO	YES	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-155	WASHER PLATE, 1/2" THICK	1	NO	NO	NO	NO	YES	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-157	WASHER PLATE, 1/2" THICK	1	NO	NO	NO	NO	YES	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-158	RICHMOND DOWEL BAR SPLICER (DB-SAE) WITH 1-9/16–8 UN THREAD AND # 11 BAR	2	NO	NO	NO	NO	YES	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-251	SHIELD WALL CAST-IN-PLACE BOLT, 1 1/8–7UNC – 2A X 1' – 0" LONG	1	NO	NO	NO	NO	YES	NO

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219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-307	NUT, 1 ½” – 6 UNC – 2B	1	NO	NO	NO	NO	YES	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-308	COUPLING NUT, 1 ½” – 6 UNC – 2B	1	NO	NO	NO	NO	YES	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-310	NUT, 1 ¼” – 7 UNC – 2B	1	NO	NO	NO	NO	YES	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-311	COUPLING NUT, 1 ¼” – 7 UNC – 2B	1	NO	NO	NO	NO	YES	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-313	NUT, 2 – 4 ½ UNC – 2B	1	NO	NO	NO	NO	YES	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-314	COUPLING NUT, 2 – 4 ½ – 7 UNC – 2B	1	NO	NO	NO	NO	YES	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-316	NUT, ¾ - 10 UNC – 2B	1	NO	NO	NO	NO	YES	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-317	COUPLING NUT, ¾ - 10 UNC – 2B	1	NO	NO	NO	NO	YES	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-452	WASHER PLATE 6” SQ X 1” THICK	2	NO	NO	NO	NO	YES	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-506	STUD, 1 ½” – 6 UNC – 2A	1	NO	NO	NO	NO	YES	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-509	STUD, 1 ¼” – 7 UNC – 2A	1	NO	NO	NO	NO	YES	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-512	STUD, 2 – 4 ½ UNC – 2A	1	NO	NO	NO	NO	YES	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-515	STUD, ¾ - 10 UNC – 2A	1	NO	NO	NO	NO	YES	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-544	SHIELD WALL SUPPORT STUD, 1 1/2–6UNC–2A	1	NO	NO	NO	NO	YES	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-553	ROOF ATTACHMENT BOLT, ROD Ø 1–5/8”	2	NO	NO	NO	NO	YES	NO

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219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-619	NELSON STUD, TYPE S3L, Ø ¾” X 3–3/16” LONG	1	NO	NO	NO	NO	YES	YES
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-643	NELSON STUD, TYPE H4L Ø 1/2” X 4–1/8” LONG	2	NO	NO	NO	NO	NO	YES
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	NOTE 1/ NOTE 18	WELD FILLER MATERIAL (ATTACHES DSC SUPPORT STRUCTURE)	1	NO	NO	NO	NO	YES	YES
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	NOTE 11	CONCRETE FILL	1	NO	YES	NO	NO	NO	NO
219-02-5107/ Fabrication Specification 219-02-115 [2.4.19]	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	NOTES 2-3, 9-10, 13	COATING	2	NO	NO	NO	NO	YES	NO
219-02-5108	0	HSM END MODULE SHIELD WALL	NOTE 1/ NOTE 9	REINFORCEMENT BARS	1	NO	NO	NO	NO	YES	NO
219-02-5108	0	HSM END MODULE SHIELD WALL	NOTE 1/ NOTE 9	CONCRETE	1	NO	YES	NO	NO	YES	NO
TMI-2 KNOCKOUT CANISTER											
02-1150946-C	3	KNOCKOUT CANISTER UPPER HEAD WELDMENT	1	1150946C POISON TUBE ASSEMBLY	3	NO	NO	YES	NO	YES	NO
02-1150946-C	3	KNOCKOUT CANISTER UPPER HEAD WELDMENT	2	1150946C TOP END CAP	3	NO	NO	YES	NO	YES	NO
02-1150946-C	3	KNOCKOUT CANISTER UPPER HEAD WELDMENT	3	1150946C BOTTOM END CAP	3	NO	NO	YES	NO	YES	NO
02-1150946-C	3	KNOCKOUT CANISTER UPPER HEAD WELDMENT	4	1150946C PIPE 1" Ø SCHEDULE 160	3	NO	NO	YES	NO	YES	NO
02-1150946-C	3	KNOCKOUT CANISTER UPPER HEAD WELDMENT	5	1150946C B_4C PELLET	3	NO	NO	YES	NO	NO	NO
02-1150968-D	2	KNOCKOUT CANISTER BOTTOM SUPPORT PLATE ASSEMBLY	1	1150968D BOTTOM SUPPORT PLATE ASSEMBLY	3	NO	YES	YES	YES	YES	NO
02-1150968-D	2	KNOCKOUT CANISTER BOTTOM SUPPORT PLATE ASSEMBLY	2	1150950E BOTTOM SUPPORT PLATE	3	NO	YES	YES	YES	YES	NO
02-1154027-F	4	KNOCKOUT CANISTER INTERNALS ASSEMBLY	1	1154027F KNOCKOUT CANISTER INTERNALS ASSEMBLY	3	NO	YES	YES	YES	YES	NO
02-1154027-F	4	KNOCKOUT CANISTER INTERNALS ASSEMBLY	2	1155233D POISON TUBE A	3	NO	NO	YES	NO	YES	NO
02-1154027-F	4	KNOCKOUT CANISTER INTERNALS ASSEMBLY	3	1150946C POISON TUBE B	3	NO	NO	YES	NO	YES	NO
02-1154027-F	4	KNOCKOUT CANISTER INTERNALS ASSEMBLY	4	1150968D BOTTOM SUPPORT PLATE ASSEMBLY	3	NO	YES	YES	YES	YES	NO
02-1154027-F	4	KNOCKOUT CANISTER INTERNALS ASSEMBLY	5	1150939D INTERMEDIATE SUPPORT PLATE A	3	NO	NO	YES	NO	YES	NO

Table 2-3: Tabulation of all In-Scope ISFSI Subcomponents

IN-SCOPE SUBCOMPONENT IDENTIFICATION						INTENDED FUNCTION					
Drawing Number	**Drawing Revision**	**Component**	**Item Num.**	**Item Description**	**Scoping Criterion**	**Confinement**	**Radiation Shielding**	**Sub-Criticality**	**Heat-Removal Capability**	**Structural Integrity**	**Retrievability**
02-1154027-F	4	KNOCKOUT CANISTER INTERNALS ASSEMBLY	7	1150937D SUPPORT RING	3	NO	NO	YES	NO	YES	NO
02-1154027-F	4	KNOCKOUT CANISTER INTERNALS ASSEMBLY	9	1150954D SEAL PLATE	3	NO	NO	YES	NO	YES	NO
02-1154027-F	4	KNOCKOUT CANISTER INTERNALS ASSEMBLY	14	1154090C CENTER TUBE	3	NO	NO	YES	NO	YES	NO
02-1154034-F	3	KNOCKOUT CANISTER INTERNALS & SHELL ASSEMBLY	1	1154034F INTERNALS & SHELL ASSEMBLY	3	NO	YES	YES	NO	YES	NO
02-1154034-F	3	KNOCKOUT CANISTER INTERNALS & SHELL ASSEMBLY	2	1150945C SHELL (KNOCKOUT & FILTER CANISTER)	3	NO	YES	YES	NO	YES	NO
02-1154034-F	3	KNOCKOUT CANISTER INTERNALS & SHELL ASSEMBLY	3	1154027F KNOCKOUT CANISTER INTERNALS ASSEMBLY	3	NO	YES	YES	YES	YES	NO
02-1154041-F	3	KNOCKOUT CANISTER ASSEMBLY	1	1154041F KNOCKOUT CANISTER ASSEMBLY	3	NO	YES	YES	YES	YES	NO
02-1154041-F	3	KNOCKOUT CANISTER ASSEMBLY	2	1154045D BOTTOM HEAD ASSEMBLY	3	NO	YES	YES	YES	YES	NO
02-1154041-F	3	KNOCKOUT CANISTER ASSEMBLY	3	1154046F KNOCKOUT CANISTER UPPER HEAD WELDMENT	3	NO	YES	YES	YES	YES	NO
02-1154045-D	5	KNOCKOUT & FILTER CANISTER LOWER HEAD ASSEMBLY	1	1154045D CANISTER LOWER HEAD ASSEMBLY	3	NO	YES	YES	YES	YES	NO
02-1154045-D	5	KNOCKOUT & FILTER CANISTER LOWER HEAD ASSEMBLY	2	1150917D CANISTER LOWER HEAD (KNOCKOUT & FILTER CANISTER)	3	NO	YES	YES	YES	YES	NO
02-1154046-F	6	FILTER & KNOCKOUT CANISTER SKIRT	1	1154046F KNOCKOUT CANISTER HEAD WELDMENT	3	NO	YES	YES	YES	YES	NO
02-1154046-F	6	FILTER & KNOCKOUT CANISTER SKIRT	3	1150943E KNOCKOUT CANISTER UPPER HEAD	3	NO	YES	YES	YES	YES	NO
02-1155233-D	2	KNOCKOUT CANISTER POISON TUBE ASSEMBLY	1	1155233D KNOCKOUT CANISTER POISON TUBE ASSEMBLY	3	NO	NO	YES	NO	YES	NO
02-1155233-D	2	KNOCKOUT CANISTER POISON TUBE ASSEMBLY	2	1155233D TUBE 2-1/8" OD X 0.065" THICK WALL	3	NO	NO	YES	NO	YES	NO
02-1155233-D	2	KNOCKOUT CANISTER POISON TUBE ASSEMBLY	3	1155233D BOTTOM END PLUG	3	NO	NO	YES	NO	YES	NO
02-1155233-D	2	KNOCKOUT CANISTER POISON TUBE ASSEMBLY	4	1155233D TOP END PLUG	3	NO	NO	YES	NO	YES	NO
02-1155233-D	2	KNOCKOUT CANISTER POISON TUBE ASSEMBLY	5	1155233D B_4C PELLET	3	NO	NO	YES	NO	NO	NO
02-1161301-D	1	KNOCKOUT CANISTER ASSEMBLY SAR	UFSAR	NOTE 3: WELD FILLER METAL	3	NO	NO	NO	NO	YES	NO

Table 2-3: Tabulation of all In-Scope ISFSI Subcomponents

IN-SCOPE SUBCOMPONENT IDENTIFICATION						INTENDED FUNCTION					
Drawing Number	Drawing Revision	Component	Item Num.	Item Description	Scoping Criterion	Confinement	Radiation Shielding	Sub-Criticality	Heat-Removal Capability	Structural Integrity	Retrievability
TMI-2 FILTER CANISTER											
02-1150949-D	5	FILTER CANISTER POISON TUBE ASSEMBLY	1	1150949D POISON TUBE ASSEMBLY	3	NO	NO	YES	NO	YES	NO
02-1150949-D	5	FILTER CANISTER POISON TUBE ASSEMBLY	2	1150949D; TUBE 2-1/8" OD X 0.065" THICK WALL	3	NO	NO	YES	NO	YES	NO
02-1150949-D	5	FILTER CANISTER POISON TUBE ASSEMBLY	3	1150949D; BOTTOM END PLUG	3	NO	NO	YES	NO	YES	NO
02-1150949-D	5	FILTER CANISTER POISON TUBE ASSEMBLY	4	1150949D; TOP END PLUG	3	NO	NO	YES	NO	YES	NO
02-1150949-D	5	FILTER CANISTER POISON TUBE ASSEMBLY	5	1150949D; B_4C PELLET	3	NO	NO	YES	NO	NO	NO
02-1150959-D	4	FILTER CANISTER UPPER HEAD WELDMENT	1	1150959D UPPER HEAD WELDMENT	3	NO	YES	YES	YES	YES	NO
02-1150959-D	4	FILTER CANISTER UPPER HEAD WELDMENT	5	1150958D FILTER CANISTER UPPER HEAD	3	NO	YES	YES	YES	YES	NO
02-1154018-F	5	FILTER CANISTER ASSEMBLY	1	1154018F FILTER CANISTER ASSEMBLY	3	NO	YES	YES	YES	YES	NO
02-1154018-F	5	FILTER CANISTER ASSEMBLY	2	1150959D UPPER HEAD WELDMENT	3	NO	YES	YES	YES	YES	NO
02-1154018-F	5	FILTER CANISTER ASSEMBLY	3	1154045D BOTTOM HEAD ASSEMBLY	3	NO	YES	YES	YES	YES	NO
02-1154020-E	3	FILTER CANISTER SUB-ASSEMBLY	1	1154020E FILTER CANISTER SUB-ASSEMBLY	3	NO	YES	YES	NO	YES	NO
02-1154020-E	3	FILTER CANISTER SUB-ASSEMBLY	3	1150945C SHELL	3	NO	YES	YES	NO	YES	NO
02-1154020-E	3	FILTER CANISTER SUB-ASSEMBLY	6	1150949D POISON TUBE ASSEMBLY	3	NO	NO	YES	NO	YES	NO
02-1161299-D	1	FILTER CANISTER ASSEMBLY SAR	UFSAR	NOTE 3: WELD FILLER METAL	3	NO	NO	NO	NO	YES	NO
TMI-2 FUEL CANISTER											
02-1095753-E	2	FUEL CANISTER NEUTRON POISON SHROUD	1	18163E100 TUBE ASSEMBLY	3	NO	YES	YES	YES	YES	NO
02-1095753-E	2	FUEL CANISTER NEUTRON POISON SHROUD	2	18163E100-1 OUTER SKIN	3	NO	YES	YES	YES	YES	NO
02-1095753-E	2	FUEL CANISTER NEUTRON POISON SHROUD	3	18163E100-2 INNER SKIN	3	NO	YES	YES	YES	YES	NO
02-1095753-E	2	FUEL CANISTER NEUTRON POISON SHROUD	4	18163E100-3 BORAL®	3	NO	YES	YES	YES	YES	NO
02-1150998-E	2	FUEL CANISTER BOTTOM PLATE ASSEMBLY	1	1150998E FUEL CANISTER BOTTOM PLATE ASSEMBLY	3	NO	YES	YES	YES	YES	NO
02-1150998-E	2	FUEL CANISTER BOTTOM PLATE ASSEMBLY	2	1150992E BOTTOM PLATE	3	NO	YES	YES	YES	YES	NO
02-1150999-F	4	FUEL CANISTER LOWER ASSEMBLY	1	1150999F FUEL CANISTER LOWER ASSEMBLY	3	NO	YES	YES	YES	YES	NO
02-1150999-F	4	FUEL CANISTER LOWER ASSEMBLY	2	1095753E BORAL® SHROUD ASSEMBLY	3	NO	YES	YES	YES	YES	NO
02-1150999-F	4	FUEL CANISTER LOWER ASSEMBLY	3	1154014F FUEL CANISTER BULKHEAD	3	NO	YES	YES	YES	YES	NO
02-1150999-F	4	FUEL CANISTER LOWER ASSEMBLY	5	1150983C FUEL CANISTER SHELL	3	NO	YES	YES	YES	YES	NO
02-1150999-F	4	FUEL CANISTER LOWER ASSEMBLY	6	1154045D LOWER HEAD ASSEMBLY	3	NO	YES	YES	YES	YES	NO
02-1150999-F	4	FUEL CANISTER LOWER ASSEMBLY	7	1150998E BOTTOM PLATE ASSEMBLY	3	NO	YES	YES	YES	YES	NO
02-1150999-F	4	FUEL CANISTER LOWER ASSEMBLY	9	1150999F CONCRETE MIX	3	NO	YES	YES	YES	YES	NO

Table 2-3: Tabulation of all In-Scope ISFSI Subcomponents

IN-SCOPE SUBCOMPONENT IDENTIFICATION						INTENDED FUNCTION					
Drawing Number	**Drawing Revision**	**Component**	**Item Num.**	**Item Description**	**Scoping Criterion**	**Confinement**	**Radiation Shielding**	**Sub-Criticality**	**Heat-Removal Capability**	**Structural Integrity**	**Retrievability**
02-1154026-F	6	FUEL CANISTER HEAD WELDMENT	1	1154026F FUEL CANISTER HEAD WELDMENT	3	NO	YES	YES	YES	YES	NO
02-1154026-F	6	FUEL CANISTER HEAD WELDMENT	2	1150989F FUEL CANISTER UPPER HEAD	3	NO	YES	YES	YES	YES	NO
02-1154026-F	6	FUEL CANISTER HEAD WELDMENT	4	1150993C SHOCK ABSORBER SUPPORT	3	NO	NO	NO	NO	YES	NO
02-1154026-F	6	FUEL CANISTER HEAD WELDMENT	5	1150995C IMPACT PLATE "D"	3	NO	NO	NO	NO	YES	NO
02-1154026-F	6	FUEL CANISTER HEAD WELDMENT	7	1150994C IMPACT PLATE "C"	3	NO	NO	NO	NO	YES	NO
02-1154026-F	6	FUEL CANISTER HEAD WELDMENT	12	1154021C FUEL CANISTER BOLT	3	NO	NO	NO	NO	YES	NO
02-1154070-F	3	FUEL CANISTER ASSEMBLY	1	1154070F FUEL CANISTER ASSEMBLY	3	NO	YES	YES	YES	YES	NO
02-1154070-F	3	FUEL CANISTER ASSEMBLY	2	1150999E FUEL CANISTER LOWER ASSEMBLY	3	NO	YES	YES	YES	YES	NO
02-1154070-F	3	FUEL CANISTER ASSEMBLY	3	1154026F FUEL CANISTER UPPER HEAD WELDMENT	3	NO	YES	YES	YES	YES	NO
02-1161300-D	B1	FUEL CANISTER ASSEMBLY SAR	UFSAR	NOTE 3: WELD FILLER METAL	3	NO	NO	NO	NO	YES	NO

2.3.3 SSCs not within the Scope of License Renewal

(NUREG-1927, Section 2.2, Section 2.4.1, Section 2.4.3 and Section 2.4.2.1)

Described below are the SSCs not within the scope of renewal. Table 2-1 also identifies these items. These SSCs are not within the scope of renewal because they do not meet scoping Criterion 1, 2, or 3. Also not within scope are those NITS subcomponents of ITS SSCs (e.g., the DSC and HSM) that do not meet Criterion 2 because their failure does not prevent fulfillment of an intended function. Table 2-4 identifies these items. Finally, all items that did not meet Criterion 3 (i.e., the TMI-2 core debris and those TMI-2 Canister subcomponents that do not support an intended function) are listed below. As such, Table 2-4 also lists the out-of-scope TMI-2 Canister subcomponents.

2.3.3.1 Overpack HSM

Section 3.1 of the TMI-2 ISFSI UFSAR specifies, "An extra HSM serves as a backup in case temporary storage of a DSC is required or in case a challenged canister needs additional confinement. This spare HSM will include a cylindrical overpack so that it can be used as an additional confinement barrier" [2.4.2]. Because the DSC Leakage design basis accident described in Section 8.2.7 of the UFSAR is a non-mechanistic event, it is considered non-credible and HSM-15, with its cylindrical overpack, are not required to ensure safe operation of the TMI-2 ISFSI. This fact is corroborated in Section 5.3.2 of the UFSAR regarding spare equipment, "As discussed in Section 8.2, the TMI-2 ISFSI is designed to withstand all postulated design basis events. Therefore, no storage component or equipment spares are required for the standardized NUHOMS®-12T system, with the exception of changeout of the HEPA filters." It follows that the overpack HSM (HSM-15) is scoped out of the renewal AMR actions.

Appendix D to this LRA proposes a license condition to preclude the use of HSM-15 and its DSC overpack from use for normal spent fuel storage operations.

2.3.3.2 Handling and Transfer Equipment

UFSAR Section 3.1.2.1 refers to the handling and transfer equipment [2.4.2]. Handling and Transfer equipment includes cask rigging, cask bottom/top spacers (Figure 4.2-9 of UFSAR) and TC lifting yoke. There is no handling and transfer equipment at the TMI-2 ISFSI and none is required for the PEO. These SSCs were all previously used for handling of the TC at the TAN facility. According to Section 3.1.2.1 of the UFSAR, "This equipment is not required to meet accident-related criteria as its failure cannot result in an unanalyzed safety condition." Also, as is stated in Section 3.4.4.1 of the UFSAR, the rigging used for TC handling at the TAN facility was never a part of the ISFSI licensed activities. It follows that the handling and transfer equipment is scoped out of the renewal AMR actions. The TC spacers are discussed in the following paragraph.

Regarding the TC spacers, the TMI-2 DSC is dimensionally similar to the standard NUHOMS®-24P system DSC, but is 23.5 inches shorter. During initial ISFSI transfer operations, the shorter length was made up by installing internal spacers into the TC cavity. These internal spacers were clamped in the TC bottom and bolted to the TC lid. The TC spacers used during the initial ISFSI loading campaign no longer remain on site; therefore, new TC spacers would need to be fabricated at the time they are required. License Condition 21 in Appendix D.2.2 is proposed to require TC spacers used at the TMI-2 ISFSI for DSC retrieval to be aged less than 20 years. Consistent with Section 2.4.3 of NUREG-1927 for replaceable components, the TC spacers have been determined to be out of scope for renewal.

2.3.3.3 Other Transfer Equipment

The remaining NUHOMS®-12T transfer equipment (Transfer Trailer, Prime mover {tractor} for towing Transfer Trailer, Cask Transport Skid/Turning Skid, HRS Insertion/Extraction Assembly, and SPS) were necessary for the successful loading of the DSCs into the HSMs. However, according to the UFSAR, Section 3.4.4.2 [2.4.2], *"the analyses described in Chapter 8 demonstrate that the performance of these items is not required to provide assurance that the DSCs and the TMI-2 Canisters can be received, handled, packaged, stored, and retrieved without undue risk to the health and safety of the public."*

The Transfer Trailer function was to move the TC and cask support skid from the TAN facility to the ISFSI location at INTEC. The Transfer Trailer is towed by a conventional heavy haul truck tractor or other suitable prime mover. The cask-turning skid was used at TAN to allow rotation of the cask between horizontal and vertical positions. The cask transport skid is mounted on the Transfer Trailer and supports the TC during transfer operations. UFSAR, Section 3.4.4.2, states that these subcomponents are classified as NITS items. The functions of the SPS are to hold the cask support skid stationary (with respect to the Transfer Trailer) during cask loading and transfer, and to provide alignment between the TC and the HSM prior to insertion of the DSC. The SPS is considered NITS since its failure would not result in a cask drop as severe as the cases evaluated in Chapter 8 of the UFSAR. The HRS provides the motive force for transferring the DSC between the HSM and the TC. Since operation of the HRS cannot result in damage to the DSC, it is considered NITS. Since failure of any of this transfer equipment would not prevent fulfillment of a function that is ITS, they are scoped out of the renewal AMR actions.

2.3.3.4 Auxiliary Equipment

Auxiliary Equipment includes, but is not limited to, a VDS and an AWS, which are used to facilitate DSC loading, draining, drying, inerting, and sealing operations. According to Section 3.4.5 of the UFSAR, these SSCs are classified as NITS items. These items no longer exist. Performance of these items is/was not required to provide reasonable assurance that TMI-2 Canisters could be received, handled, packaged, stored, and retrieved without undue risk to the health and safety of the public. Failure of any part of these systems may have resulted in delay of operations, but would not have resulted in a hazard to the public or operating personnel. Therefore, these SSCs need not have complied with the requirements of 10 CFR Part 72 (UFSAR, Section 3.4.5). The auxiliary equipment was exclusively used to load the DSCs and prepare them for storage. Since no additional DSCs will be loaded and the auxiliary equipment is not required for retrieval operations, the auxiliary equipment does not meet any of the scoping criteria, and therefore is not within the scope of renewal.

2.3.3.5 Miscellaneous Equipment

ISFSI Miscellaneous equipment (e.g., ISFSI security fences and gates, lighting, lightning protection, communications, and monitoring/alarm equipment) is not part of the TMI-2 ISFSI storage system and is specifically excluded from the scope of license renewal by Section 2.4.3 of NUREG-1927 [2.4.1].

2.3.3.6 Dry Film Lubricant

The 'high contact pressure dry film lubricant' was provided to facilitate DSC transfer into the HSM as discussed in UFSAR, Appendix E, Section 4.2.5.3 [2.4.2]. According to Table 3.4-1 and Section 4.2.5.1 of the UFSAR, this dry film lubricant is used on the top surface of the DSC support structure rails. The dry film lubricant (categorized as a consumable) is NITS according to Table 3.4-1 of the UFSAR. During transfer operations, the DSC slides out of the TC onto hardened wear-resistant rails inside the HSM. The DSC support structure in the HSM supports the structural loads during DSC storage, while the rail surfaces serve as both sliding surfaces during transfer operations and load transfer into the support structure. The support rail surfaces that contact the DSC outer shell surface are coated with this lubricant, minimizing frictional forces during DSC insertion and withdrawal. This is a high contact pressure dry film graphite lubricant provided to facilitate DSC transfer operations [2.4.13]. Since the lubricant is used only for reducing friction while sliding a DSC along the support rail, once the DSC is in place within the HSM, the lubricant performs no intended function during the PEO.

The following discussion provides support for the determination that the dry film lubricant is not a required SSC for retrievability purposes. As stated above, the sliding surfaces of the DSC support rails of all the HSMs are fabricated from hardened steel and are coated with a dry film lubricant to minimize friction during insertion and retrieval of the DSC. Graphite lubricants are suitable for very high and cryogenic temperature applications. The effect of radiation on these lubricants does not credibly affect its intended function, since these are inorganic and consist entirely of graphite. The design basis calculations in Section 8.1.1.1 of the UFSAR employed a coefficient of friction of 0.25 that is higher than the coefficient of friction associated with these types of lubricants (0.15 per [2.4.20]). The HRS to be used for DSC transfer is capable of exerting an extraction force equal to the loaded weight of a DSC (i.e., 70,000 pounds). An effective coefficient of friction of 100% of the loaded DSC weight has been used for this *"Jammed DSC"* analysis (Section 8.1.2.1 of the UFSAR). The DSC support structure is also designed for this loading in Section 8.1.1.4 of the UFSAR. Thus, lubricant failure does not prevent the HSM or the DSC from satisfactorily accomplishing its intended functions, and, therefore is not within the scope of renewal.

2.3.3.7 TMI-2 Core Debris

The material stored inside the TMI-2 Canisters consists of TMI-2 core debris removed from the damaged TMI-2 reactor during defueling operations (UFSAR, Section 3.1.1) [2.4.2]. Retrieved materials from the TMI-2 reactor core include rubble bed debris, partially intact fuel assemblies, debris bed stratified material, miscellaneous core component pieces (fuel rod segments, neutron startup sources, spacer grids, end fittings, control rod assembly spiders, springs, fuel pellets, etc.), and in-core instrument assemblies. In addition, non-core material, as described in Section 1.3, is also considered part of the TMI-2 "core-debris". This debris can range in size and configuration from partially intact fuel assemblies in the TMI-2 Fuel Canisters, to micron-sized particulate adhered to filter media in the TMI-2 Filter Canisters. Section 3.3.7.1.1 of the UFSAR states: *"A majority of the cladding on the fuel rods was either melted during the accident, or was cut during dismantling of the core debris for storage in the TMI-2 Canisters"*. Therefore, the fuel cladding cannot and is not relied on to perform an intended function. Section 2.4.2.1 of NUREG-1927 states: *"The spent fuel cladding and assembly hardware provide structural support to ensure that the spent fuel is maintained in a known geometric configuration."* However, for the TMI-2 ISFSI, this is the function of the TMI-2 Canister, not the TMI-2 core debris payloads. Therefore, the condition of the TMI-2 core debris is not within the scope of renewal and is not reviewed for any aging effects and aging mechanisms that may lead to a change in the analyzed fuel configuration.

Table 2-4: Tabulation of all Out-of-Scope ISFSI Subcomponents

OUT-OF-SCOPE SUBCOMPONENT IDENTIFICATION					INTENDED FUNCTION					
Drawing Number	**Drawing Revision**	**Component**	**Item Num.**	**Item Description**	**Confinement**	**Radiation Shielding**	**Sub-Criticality**	**Heat-Removal Capability**	**Structural Integrity**	**Retrievability**
DRY-SHIELDED CANISTER (DSC)										
219-02-1001	1	DSC SHELL ASSEMBLY	7	ALIGNMENT PLATE, 1-3/4" PLATE	NO	NO	NO	NO	NO	NO
219-02-1002	1	DSC BASKET-SHELL ASSEMBLY	3	LIFTING LUG & KEY, 3/4" PLATE	NO	NO	NO	NO	NO	NO
219-02-1002	1	DSC BASKET-SHELL ASSEMBLY	4	LIFTING LUG, 3/4" PLATE	NO	NO	NO	NO	NO	NO
219-02-1002	1	DSC BASKET-SHELL ASSEMBLY	7	VENT PORT BOTTOM SHIELD 2" PLATE	NO	NO	NO	NO	NO	NO
219-02-1002	1	DSC BASKET-SHELL ASSEMBLY	8	PURGE PORT KEY, 1" PLATE	NO	NO	NO	NO	NO	NO
219-02-1003	1	DSC MAIN ASSEMBLY	5	PURGE PORT TUBE	NO	NO	NO	NO	NO	NO
219-02-1003	1	DSC MAIN ASSEMBLY	6	PURGE PORT MECHANICAL TUBE	NO	NO	NO	NO	NO	NO
219-02-1003	1	DSC MAIN ASSEMBLY	8	BOLT, 3/4 – 10 UNC - 2B X 4.50" LONG	NO	NO	NO	NO	NO	NO
219-02-1003[1]	1	DSC MAIN ASSEMBLY	19	SHIELD INSERT	NO	NO	NO	NO	NO	NO
219-02-1003	1	DSC MAIN ASSEMBLY	Note 8	ANTI-SEIZE LUBRICANT	NO	NO	NO	NO	NO	NO
219-02-1010	2	DSC PURGE PORT FILTER ASSEMBLY	3	DUST HOOD	NO	NO	NO	NO	NO	NO
219-02-1010	2	DSC PURGE PORT FILTER ASSEMBLY	4	HANGER BASKET	NO	NO	NO	NO	NO	NO
219-02-1010	2	DSC PURGE PORT FILTER ASSEMBLY	7	SAMPLE TUBE PLUG	NO	NO	NO	NO	NO	NO
219-02-1010	2	DSC PURGE PORT FILTER ASSEMBLY	13	SCREW, HEX HD, 3/8 - 16 UNC - 2A X 1.00" LONG	NO	NO	NO	NO	NO	NO
219-02-1010	2	DSC PURGE PORT FILTER ASSEMBLY	21	SEAL	NO	NO	NO	NO	NO	NO
219-02-1010	2	DSC PURGE PORT FILTER ASSEMBLY	Note 3	THREAD LUBRICANT	NO	NO	NO	NO	NO	NO
219-02-1011	2	DSC VENT PORT FILTER ASSEMBLY	3	DUST HOOD	NO	NO	NO	NO	NO	NO
219-02-1011	2	DSC VENT PORT FILTER ASSEMBLY	4	HANGER BASKET	NO	NO	NO	NO	NO	NO
219-02-1011	2	DSC VENT PORT FILTER ASSEMBLY	7	SAMPLE TUBE PLUG	NO	NO	NO	NO	NO	NO
219-02-1011	2	DSC VENT PORT FILTER ASSEMBLY	13	SCREW, HEX HD, 3/8 - 16 UNC - 2A X 1.00" LONG	NO	NO	NO	NO	NO	NO
219-02-1011	2	DSC VENT PORT FILTER ASSEMBLY	21	SEAL	NO	NO	NO	NO	NO	NO
219-02-1011	2	DSC VENT PORT FILTER ASSEMBLY	Note 3	THREAD LUBRICANT	NO	NO	NO	NO	NO	NO
Fabrication Specification 219-02-107 [2.4.14]	1	DSC ASSEMBLY	N/A	VACUUM GREASE	NO	NO	NO	NO	NO	NO
HORIZONTAL STORAGE MODULE (HSM)										
219-02-5100	1	HSM ISFSI GENERAL ARRANGEMENT	5100-107	SURVEY MARKER	NO	NO	NO	NO	NO	NO
219-02-5100	1	HSM ISFSI GENERAL ARRANGEMENT	5100-402	WASHER, Ø 1-1/8"	NO	NO	NO	NO	NO	NO
219-02-5100	1	HSM ISFSI GENERAL ARRANGEMENT	5100-404	WASHER, Ø 3/4"	NO	NO	NO	NO	NO	NO
219-02-5100	1	HSM ISFSI GENERAL ARRANGEMENT	5100-406	WASHER, Ø 1-1/2"	NO	NO	NO	NO	NO	NO
219-02-5100	1	HSM ISFSI GENERAL ARRANGEMENT	N/A	GREASE, NEVER-SEEZ®	NO	NO	NO	NO	NO	NO
219-02-5101	1	STANDARD MODULE MAIN ASSEMBLY	5101-101	REAR SHIM PLATE, 8-1/2" X 1' – 7 1/2" THICK AS REQUIRED	NO	NO	NO	NO	NO	NO
219-02-5101	1	STANDARD MODULE MAIN ASSEMBLY	5101-102	FRONT SHIM PLATE, THICK AS REQUIRED	NO	NO	NO	NO	NO	NO
219-02-5101	1	STANDARD MODULE MAIN ASSEMBLY	5101-103	STICK-ON TARGET, BRUNSON #720	NO	NO	NO	NO	NO	NO
219-02-5101	1	STANDARD MODULE MAIN ASSEMBLY	5101-112	RAIL SHIM PLATE, SIZE & THICK AS REQUIRED	NO	NO	NO	NO	NO	NO
219-02-5101	1	STANDARD MODULE MAIN ASSEMBLY	5101-113	PLUG, Ø 2"	NO	NO	NO	NO	NO	NO
219-02-5101	1	STANDARD MODULE MAIN ASSEMBLY	5101-114	PLUG, Ø 3/4"	NO	NO	NO	NO	NO	NO
219-02-5101	1	STANDARD MODULE MAIN ASSEMBLY	5101-115	PLUG, Ø 5/8"	NO	NO	NO	NO	NO	NO
219-02-5101	1	STANDARD MODULE MAIN ASSEMBLY	5101-116	CONSEAL® 101 OR EQUIVALENT 3/4" X 3/4", CONCRETE SEALANTS, INC.	NO	NO	NO	NO	NO	NO
219-02-5101	1	STANDARD MODULE MAIN ASSEMBLY	5101-405	WASHER, Ø 3/4"	NO	NO	NO	NO	NO	NO

Table 2-4: Tabulation of all Out-of-Scope ISFSI Subcomponents

OUT-OF-SCOPE SUBCOMPONENT IDENTIFICATION					INTENDED FUNCTION					
Drawing Number	**Drawing Revision**	**Component**	**Item Num.**	**Item Description**	**Confinement**	**Radiation Shielding**	**Sub-Criticality**	**Heat-Removal Capability**	**Structural Integrity**	**Retrievability**
219-02-5101	1	STANDARD MODULE MAIN ASSEMBLY	5101-409	WASHER, Ø 1-1/4"	NO	NO	NO	NO	NO	NO
219-02-5101	1	STANDARD MODULE MAIN ASSEMBLY	N/A	GREASE, NEVER-SEEZ®	NO	NO	NO	NO	NO	NO
219-02-5101	1	STANDARD MODULE MAIN ASSEMBLY	N/A	WELD FILLER MATERIAL (NITS COMPONENTS)	NO	NO	NO	NO	NO	NO
219-02-5103	1	HSM STANDARD MODULE BASE UNIT	N/A	REINFORCEMENT BARS, #4	NO	NO	NO	NO	NO	NO
219-02-5104	2	HSM ROOF SLAB	5104-101	SLEEVE EMBEDMENT, Ø4" SCHEDULE 40 PIPE	NO	NO	NO	NO	NO	NO
219-02-5104	2	HSM ROOF SLAB	5104-102	3/4" DROP-IN ANCHOR, POWERS RAWL NUMBERS 6212 OR 6232, OR EQUIVALENT	NO	NO	NO	NO	NO	NO
219-02-5104	2	HSM ROOF SLAB	5104-103	PLUG Ø 3/4"	NO	NO	NO	NO	NO	NO
219-02-5104	2	HSM ROOF SLAB	N/A	REINFORCEMENT BARS, #4	NO	NO	NO	NO	NO	NO
219-02-5104	2	HSM ROOF SLAB	N/A	WELDED WIRE FABRIC	NO	NO	NO	NO	NO	NO
219-02-5105	1	HSM DSC SUPPORT STRUCTURE	5105-108	SUPPORT RAIL PLATE, 3/16" THICK	NO	NO	NO	NO	NO	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-104	SPACER PAD, ROLLED PLATE 1" THICK	NO	NO	NO	NO	NO	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-122	Ø 2" PIPE, SCHEDULE 80	NO	NO	NO	NO	NO	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-123	FEMALE ADAPTER, Ø 2" SCHEDULE 80	NO	NO	NO	NO	NO	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-124	NIPPLE STYLE SCREEN, Ø 2" MCMASTER-CARR® #9806K74 OR EQUIVALENT	NO	NO	NO	NO	NO	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-128	LOCK PLATE, ¼" THICK	NO	NO	NO	NO	NO	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-129	6" X 6" WIRE CLOTH, MCMASTER-CARR® #9226T24 OR EQUIVALENT	NO	NO	NO	NO	NO	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-142	ANGLE, L3" X 3" X 1/4"	NO	NO	NO	NO	NO	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-146	PURGE PORT PIPE SLEEVE, 10 GAUGE GALVANIZED SHEET	NO	NO	NO	NO	NO	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-147	VENT PORT PIPE SLEEVE, 10 GAUGE GALVANIZED SHEET	NO	NO	NO	NO	NO	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-150	MODULAR SPACER CHANNEL, C6 X 13 X 1' – 0" LONG (± 1/4") LONG	NO	NO	NO	NO	NO	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-156	LOCK BAR, 3/8" THICK	NO	NO	NO	NO	NO	NO
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-259	DRIVE SCREW, #8 X ½" LONG	NO	NO	NO	NO	NO	NO

Table 2-4: Tabulation of all Out-of-Scope ISFSI Subcomponents

OUT-OF-SCOPE SUBCOMPONENT IDENTIFICATION					INTENDED FUNCTION					
Drawing Number	**Drawing Revision**	**Component**	**Item Num.**	**Item Description**	**Confinement**	**Radiation Shielding**	**Sub-Criticality**	**Heat-Removal Capability**	**Structural Integrity**	**Retrievability**
219-02-5107	1	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-643	NELSON STUD, TYPE H4L Ø 1/2" X 4 -1/8" LONG	NO	NO	NO	NO	NO	NO
219-02-5108	0	HSM END MODULE SHIELD WALL	5108-101	SLEEVE EMBEDMENT, Ø 2-1/2" SCHEDULE 40 PIPE	NO	NO	NO	NO	NO	NO
TMI-2 KNOCKOUT CANISTER										
02-1150968-D	2	KNOCKOUT CANISTER BOTTOM SUPPORT PLATE ASSEMBLY	3	1150966D FILTER MESH PLATE	NO	NO	NO	NO	NO	NO
02-1154027-F	4	KNOCKOUT CANISTER INTERNALS ASSEMBLY	10	1154030C END CAP ASSEMBLY	NO	NO	NO	NO	NO	NO
02-1154027-F	4	KNOCKOUT CANISTER INTERNALS ASSEMBLY	11	1155247E INLET TUBE	NO	NO	NO	NO	NO	NO
02-1154030-C	2	KNOCKOUT CANISTER END CAP ASSEMBLY	1	1154030C KNOCKOUT CANISTER END CAP ASSEMBLY	NO	NO	NO	NO	NO	NO
02-1154030-C	2	KNOCKOUT CANISTER END CAP ASSEMBLY	2	1150961C END CAP	NO	NO	NO	NO	NO	NO
02-1154030-C	2	KNOCKOUT CANISTER END CAP ASSEMBLY	3	1154030C ¾" OD X 0.035" THICK WALL TUBING	NO	NO	NO	NO	NO	NO
02-1154034-F	3	KNOCKOUT CANISTER INTERNALS & SHELL ASSEMBLY	4	1150960C CHOCK BLOCK (KNOCKOUT & FILTER CANISTER)	NO	NO	NO	NO	NO	NO
02-1154041-F	3	KNOCKOUT CANISTER ASSEMBLY	4	1154043C INLET/OUTLET COUPLER	NO	NO	NO	NO	NO	NO
02-1154041-F	3	KNOCKOUT CANISTER ASSEMBLY	5	1154099A PURGE INLET QUICK DISCONNECT ¼" NPT	NO	NO	NO	NO	NO	NO
02-1154041-F	3	KNOCKOUT CANISTER ASSEMBLY	6	1154110A DEWATERING OUTLET QUICK DISCONNECT 3/8" NPT	NO	NO	NO	NO	NO	NO
02-1154041-F	3	KNOCKOUT CANISTER ASSEMBLY	7	1154034F INTERNALS & SHELL ASSEMBLY	NO	NO	NO	NO	NO	NO
02-1154041-F	3	KNOCKOUT CANISTER ASSEMBLY	8	1154106B NAME PLATE, ASME	NO	NO	NO	NO	NO	NO
02-1154041-F	3	KNOCKOUT CANISTER ASSEMBLY	9	1154094A CLOSE NIPPLE ¼" NPT	NO	NO	NO	NO	NO	NO
02-1154041-F	3	KNOCKOUT CANISTER ASSEMBLY	10	1154102A REDUCING BUSHING 1-½" X 3/8" NPT	NO	NO	NO	NO	NO	NO
02-1154041-F	3	KNOCKOUT CANISTER ASSEMBLY	11	1154076C RELIEF VALVE ASSEMBLY	NO	NO	NO	NO	NO	NO
02-1154041-F	3	KNOCKOUT CANISTER ASSEMBLY	12	1154086C CAP 3/8" NPT	NO	NO	NO	NO	NO	NO
02-1154041-F	3	KNOCKOUT CANISTER ASSEMBLY	13	1154075C CAP ¼" NPT	NO	NO	NO	NO	NO	NO
02-1154041-F	3	KNOCKOUT CANISTER ASSEMBLY	Note 6	CLOSE NIPPLE FITTING THREAD SEALANT	NO	NO	NO	NO	NO	NO
02-1154042-C	2	KNOCKOUT CANISTER ASSEMBLY	1	1154042C INLET TUBE SLEEVE 2-¾" OD X 0.188" THICK WALL	NO	NO	NO	NO	NO	NO
02-1154045-D	5	KNOCKOUT & FILTER CANISTER LOWER HEAD ASSEMBLY	4	1150940A H_2O_2 RECOMBINER CATALYST PELLET	NO	NO	NO	NO	NO	NO
02-1154045-D	5	KNOCKOUT & FILTER CANISTER LOWER HEAD ASSEMBLY	5	1150972A SILICON COATED RECOMBINER CATALYST	NO	NO	NO	NO	NO	NO
02-1154045-D	5	KNOCKOUT & FILTER CANISTER LOWER HEAD ASSEMBLY	6	1155222C BASKET	NO	NO	NO	NO	NO	NO
02-1154045-D	5	KNOCKOUT & FILTER CANISTER LOWER HEAD ASSEMBLY	7	1155223C SCREEN	NO	NO	NO	NO	NO	NO
02-1154046-F	6	FILTER & KNOCKOUT CANISTER SKIRT	2	1150944C FILTER & KNOCKOUT CANISTER SKIRT	NO	NO	NO	NO	NO	NO
02-1154046-F	6	FILTER & KNOCKOUT CANISTER SKIRT	4	1154039C LEAD-IN SLEEVE KNOCKOUT CANISTER	NO	NO	NO	NO	NO	NO

Table 2-4: Tabulation of all Out-of-Scope ISFSI Subcomponents

OUT-OF-SCOPE SUBCOMPONENT IDENTIFICATION					INTENDED FUNCTION					
Drawing Number	Drawing Revision	Component	Item Num.	Item Description	Confinement	Radiation Shielding	Sub-Criticality	Heat-Removal Capability	Structural Integrity	Retrievability
02-1154046-F	6	FILTER & KNOCKOUT CANISTER SKIRT	5	1154042C INLET TUBE SLEEVE KNOCKOUT CANISTER	NO	NO	NO	NO	NO	NO
02-1154046-F	6	FILTER & KNOCKOUT CANISTER SKIRT	6	1154053C KNOCKOUT CANISTER FILTER COVER	NO	NO	NO	NO	NO	NO
02-1154046-F	6	FILTER & KNOCKOUT CANISTER SKIRT	7	1150940A H_2O_2 RECOMBINER CATALYST PELLET	NO	NO	NO	NO	NO	NO
02-1154046-F	6	FILTER & KNOCKOUT CANISTER SKIRT	8	1150972A SILICON COATED RECOMBINER CATALYST	NO	NO	NO	NO	NO	NO
02-1154046-F	6	FILTER & KNOCKOUT CANISTER SKIRT	9	1154072D FILTER SCREEN ASSEMBLY	NO	NO	NO	NO	NO	NO
02-1154053-C	2	KNOCKOUT & FILTER CANISTER SCREEN	1	1154053C KNOCKOUT FILTER CANISTER SCREEN	NO	NO	NO	NO	NO	NO
02-1154053-C	2	KNOCKOUT & FILTER CANISTER SCREEN	2	1154053C 3/16” ∅ ROD	NO	NO	NO	NO	NO	NO
02-1154053-C	2	KNOCKOUT & FILTER CANISTER SCREEN	3	1154053C WIRE CLOTH 8 MESH OF 0.047” ∅ WIRE	NO	NO	NO	NO	NO	NO
02-1154072-D	2	KNOCKOUT FILTER SCREEN ASSEMBLY	1	1154072D FILTER SCREEN ASSEMBLY	NO	NO	NO	NO	NO	NO
02-1154072-D	2	KNOCKOUT FILTER SCREEN ASSEMBLY	2	1154072D 12" SCHEDULE 10 PIPE (WALL 0.203”)	NO	NO	NO	NO	NO	NO
02-1154072-D	2	KNOCKOUT FILTER SCREEN ASSEMBLY	3	1154072D RING 5/16” ∅WIRE	NO	NO	NO	NO	NO	NO
02-1154072-D	2	KNOCKOUT FILTER SCREEN ASSEMBLY	4	1154072D SCREEN 4 MESH OF 0.063” ∅ WIRE	NO	NO	NO	NO	NO	NO
02-1154072-D	2	KNOCKOUT FILTER SCREEN ASSEMBLY	5	1154072D SCREEN 20 MESH OF 0.020” ∅ WIRE	NO	NO	NO	NO	NO	NO
02-1154072-D	2	KNOCKOUT FILTER SCREEN ASSEMBLY	6	1154072D BUSHING - A	NO	NO	NO	NO	NO	NO
02-1154072-D	2	KNOCKOUT FILTER SCREEN ASSEMBLY	7	1154072D BUSHING - B	NO	NO	NO	NO	NO	NO
02-1154072-D	2	KNOCKOUT FILTER SCREEN ASSEMBLY	Note 3	SILVER SOLDER FILLER	NO	NO	NO	NO	NO	NO
02-1154075-D	2	PURGE FITTING CAPS	1	1154075C CAP, PURGE FITTING	NO	NO	NO	NO	NO	NO
02-1154075-D	2	PURGE FITTING CAPS	2	1154098A SOCKET, HANSEN PT NO. ML2-H16 (1/4” NPT)	NO	NO	NO	NO	NO	NO
02-1154075-D	2	PURGE FITTING CAPS	3	1154075C END CAP	NO	NO	NO	NO	NO	NO
02-1154076-C	2	CANISTER RELIEF VALVE ASSEMBLY	1	1154076C RELIEF VALVE ASSEMBLY	NO	NO	NO	NO	NO	NO
02-1154076-C	2	CANISTER RELIEF VALVE ASSEMBLY	2	1154096A RELIEF VALVE CIRCLE SEAL PART NUMBER D562TI 2M15ASME	NO	NO	NO	NO	NO	NO
02-1154076-C	2	CANISTER RELIEF VALVE ASSEMBLY	4	1154098A SOCKET, QUICK CONNECT, HANSEN ¼” NPT	NO	NO	NO	NO	NO	NO
02-1154076-C	2	CANISTER RELIEF VALVE ASSEMBLY	5	1155817A STREET TEE CAJON, PART NO. SS-4-ST	NO	NO	NO	NO	NO	NO
02-1154076-C	2	CANISTER RELIEF VALVE ASSEMBLY	6	1155818A HEX NIPPLE CAJON, PART NO. SS-4-HN	NO	NO	NO	NO	NO	NO
02-1154076-C	2	CANISTER RELIEF VALVE ASSEMBLY	Note 1	CLOSE NIPPLE FITTING THREAD SEALANT	NO	NO	NO	NO	NO	NO
02-1154086-C	1	PURGE FITTING CAPS	1	1154086C CAP DEWATERING ASSEMBLY	NO	NO	NO	NO	NO	NO
02-1154086-C	1	PURGE FITTING CAPS	2	1154086C CAP	NO	NO	NO	NO	NO	NO
02-1154086-C	1	PURGE FITTING CAPS	3	1154097A SOCKET, HANSEN PT NO. ML3-H21 (3/8” NPT) W/OUT TRIM	NO	NO	NO	NO	NO	NO
02-1155247-E	0	KNOCKOUT CANISTER INLET TUBE	1	1155247E INLET TUBE 2 ¼” OD X 0.065” WALL	NO	NO	NO	NO	NO	NO
02-1161301-D	1	KNOCKOUT CANISTER ASSEMBLY SAR	UFSAR	02-1155827-C/02-1095959-A SPECIAL TYPE D PIPE PLUG, KNOCKOUT CANISTER CONNECTOR (2" ∅)	NO	NO	NO	NO	NO	NO
02-1161301-D	1	KNOCKOUT CANISTER ASSEMBLY SAR	UFSAR	DWG-513816-03, TMI-2 CANISTER CLOSURE DEVICE (2" ∅ NPT CAP)	NO	NO	NO	NO	NO	NO
TMI-2 FILTER CANISTER										
02-1150959-D	4	FILTER CANISTER UPPER HEAD WELDMENT	2	1154053C SCREEN ASSEMBLY	NO	NO	NO	NO	NO	NO
02-1150959-D	4	FILTER CANISTER UPPER HEAD WELDMENT	3	1150957B PLUG	NO	NO	NO	NO	NO	NO

Table 2-4: Tabulation of all Out-of-Scope ISFSI Subcomponents

OUT-OF-SCOPE SUBCOMPONENT IDENTIFICATION					INTENDED FUNCTION					
Drawing Number	**Drawing Revision**	**Component**	**Item Num.**	**Item Description**	**Confinement**	**Radiation Shielding**	**Sub-Criticality**	**Heat-Removal Capability**	**Structural Integrity**	**Retrievability**
02-1150959-D	4	FILTER CANISTER UPPER HEAD WELDMENT	4	1150940A H_2O_2 RECOMBINER CATALYST PELLET	NO	NO	NO	NO	NO	NO
02-1150959-D	4	FILTER CANISTER UPPER HEAD WELDMENT	6	1150972A SILICON COATED RECOMBINER CATALYST	NO	NO	NO	NO	NO	NO
02-1150959-D	4	FILTER CANISTER UPPER HEAD WELDMENT	7	1150944C FILTER & KNOCKOUT CANISTER SKIRT	NO	NO	NO	NO	NO	NO
02-1154018-F	5	FILTER CANISTER ASSEMBLY	4	1154020E FILTER CANISTER SUB-ASSEMBLY	NO	NO	NO	NO	NO	NO
02-1154018-F	5	FILTER CANISTER ASSEMBLY	5	1154044C INLET/OUTLET COUPLER	NO	NO	NO	NO	NO	NO
02-1154018-F	5	FILTER CANISTER ASSEMBLY	6	1154099A PURGE INLET QUICK DISCONNECT ¼” NPT	NO	NO	NO	NO	NO	NO
02-1154018-F	5	FILTER CANISTER ASSEMBLY	7	1154110A DEWATERING OUTLET QUICK DISCONNECT 3/8” NPT	NO	NO	NO	NO	NO	NO
02-1154018-F	5	FILTER CANISTER ASSEMBLY	8	1154106B NAME PLATE, ASME	NO	NO	NO	NO	NO	NO
02-1154018-F	5	FILTER CANISTER ASSEMBLY	9	1154086C CAP 3/8” NPT	NO	NO	NO	NO	NO	NO
02-1154018-F	5	FILTER CANISTER ASSEMBLY	10	1154075C CAP ¼” NPT	NO	NO	NO	NO	NO	NO
02-1154018-F	5	FILTER CANISTER ASSEMBLY	11	1154094A CLOSE NIPPLE ¼” NPT	NO	NO	NO	NO	NO	NO
02-1154018-F	5	FILTER CANISTER ASSEMBLY	12	1154095A CLOSE COUPLING 3/8” NPT	NO	NO	NO	NO	NO	NO
02-1154018-F	5	FILTER CANISTER ASSEMBLY	13	1154076C RELIEF VALVE ASSEMBLY	NO	NO	NO	NO	NO	NO
02-1154018-F	5	FILTER CANISTER ASSEMBLY	Note 6	CLOSE NIPPLE FITTING THREAD SEALANT	NO	NO	NO	NO	NO	NO
02-1154020-E	3	FILTER CANISTER SUB-ASSEMBLY	2	1095757D FILTER BUNDLE ASSEMBLY	NO	NO	NO	NO	NO	NO
02-1154020-E	3	FILTER CANISTER SUB-ASSEMBLY	4	1150960C CHOCK BLOCK	NO	NO	NO	NO	NO	NO
02-1154020-E	3	FILTER CANISTER SUB-ASSEMBLY	5	1154050C DRAIN TUBE FERRULE	NO	NO	NO	NO	NO	NO
02-1161299-D	1	FILTER CANISTER ASSEMBLY SAR	UFSAR	02-1155826-C/02-1095959-A SPECIAL TYPE D PIPE PLUG, KNOCKOUT CANISTER CONNECTOR (2.5"∅)	NO	NO	NO	NO	NO	NO
02-1161299-D	1	FILTER CANISTER ASSEMBLY SAR	UFSAR	DWG-513817-03, TMI-2 CANISTER CLOSURE DEVICE (2.5" ∅ NPT CAP)	NO	NO	NO	NO	NO	NO
TMI-2 FUEL CANISTER										
02-1095753-E	2	FUEL CANISTER NEUTRON POISON SHROUD	5	18163E100-4 FAIRING STRIP	NO	NO	NO	NO	NO	NO
02-1150998-E	2	FUEL CANISTER BOTTOM PLATE ASSEMBLY	3	1154006D IMPACT PLATE A	NO	NO	NO	NO	NO	NO
02-1150998-E	2	FUEL CANISTER BOTTOM PLATE ASSEMBLY	4	1154007D IMPACT PLATE B	NO	NO	NO	NO	NO	NO
02-1150998-E	2	FUEL CANISTER BOTTOM PLATE ASSEMBLY	5	1154103A STANDOFF	NO	NO	NO	NO	NO	NO
02-1150998-E	2	FUEL CANISTER BOTTOM PLATE ASSEMBLY	6	1154105A RIB	NO	NO	NO	NO	NO	NO
02-1150998-E	2	FUEL CANISTER BOTTOM PLATE ASSEMBLY	7	1154009D FILTER DISK	NO	NO	NO	NO	NO	NO
02-1150999-F	4	FUEL CANISTER LOWER ASSEMBLY	4	1154033C LOCATING PIN	NO	NO	NO	NO	NO	NO
02-1150999-F	4	FUEL CANISTER LOWER ASSEMBLY	8	1155381C DRAIN TUBE	NO	NO	NO	NO	NO	NO
02-1150999-F	4	FUEL CANISTER LOWER ASSEMBLY	10	1150999F ANCHOR STRAP	NO	NO	NO	NO	NO	NO
02-1154026-F	6	FUEL CANISTER HEAD WELDMENT	3	1150988C FUEL CANISTER SKIRT	NO	NO	NO	NO	NO	NO
02-1154026-F	6	FUEL CANISTER HEAD WELDMENT	6	1154055C FUEL CANISTER RECOMBINER CATALYST SCREEN	NO	NO	NO	NO	NO	NO

Table 2-4: Tabulation of all Out-of-Scope ISFSI Subcomponents

OUT-OF-SCOPE SUBCOMPONENT IDENTIFICATION					INTENDED FUNCTION					
Drawing Number	**Drawing Revision**	**Component**	**Item Num.**	**Item Description**	**Confinement**	**Radiation Shielding**	**Sub-Criticality**	**Heat-Removal Capability**	**Structural Integrity**	**Retrievability**
02-1154026-F	6	FUEL CANISTER HEAD WELDMENT	8	1154115B ¼" NPT SPECIAL NIPPLE	NO	NO	NO	NO	NO	NO
02-1154026-F	6	FUEL CANISTER HEAD WELDMENT	9	1154095A CLOSE NIPPLE 3/8" NPT	NO	NO	NO	NO	NO	NO
02-1154026-F	6	FUEL CANISTER HEAD WELDMENT	10	1154099A PURGE INLET QUICK DISCONNECT ¼" NPT	NO	NO	NO	NO	NO	NO
02-1154026-F	6	FUEL CANISTER HEAD WELDMENT	11	1154110A DEWATERING OUTLET QUICK DISCONNECT 3/8" NPT	NO	NO	NO	NO	NO	NO
02-1154026-F	6	FUEL CANISTER HEAD WELDMENT	13	1154111A TOLERANCE RING	NO	NO	NO	NO	NO	NO
02-1154026-F	6	FUEL CANISTER HEAD WELDMENT	20	1154104A RIB	NO	NO	NO	NO	NO	NO
02-1154026-F	6	FUEL CANISTER HEAD WELDMENT	21	1150972A SILICON COATED RECOMBINER CATALYST	NO	NO	NO	NO	NO	NO
02-1154026-F	6	FUEL CANISTER HEAD WELDMENT	22	1150940A H_2O_2 RECOMBINER CATALYST PELLET	NO	NO	NO	NO	NO	NO
02-1154026-F	6	FUEL CANISTER HEAD WELDMENT	Note 16	CLOSURE BOLT LUBRICANT	NO	NO	NO	NO	NO	NO
02-1154026-F	6	FUEL CANISTER HEAD WELDMENT	Note 6	CLOSE NIPPLE FITTING THREAD SEALANT	NO	NO	NO	NO	NO	NO
02-1154055-C	2	FUEL CANISTER RECOMBINER CATALYST SCREEN	1	1154055C FUEL CANISTER RECOMBINER CATALYST SCREEN	NO	NO	NO	NO	NO	NO
02-1154055-C	2	FUEL CANISTER RECOMBINER CATALYST SCREEN	2	1154055C 3/16" ∅ ROD	NO	NO	NO	NO	NO	NO
02-1154055-C	2	FUEL CANISTER RECOMBINER CATALYST SCREEN	3	1154055C WIRE CLOTH 8 MESH OF 0.047"∅ WIRE	NO	NO	NO	NO	NO	NO
02-1154070-F	3	FUEL CANISTER ASSEMBLY	4	1154075C CAP ¼" NPT	NO	NO	NO	NO	NO	NO
02-1154070-F	3	FUEL CANISTER ASSEMBLY	5	1154086C CAP 3/8" NPT	NO	NO	NO	NO	NO	NO
02-1154070-F	3	FUEL CANISTER ASSEMBLY	6	1154076C RELIEF VALVE ASSEMBLY	NO	NO	NO	NO	NO	NO
02-1154070-F	3	FUEL CANISTER ASSEMBLY	7	1154106B NAME PLATE, ASME	NO	NO	NO	NO	NO	NO
02-1154070-F	3	FUEL CANISTER ASSEMBLY	Note 7	CLOSURE BOLT LUBRICANT	NO	NO	NO	NO	NO	NO
02-1161300-D	B1	FUEL CANISTER ASSEMBLY SAR	UFSAR	DRAWING 346789, SMALL GASKET (DRAIN LINE SEAL)	NO	NO	NO	NO	NO	NO
02-1161300-D	B1	FUEL CANISTER ASSEMBLY SAR	UFSAR	DRAWING 346788, LARGE GASKET (MAIN SEAL)	NO	NO	NO	NO	NO	NO

[1]-Added with Transnuclear West ECN 99-0637 [2.4.16] for DSC Serial Numbers (S/N) DOE12T-003 through DOE12T-029 only.

2.4 REFERENCES (CHAPTER 2)

2.4.1 U.S. Nuclear Regulatory Commission, NUREG-1927, Revision 1, "Standard Review Plan for Renewal of Specific Licenses and Certificates of Compliance for Dry Storage of Spent Nuclear Fuel," June, 2016, NRC Accession Number ML16179A148.

2.4.2 U.S. Department of Energy, 2011 Update Report, "Submittal of TMI-2 ISFSI Update Reports (Docket 72-20) (EM-FMDP-11-024)," March 02, 2011.

2.4.3 McConnell, J.W. Jr., A.L. Ayers, Jr., M.J. Tyacke, "Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety," NUREG/CR-6407, NRC, February, 1996.

2.4.4 U.S. Nuclear Regulatory Commission, Interim Staff Guidance, SFST-ISG-2, Revision 2, "Fuel Retrievability," April 26, 2016, NRC Accession Number ML16117A080.

2.4.5 VECTRA Calculation Number 219-02.0401, Revision 0, "HSM and Cask Dose Rate Calculation," VECTRA Technologies, Inc., September 27, 1996.

2.4.6 VECTRA Calculation Number 219-02.0403, Revision 0, "Top End Dose Rates for TMI-2 Canisters," VECTRA Technologies, Inc., September 25, 1996.

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CHAPTER 3:
AGING MANAGEMENT REVIEW

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3.1 INTRODUCTION

(NUREG-1927, Section 3.2)

This chapter describes the AMR of the TMI-2 ISFSI. The purpose of the AMR is to assess the SSCs determined to be within the scope of renewal. The AMR addresses aging effects and mechanisms that could adversely affect the ability of the SSCs to perform their intended functions during the PEO.

Section 3.2 presents a summary of the TMI-2 ISFSI along with the pre-application inspections and other relevant DSS Operating Experience (OE). This includes an overview of AMR-relevant design, fabrication, and maintenance (if applicable) aspects for each of the storage system SSCs. This section provides valuable input to both the AMR process and the AMAs.

Section 3.3 describes the AMR methodology, which follows the guidance and the processes of NUREG-1927 [3.11.1]. This section addresses each of the major steps of the AMR: Section 3.3.1 (Identification of Materials and Environments), Section 3.3.2 (Identification of Aging Effects Requiring Management), and Section 3.3.3 (Identification of the AMAs Required to Manage the Effects of Aging).

Sections 3.4, 3.5, 3.6, 3.7, and 3.8 provide the AMR results for the DSC, HSM, TC, Basemat and Approach Slab, and TMI-2 Canister, respectively. Each of these sections provides a description of the SSC, the materials of construction, the environments, and an evaluation of the potential aging effects and the associated aging mechanisms. The aging effects and associated aging mechanisms that could cause degradation resulting in loss of intended function are evaluated for each SSC. These evaluations result in the final aging effects requiring management, and the required AMAs: either TLAAs or AMPs. The results of the AMR and the implementation of the associated AMAs described in this chapter provide reasonable assurance that the intended functions of the TMI-2 ISFSI SSCs will be maintained during the requested 20-year PEO. Any identified TLAAs are presented in Appendix B with other supplemental/support evaluations presented directly in the aging effects subsections. Any other analyses included within the context of the LRA are not TLAAs by definition but support the AMR (e.g., excluding an aging mechanism or effect or showing that an aging effect does not need to be managed).

Consistent with Figure 3-1 of NUREG-1927 [3.11.1], where a TLAA or other supporting analysis as described above, does not adequately predict degradation associated with an identified aging effect, an AMP is created to summarize the activities implemented to monitor and manage the aging effects. The AMPs credited for managing the effects of aging degradation are presented in Appendix A of this LRA.

As described in NEI 14-03 [3.11.54], tollgates may be included in the renewed site-specific license and associated UFSAR. DOE-ID performs and documents via an assessment of the aggregate impact of aging-related OE, research, monitoring, and inspections at specific points in time during the PEO. This is known as a tollgate assessment; Section 3.9 describes using tollgates for the TMI-2 ISFSI.

3.2 OPERATING EXPERIENCE REVIEW

(NUREG-1927, Section 3.4.1.1 and Section 3.4.1.2)

3.2.1 Operating Experience Review Process

(NUREG-1927, Section 3.6.1.10)

In accordance with Section 3.6.1.10 of NUREG-1927 [3.11.1], this section summarizes OE information that is applicable for the TMI-2 ISFSI. The applicable OE information described in this section is used to assess age-related degradation mechanisms, justify the AMR conclusions, and provide an informed basis for the AMPs discussed in Appendix A. OE reviewed for applicability included: internal and industrywide condition reports, international and non-nuclear OE, pre-application inspection results, licensee event reports, DSS vendor safety bulletins, NRC Generic Communications, consensus codes and guides, and applicable industry-initiatives, such as DOE or Electric Power Research Institute (EPRI) sponsored inspections. Based on this review, pertinent material is described in this section.

No additional stored material has been added to the TMI-2 ISFSI since 2001, and the license does not allow any additional material to be added, therefore, the ISFSI is considered to be in a static state. Since that time, ISFSI activities have included primarily inspections and repairs, as needed, including those from the freeze-thaw cracking incidents as outlined in Section 3.2.3.2.1.

The TMI-2 ISFSI is composed of a modified NUHOMS® HSM with a carbon steel DSC. Therefore, the information reviewed in this section includes both reports from the TMI-2 ISFSI and the Standardized NUHOMS® systems that provided the original design framework for the TMI-2 ISFSI NUHOMS®-12T DSS. The NUHOMS® 1004 CoC LRA [3.11.25] was reviewed to identify similar aging conditions that have occurred during system operations that could have an effect on degradation due to aging of HSM SSCs as applicable to the TMI-2 ISFSI. This process served to identify the inspection and monitoring attributes that should be considered in the development of the HSM AMP. A summary of the relevant conditions is discussed in Section 3.2.4.1.

The pre-application inspection observations from the TMI-2 ISFSI, as discussed in Section 3.2.3, provide the basis for the site-specific OE and verify the condition of SSCs and SSC subcomponents are as expected. Because of the difference in materials, information from the pre-application inspection reports from similar NUHOMS® based site-specific ISFSI LRAs are generally not applicable to the TMI-2 ISFSI DSCs. However, the information from other ISFSI systems using carbon steel as a confinement barrier was reviewed as part of the AMR process to identify applicable actual or potential aging effects and associated aging mechanisms specific to the carbon steel confinement components. These include the site-specific LRAs for the Fort St. Vrain (FSV) ISFSI and the VSC-24 DSS. These are discussed in Sections 3.2.2.1 and 3.2.4.2, respectively. Each of these LRAs is considered relevant because these ISFSIs are based on similar confinement system designs, with similar material and environmental combinations.

Section 3.2.2.2 addresses similarities between the TMI-2 ISFSI and the Irradiated Fuel Storage Facility (IFSF) located at INL on the same INTEC site as the TMI-2 ISFSI. The IFSF is also used to store SNF in carbon steel canisters in an open-air concrete facility. The IFSF also offers pertinent OE in the form of corrosion rates on coupons of equivalent materials and corrosion modes. As such, the information from the IFSF is directly used to inform the TMI-2 ISFSI AMR.

In addition to specific ISFSI and DSS information, relevant regulatory and other industry information was reviewed. All of this OE was reviewed for any conditions that could affect the aging conditions of the TMI-2 ISFSI and its SSCs. This review included OE from applicable NRC Information Notices (INs), guidance documents, and bulletins. This OE is discussed in Section 3.2.4.3.

3.2.2 TMI-2 ISFSI Operating Experience

(NUREG-1927, Section 3.6.1.10)

The following sections evaluate OE from facilities that are either licensed by the NRC or operated near the TMI-2 ISFSI and offer relevant and complementary data for the AMR. Section 3.2.2.1 addresses similarities between the two operational DOE-ID ISFSIs (TMI-2 and FSV) and provides relevant data used to inform the TMI-2 ISFSI LRA. Section 3.2.2.2 addresses similarities between the TMI-2 and IFSF located in the same INTEC facility as the TMI-2 ISFSI. The IFSF is also used to store SNF in carbon steel canisters in an open-air concrete facility, lending itself as a representative condition consistent with environmental and material conditions at the TMI-2 ISFSI. It follows that information from the IFSF is used to inform the TMI-2 ISFSI AMR.

3.2.2.1 FSV Operating Experience Similarities

As part of the NRC approval of the FSV ISFSI license renewal, Section 9.8 was added to the FSV SAR with some key AMAs [3.11.174]. These AMAs have relevance to the HSM AMP for the TMI-2 ISFSI and provide justification for the effectiveness of the AMP elements. These sections of FSV AMAs are outlined below for their OE applicability to the TMI-2 ISFSI. In addition, there are similarities between the two ISFSIs in terms of materials, environments and hydrogen monitoring operations, all of which are described below. This applicable OE provides key justifications for AMR conclusions.

3.2.2.1.1 FSV Storage System

The FSV ISFSI was designed for vertical storage of High Temperature Gas Cooled Reactor (HTGR) fuel elements [3.11.172]. There are six spent fuel elements stored in a Fuel Storage Container (FSC) in which the FSCs are stored in six modular vaults. The vaults are constructed of reinforced high strength concrete similar to the TMI-2 HSMs. Inset and grouted into the vault module floor are the support stools for the FSCs. Separate from the six vault modules, three Standby Storage Wells (SSWs) are incorporated into the FSV ISFSI. These three SSWs provide a means to store and seal an FSC that could develop a leak. The SSWs allow for individual FSC leak checking in a location remote from the radiation fields associated with the storage vaults. The SSW can be closed using a shield plug and sealed using a sealing cover plate. A sampling point with a self-sealing coupling, allows the SSW volume to be leak tested.

3.2.2.1.2 Usage of Carbon Steel Storage Canisters

Like the TMI-2 DSCs, the FSCs and SSWs at the FSV ISFSI are cylindrical tubular confinement vessels made of carbon steel. Similar to the TMI-2 ISFSI, the fuel storage medium within the FSC is air with decay heat removed passively by an ambient air system. In addition, if the SSW is occupied by a loaded FSC, the decay heat is dissipated to the surrounding air. Due to the remote location of both the TMI-2 and FSV ISFSI, atmospheric conditions in Idaho and Colorado are similar; hence, conditions facilitating corrosion mechanisms are also similar.

Similar to the DSC and DSC support structure steel surfaces, the outer surfaces of the ½-in. thick carbon steel body of the FSC are protected from atmospheric corrosion by application of a flame sprayed aluminum coating. Also, similar to the DSC, dual metallic O-rings integrating a leak checkable sealing arrangement form the seal between the closure lid and FSC body. In addition, the 3/8-in. thick carbon steel SSW exterior surfaces are coated with the aluminum protective coating. The SSW was initially unsealed, when in 2008 moisture was found condensing onto the uncoated inner walls, causing localized corrosion [3.11.171]. In February 2009, the SSWs were dried, cleaned, inspected, and sealed by reinstalling the SSW lids with dual metallic O-rings to prevent further moisture from entering the SSWs.

Completion of several FSV ISFSI aging management recommendations, including a corrosion analysis, resulted in no formal AMAs on the SSW components during the FSV ISFSI's PEO. The FSV ISFSI SER [3.11.173] states that for rural environments similar to the FSV ISFSI, the long-term corrosion rate of the SSWs is 0.985 mils per year (mpy), resulting in a calculated wall thickness of 0.325 inches after 50 years. However, the SSW corrosion analysis performed indicated a wall thickness of 0.372 inches remained in the lower portion of the SSW wall after 50 years of atmospheric exposure [3.11.171]. This thickness results in a long-term corrosion rate calculated for the SSW tube of 0.08 mpy.

3.2.2.1.3 Hydrogen Monitoring Activities

Despite discussion in the FSV SAR on the low probability of any significant corrosion occurring on the inside surfaces of an FSC, an AMP commitment was made to the NRC in order to confirm the absence of any significant corrosion within the FSC interior. The NRC viewed the presence of any significant hydrogen as being indicative of corrosion. The commitment specifies that the gas inside one FSC in each of the six vault modules be sampled for hydrogen.

This AMP commitment is relevant to the TMI-2 ISFSI. Hydrogen sampling of TMI-2 ISFSI DSCs has been occurring on an annual basis [3.11.113] as part of the existing LCO 3.2.3. Although like the FSCs, the DSCs are sealed, they are also vented through HEPA filters to the outside atmosphere. Such hydrogen sampling is required by the TMI-2 ISFSI TS and provides congruity between both ISFSI operating conditions. A hydrogen-monitoring program provides a framework for evaluating and confirming corrosion rates.

3.2.2.1.4 Concrete Monitoring Activities

The FSV ISFSI AMR for the concrete storage vault modules references the NRC General Aging Lessons Learned (GALL) Report [3.11.126]. It followed, that the FSV AMP instituted a concrete surface monitoring program. This program provides a means for monitoring and mitigating potential aging effects of the modular vault system. As a result, a new Section 5.5.5, "Aging Management Program" was added to the FSV Technical Specifications [3.11.175]. The following FSV AMP commitments outline some key aspects of the program.

- The FSV ISFSI AMP involves monitoring the exterior concrete surfaces of the storage vaults. It includes visual inspection of the accessible concrete (including below grade concrete, if exposed during excavation) and any exposed steel embedments and attachments.
- Inaccessible areas of the vaults that can be remotely inspected will be visually inspected every 10 years to assess SSC wall and floor surfaces for signs of degradation.
- Concrete and metal SSC conditions exceeding American Concrete Institute (ACI) 349.3R-02, Section 5.2, second tier-criteria [3.11.70] require repairs, additional inspections, or both.
- A concrete inspector training and qualification program consistent with Chapter 7 of ACI 349.3R-02 is developed.

A comparable HSM surface monitoring program [3.11.168] for mitigating potential aging effects is already being implemented at the TMI-2 ISFSI, and has been reviewed by the NRC and found to be acceptable for monitoring the HSM concrete aging conditions [3.11.167]. As part of this program, HSM base module, roof slab, and End Shield Wall concrete inspections are being performed annually at the TMI-2 ISFSI. As described in Section 3.2.3.1, in 2012, remote visual inspections using a borescope video probe and prototype delivery system were conducted on concrete and steel surfaces for both the FSV and TMI-2 ISFSIs [3.11.181]. A procedure is already developed and has been used to perform these remote visual inspections at the TMI-2 ISFSI [3.11.170].

3.2.2.2 IFSF Operating Experience Similarities

The IFSF is an INTEC facility designed to provide safe, interim, fuel storage [3.11.89]. Construction of the IFSF proper was completed in December 1974. Some of the main operations performed in the IFSF include receiving nuclear fuels from other facilities, repackaging and conditioning fuels for interim storage, safely storing fuels, and storing fuel-loaded storage casks on an interim basis. As shown in Figure 3-1, the IFSF is located in the southwest corner of the INTEC area, approximately 900 feet south by southwest of the TMI-2 ISFSI. Due to the proximity and similarity between the environments and materials of construction of the two facilities, the IFSF provides relevant OE for the TMI-2 ISFSI AMR. In addition, corrosion rate measurements of both the IFSF carbon steel canisters and corrosion coupon samples have been conducted at the IFSF. This OE provides credible bases that relate to the TMI-2 ISFSI aging effects assessments lending itself as a validation for AMR conclusions.

3.2.2.2.1 IFSF Storage System Description

The IFSF is divided into functional areas, each designed, and equipped for a specific task. The IFSF functional areas shown in Figure 3-2 include (1) the cask receiving area (including east/west truck bay, north/south truck bay, and truck ramp), (2) the cask transfer pit and permanent containment structure, (3) the fuel handling cave, (4) the fuel storage area, (5) the crane maintenance area, (6) the control and instrument rooms, (7) miscellaneous support areas, and (8) the fuel storage basin interfaces. The IFSF is 50-ft wide, 125-ft long, 32-ft tall, and has a footprint of 6,250 ft^2 excluding the truck bays (including the cask receiving area, east/west truck bay, and north/south truck bay). The IFSF is constructed primarily of reinforced concrete. The concrete walls and roof are designed to provide shielding and structural integrity of the facility against natural phenomena.

The fuel storage area and fuel storage racks shown in Figure 3-3 are the main areas of comparison in terms of similarity to the TMI-2 ISFSI. The fuel storage area occupies the west end of the IFSF and nominally measures 41-ft in the north/south direction by 71-ft in the east/west direction. The north exterior wall is 4-ft 2-in. thick, the south exterior wall is 4-ft 9-in. thick, and the original west wall is 5-ft 6-in. thick. A west wall modification in 1997 added a wall thickness of 3-ft 1.5-in. of reinforced concrete. The fuel storage area houses the carbon-steel storage rack, which measures 36-ft wide × 68-ft long × 11-ft tall. The rack supports the 636 fuel storage canisters, each of which is 18-in. in diameter and approximately 11-ft long. The rack has 38 rows of canisters, alternating 17 and 18 canisters per row. The rack sits on the fuel storage floor; and the storage rack supports the canisters approximately 2.5-in. above the facility floor.

The top, ends, and sides of the storage rack, except for the openings for the fuel storage canisters, are covered with sheet metal, which allows the rack to serve as a plenum for cooling air in addition to providing canister positioning and support. Air can be supplied to provide positive airflow through the stored canisters. The storage canisters have lids to limit air contact with the stored fuel. The fuel canisters are not sealed, but the lid is not normally removed under normal storage conditions. Many fuels stored at the IFSF contain cladding and some fuels that are in a readily dispersible form are contained in cans. In addition, Fuel Storage Devices (FSDs) are pieces of equipment used to package SNF in a configuration that is safe for handling in the IFSF, transferring within the IFSF, and storing in an IFSF canister as determined by structural evaluations and criticality safety evaluations. FSDs encompass a variety of cans, baskets, buckets, inserts, spacers, and canisters. The specific application of these devices is unique to each type of fuel. The IFSF racks, most of the storage canisters, and some of the FSDs are constructed of carbon steel.

3.2.2.2.2 IFSF Corrosion Monitoring Plan

Technical Safety Requirements for the IFSF call for a corrosion-monitoring program (PLN-1625) [3.11.169]. The IFSF Corrosion Monitoring Plan (PLN-1625) consists of documented inspections and corrosion measurements. Due to accessibility limitations, inspections are somewhat limited in scope at the IFSF. Therefore, reliance is placed in part on periodic corrosion measurements of coupons located in the storage area, as discussed in Section 3.2.2.2.4.

In addition, as described in Section 3.2.2.2.3, corrosion estimates from pieces cut from two unused carbon steel canisters (Engineering Design File) (EDF-6498, "Corrosion Evaluation of the IFSF CS Canisters" [3.11.176]) indicated that their expected life was 1,454 years, assuming no changes to the storage environment or from fuel stored within. EDF-6498 indicated that corrosion, and therefore the environment inside and outside an empty carbon steel canister was similar.

In terms of the IFSF environment, the IFSF supply-air ventilation system is filtered but otherwise unconditioned with untreated ambient air entering directly from the outside at the western end and exiting at the eastern end of the storage facility. The temperatures of both the IFSF and TMI-2 ISFSI are near ambient conditions; in fact, the IFSF does not require its ventilation system to be operable in order to remove decay heat (Section 2.5.9.1 of [3.11.89]). The significant diurnal air temperature fluctuations at the west end (air inlet) evens out almost completely at the east end (air outlet) due to the storage area thermal mass. However, the average facility temperature increases slightly from west to east due to the fuel decay heat and area lights. Therefore, the west end generally undergoes more temperature extremes and the east end is slightly warmer on average, and therefore dryer. The oxidizing agent in a dry environment is oxygen and water films may form during short periods of the year when condensation is likely. EDF-5579, "Corrosion Potential of the Irradiated Fuel Storage Facility Environment", [3.11.177] estimated the corrosion potential to be low within the IFSF storage area. Using this corollary to the TMI-2 ISFSI also provides credence to age-related assessments made for the AMR in Section 3.4.4.2.

PLN-1625 indicated there is little reason to assume that dry and inert SNF causes changes to the interior canister environment. This is a pertinent fact in support of conditions relative to the heated and vacuum-dried TMI-2 Canisters inside a DSC. It was noted that if wet fuel was present, a significant increase in moisture levels occurs throughout the canister due to evaporation mechanisms, condensation mechanisms, or dripping. Atmospheric gases such as carbon dioxide, which may also be generated from certain types of stored fuel, dissolve in water to form carbonic acid. The water may also contain corrosive ions such as chlorides. Corrosion will therefore be higher in a moist air environment than a dry air environment. In addition, canister environments are likely to be more corrosive if the stored SNF is highly irradiated due to the increased temperatures within, which tends to increase corrosion rates with higher temperatures. Radiation may also radiolytically decompose compounds that increase corrosion. Since the IFSF mostly contains SNF that have been stored for more than 10 years or have not been highly irradiated, radiation levels are not sufficiently high to increase measurably the corrosion rates. Low radiation levels are another similarity to the TMI-2 ISFSI, with the TMI-2 core debris having been in dry storage for 20 years, plus another previous 20 years of wet storage since the date of the TMI-2 accident.

3.2.2.2.3 Carbon Steel Canister Corrosion Estimations

In November 2005, three IFSF carbon steel canisters, two for destructive testing, and one for the long-term corrosion monitoring program were selected from canisters being removed from the IFSF [3.11.176]. The canisters selected were in the rows closest to the west wall and considered more likely to have water condensing on them, and thus have a higher likelihood of corrosion. The carbon steel canisters selected had been empty since they were stored in the IFSF and environmental conditions on both interior and exterior surfaces had been the same since the facility's commission in December 1974. The same general corrosion observations were evident between the inside and outside surfaces for the 31 years in operation. A light, uniform oxide layer covered the inside and outside surfaces of the carbon steel canisters. There was no excessive corrosion product buildup, no other changes, such as swelling or cracks, no observable localized corrosion, no pits, and no through-wall penetrations.

The carbon steel canister cylinder body was made of an American Society for Testing and Materials (ASTM) A53 B, 18-in. Schedule-10 pipe, with an ASTM A36 5/8-in. thick top, and ½-in. thick base-plate [3.11.176]. Initial canister wall thicknesses were measured to an accuracy of ± 3 mils in three different positions from top to bottom lengthwise along the canister pipe body. To gauge the variations at each position, the thicknesses of three points were measured 120° apart. For the base-plate thickness measurements, six points were chosen near the edge of the plate 60° apart. The averaged pipe wall thicknesses for the three canisters were 258, 261, and 249 mils, respectively. The averaged base-plate thicknesses for each of the canisters were 504, 508, and 503 mils, respectively.

The two canisters with the lesser average wall thickness were selected for destructive testing (i.e., corrosion specimen estimation). First, a video inspection was performed, scanning the entire surface of the canisters, inside and out, including all crucial support areas (e.g., lid, bottom, and support ring). A foot-by-foot inspection was then conducted to identify locations for specimen cutting. A metallurgical engineer watched the video, selecting likely corrosion locations, with the locations being marked. Sixteen corrosion specimens were cut from the two canisters for further evaluation. To control the temperature of the cuts, cooling lubricants were applied during cutting, preserving the as-found condition of the oxide coatings.

In early 2006, laboratory examinations were performed on the specimens. First, pictures were taken of the inside and outside surfaces of each specimen; then weights, dimensions, and thicknesses of the specimens were measured, with the oxide coating left intact. After the initial measurements, the flat specimens were scrubbed with ammonium citrate dibasic to remove the oxide layer. The weights and thicknesses of the specimens were measured again after cleaning. Oxidation (control) coupons of ASTM A53 Grade B and A36 steel for these cleaning processes were used. Evaluation of the control coupons indicated that the loss of sound metal during the cleaning process was zero. Finally, the specimens were sectioned and pictures of the cross sections taken.

By evaluating the weight losses and thickness reductions, conducting laboratory examinations, and comparing these data to the manufacturing tolerances, the corrosion rate and life expectancy of the carbon steel canisters was estimated. Flat specimens were cut from locations where the likelihood of corrosion was observed on the inner surfaces. The likelihoods were evidenced by marks like curved lines, a group of parallel lines, a group of circled lines, or lines close to the pipe seam. Therefore, the flat specimens cut from these locations were thought to present the worst possible corrosion. However, a closer visual examination of the flat specimens performed later indicated that the marks seen in the video tape were only scratches, perhaps from manufacture or transportation. No pits or through-wall penetrations were observed. The thickness of the four corners and the center of each flat specimen, before and after cleaning, were measured by an Ultrasonic Thickness gauge. Using an exposure time of 31 years (December 1974 to November 2005) and converting the ferric oxide thickness to iron thickness based on their densities (5.21 g/cm^3 for ferric oxide and 7.86 g/cm^3 for iron), the corrosion rates were calculated.

The corrosion rates measured from different specimens on the same canister were different. For the canisters' life expectancy, the highest specimen corrosion rate instead of the average corrosion rate of a canister was used because a canister could fail at one location that suffered the most serious corrosion attack. The corrosion rate of a specimen was the average of five measurements on that specimen, representing the average corrosion at the location where the specimen was cut. The highest corrosion rate calculated from the thickness measurements was 0.060 mpy. The highest corrosion rate measured by the weight loss method was 0.030 mpy. According to EDF-6498 [3.11.176], the weight loss method is the method normally used and the corrosion rate calculated from the weight loss method should generate results that are more reliable. However, the corrosion rate from the thickness reduction method was considered more conservative and therefore reported in the conclusions.

Security-Related Information
Figure Withheld Under 10 CFR 2.390.

Figure 3-1: INTEC Facility Area Plot Plan

Security-Related Information
Figure Withheld Under 10 CFR 2.390.

Figure 3-2: IFSF Plan and Cross-Sectional Views

Security-Related Information
Figure Withheld Under 10 CFR 2.390.

Figure 3-3: IFSF Fuel Storage Area and Fuel Storage Rack and Canister Detail

3.2.2.2.4 Corrosion Coupons

As described in Section 3.2.2.2.3, measurements of corrosion rates in the IFSF were made from December 1, 2005 to March 9, 2006 when two carbon steel storage canisters that had been in the facility for 31 years were cut up and measured [3.11.176]. A conservative corrosion rate of 0.060 mpy was determined by evaluating the weight losses of cut segments, thickness reductions determined by conducting laboratory examinations, and comparing these data to the manufacturing tolerances. However, since there was no previous measurement data available, there was some uncertainty in these measurements and therefore corroboration was requested. As a result, corrosion coupons were placed in the IFSF on March 3, 2011 in order to obtain additional corrosion rate data on a routine basis, as reported in engineering evaluations. The first of two sets of coupons was removed from the IFSF on March 20, 2013 [3.11.90], while the second set was removed on March 2, 2015 [3.11.91]. The results of the corrosion coupon evaluations compared favorably with the previous IFSF canister corrosion evaluation. The following discussion describes the corrosion coupons and the results from these two reports.

The corrosion coupons are installed in the IFSF rack at storage location J-3, which is in the middle of the third row from the west end of the facility. The corrosion coupons are used to measure corrosion in the IFSF over the remaining life of the facility. As shown in Figure A-4 of [3.11.91], there are 16 spool racks comprised of both short and long spool racks. These spool racks were hung onto a corrosion coupon tree that is designed such that the tree is placed in the open air at various storage locations within the IFSF storage rack. This allows for measuring differences in corrosion rates from one location to another. The coupons on the tree are welded corrosion coupons that include various types such as Type 1020 carbon steel, ASTM A36 carbon steel and Type 304L stainless steel. The coupons allow for measurement of uniform corrosion, crevice corrosion, carbon steel to stainless steel galvanic corrosion, and 304L Stress Corrosion Cracking (SCC) (see installation photos in [3.11.90] and [3.11.91]).

On March 20, 2013, a video inspection of the SCC coupons was performed and the first set of corrosion coupons was removed, cleaned, and examined after 2.05 years of exposure [3.11.90]. There were 16 corrosion coupons on spool-rack number 2 along with 6 control coupons. The coupons were sent to an independent laboratory for evaluation. Photographs documented the initial recovery condition of the coupons. Then the coupons were cleaned and weighed and once they were determined to be clean, photographs of each coupon were taken to document their after-condition. The control coupons were used to determine coupon material loss due to the chemical cleaning process. The stainless-steel corrosion rates were lower than the measurement detection limit (less than the estimated cumulative measurement error) for these coupons. The reported stainless steel Type 304L uniform and galvanic corrosion rates were both < 0.0006 mpy; while the stainless-steel Type 304L reported crevice corrosion rate was < 0.0007 mpy. The 1020 carbon steel average corrosion rates were 0.0475 ± 0.004 mpy (crevice), 0.0410 ± 0.004 mpy (galvanic) and 0.0274 ± 0.003 mpy (uniform). Each of these corrosion rates reflected the average of two coupons for each corrosion type. In addition to these results, there was no evidence of corrosion or cracking on the stainless-steel Type 304L SCC coupons. These coupons were left on the air rack for continued exposure. Of note, the carbon steel galvanic coupons are placed back-to-back with the stainless steel galvanically coupled coupons.

Similarly, on March 02, 2015, a video inspection of stainless steel SCC coupons was performed and a second set of corrosion coupons was removed and sent to an independent laboratory for cleaning and evaluation after 4 years of exposure [3.11.91]. The lack of change in the Type 304L SCC coupons indicated that there was no evidence of corrosion or cracking on these coupons. They were left on the air rack for continued exposure. Regarding the corrosion coupons, there were eight corrosion coupons on spool-rack number 4 and four control coupons that were sent to the laboratory for evaluation. Photographs documented the initial recovery condition of the coupons. Then the coupons were cleaned and weighed and once they were determined to be clean, photographs of each coupon were taken to document their after-condition. The control coupons were used to determine coupon material loss due to the chemical cleaning process. The average 304L stainless steel corrosion rate was 0.0002 ± 0.0006 mpy for two galvanic coupons. The average ASTM A36 carbon steel corrosion rates were 0.0364 ± 0.0172 mpy for the crevice corrosion coupons, 0.0356 ± 0.0121 mpy for the uniform corrosion coupons, and 0.0299 ± 0.0153 mpy for the galvanic corrosion coupons. Each of these corrosion rates reflected the average of two coupons for each corrosion type. The maximum carbon steel general corrosion rate measured for the IFSF was 0.0365 mpy on coupon *"CS-168"*. Of note, the carbon steel galvanic coupons are placed back-to-back with the stainless steel galvanically coupled coupons.

3.2.3 Pre-Application Inspections

(NUREG-1927, Section 3.4.1.1, Section 3.4.1.2 and Section 3.6.1.10)

This section provides a discussion of the TMI-2 ISFSI pre-application inspections conducted. This includes the 2012 inspections of the interior of the HSMs providing the state of the DSC exterior and DSC support structure. This section also describes the 2012 pre-application visual inspections of the HSM exteriors. These inspections chronologically describe the state of the HSM concrete prior to repairs initiated in 2009 leading up to the current state of the HSMs beginning in 2012. The OE from this section is used to inform the LRA and specifically the AMPs described in Appendix A.

3.2.3.1 Sheltered Environment 2012 Inspections

In July 2012, a technology development project was undertaken to introduce a remote inspection method for use at the TMI-2 ISFSI as well as other locations. This was documented in the reports "Technology Development/Remote Visual Inspection of the TMI-2 ISFSI HSM 16, DSC, and DSC Support Structure" [3.11.180], and "Remote Visual Inspection Technology Development and Application" [3.11.181]. The project demonstrated the use of an Everest XLG3® Video Probe system [3.11.182] which allows for both remote inspection and feature measurement, depending on the installed optical probe tip. This allowed for an initial inspection/viewing of the HSM/DSC Sheltered Environment (See Section 3.3.1.2) to be followed by measurements of any features of interest. The development project utilized the overpack installed in HSM-15 and HSM-16/ DSC DOE12T-002. The overpack has not been utilized (i.e., contains no radiological source) and was used as a demonstration platform for the project. Selective photographs of the HSM-16 DSC support structure and DSC DOE12T-002 are included in Appendix B of [3.11.181].

A prototype delivery system for application of the Everest XLG3® was also developed for the TMI-2 ISFSI pre-application inspections. The prototype delivery system accommodated a 25-ft probe and various optical tips. The prototype delivery system components included a 17-ft insertion tube, a remotely operated 90° articulating joint, and various 1-ft to 9-ft exchangeable end optical tips. The complete system is shown in Figure 2 of [3.11.181]. The system was designed to insert the probe and optical tips through the HSM floor drain port, accessing the HSM internal spaces, DSC, and DSC support structure. The delivery system was used to position the video probe's 25-ft optical cable inside the HSM, allowing for the viewing, recording, and measuring of various targets.

The Everest XLG3® system is capable of viewing efflorescence residue on HSM concrete, concrete cracks as small as 0.011-in. wide, discoloration on surfaces, zinc coating discontinuities, and potential corrosion on surfaces, including on welds and fastening hardware [3.11.181].

The demonstration project resulted in these findings:

- Very minor corrosion in areas where the zinc coatings have been damaged from abrasion during component handling or DSC loading operations
- Minor fine cracking (checking) [3.11.183] of the primer coating on DSC shell surface
- Water staining on HSM concrete interior walls

Following the development project, a pre-application inspection was performed on HSM-16/ DSC DOE12T-002 in December 2012 [3.11.83]. As indicated in Section 3.2.2.1.4, a DOE-ID NLF contractor procedure is already developed and was used to perform this remote visual inspection at the TMI-2 ISFSI [3.11.170].

Factors considered in the selection of the DSC for the pre-application inspection included: length of time since installation, low payload heat generation, low radiological source term, and material combinations. The selected DSC was chosen for the pre-application inspection, as it was both the first DSC loaded at the TMI-2 ISFSI and had the lowest heat load. The payload comprises 8 TMI-2 Filter Canisters with only 24 pounds of TMI-2 core debris (See Table 3-2). Both factors result in a credibly low-heat load bounding DSC condition. As described in 3.4.3.2, the low heat generation is expected to result in increased condensation that would lead to increased corrosion potential.

3.2.3.1.1 Pre-Application Inspection Results

Remote visual inspections were performed on the interior of HSM-16 (DSC DOE12T-002), including the HSM interior concrete, DSC, and DSC steel support structure. Selected photographs of the DSC are provided on pages 12 through 25 of [3.11.83]. The findings from these inspections were presented to the NRC in a pre-renewal meeting held in September 2013 [3.11.133]. The photographs depict areas where the protective coatings at weld locations appear intact. The photographs from [3.11.83] also show an area adjacent to the support rails where the protective coating appears scraped from the side of the DSC, with no evidence of subsequent corrosion (See Figure 3-4). The black streaks are from a Dry Film Lubricant that was placed on the rail when the DSC was slid into place. It was not entirely clear what the source of the scrape, but may have been the result of DSC misalignment during insertion. This may have been due to either DSC rotation during loading or DSC removal and reinsertion. In either case, alignment was likely necessary between the HEPA Purge and Vent Filters and the cylindrical access ports through the HSM concrete. This location of wear on DOE12T-002 is considered as a location for future monitoring in the AMP as covered in Appendix A1. Of note, DOE12T-002 was the lightest DSC loaded into the DSC so might not be bounding in terms of wear aging mechanisms. Therefore, the DSC AMP may consider one of the heavier DSCs as part of the selection criteria of the substitute DSC in Section A1.4.1.

Other areas in the photos of [3.11.83] show coating exhibiting what appears to be a fine checking pattern [3.11.183]. This same condition was noted during the July demonstration project. The condition may have been the result of either too thick of a coating application or a formulation error initially, but by all appearances seems to be a coating surface defect only and considered inconsequential [3.11.184]. This would be an area requiring a review during the baseline inspections and trended to see if the checking pattern has worsened. However, the only indications of corrosion were slight staining starting to show through the coating in a few locations on the surface of the DSC. Of note, no further assessment of these conditions was performed during the 2012 inspection and thus no definitive conclusions as to the condition of the protective coating drawn. The proposed baseline inspection in the Appendix A AMPs is a VT-3 inspection (Section XI, Paragraph IWA-2213 of the ASME Boiler and Pressure Vessel Code (BPVC) [3.11.179]) that requires detection of flaws ≥ 0.105 in. from a distance of 4-ft. For the 2012 pre-application inspections, the dimensions measured for the flaws in one case (Page 23 of [3.11.83]) in the protective coating were measured from a distance of 0.354 in. and measure 0.047 in. wide. This close of an image resolution would be expected to be undetectable given the VT-3 acceptance criterion.

In addition, observations from the photographs indicated evidence of calcium streaks on the inner HSM walls, measuring 0.187 in. wide in one photograph. Based on the inspection photographs, the DSC support structure appears to be in excellent condition with coating still exhibiting a glossy finish. There were no areas where unanticipated degradation was observed, as any such conditions would have been evaluated using the DOE-ID NLF contractor corrective action program.

Figure 3-4: Scrape Shown on Underside of DSC S/N DOE12T-002 Inside of HSM-16 [3.11.83]

3.2.3.2 Outdoor Environment HSM Inspections

3.2.3.2.1 Preliminary Inspection/Repair/Testing Summary 2000 - 2011

In October 2000, a visual inspection was performed by the HSM design agent and fabricator (Transnuclear West, Inc.) to evaluate shield wall spalling and cracking in the HSMs [3.11.191]. It concluded that the conditions were cosmetic [3.11.116].

A visual inspection of the HSMs was performed again in October 2007 to assess efflorescence growth and cracking [3.11.86]. Efflorescence was tested and found to be calcium carbonate, common to concrete exposed to wet-to-dry cycles. Determination of the cause of the cracking was due to environmental conditions and volume changes within the concrete mass. Recommendations were to continue to monitor conditions and to consider providing protection against water penetration to reduce the severity of freeze attack.

A visual inspection of the HSMs was performed in September 2008 to document efflorescence growth, cracking, and to evaluate general conditions [3.11.117]. Comparisons between the 2000 and 2007 inspections concluded that the cracks were increasing in severity. Recommendations were to hire a firm knowledgeable in concrete examination and testing to determine the cause of the cracking.

Wiss, Janney, Elstner Associates (WJE) were contracted in July 2009 to perform a thorough and detailed HSM concrete examination. WJE performed visual inspection, hammer sounding, water percolation tests at roof anchor bolt-through holes, and laboratory testing of core samples. The testing included depth of carbonation, petrographic examinations, chloride content and compressive strength measurements. Contractor report WJE No. 2008.1917 [3.11.15] documented the results with a site investigation summary provided by DOE-ID in EDF-9516 [3.11.185].

Overall, the concrete quality was found to be adequate, but that it did have some properties (high paste content, variable water-cement ratio, weak paste-aggregate bond) that made it prone to surface shrinkage cracking, which was found to be widespread in the roof slabs and base units. However, no serious deleterious internal reactions were found, and alkali-silica reaction (ASR) and delayed ettringite formation (DEF) along with corrosion were not considered factors in the distress observed. The primary observation was that severe cracking in the roof slabs and base units was caused from freezing of trapped water in the roof anchor bolt-through holes. WJE recommended a repair approach for the freeze-thaw cracking.

The repair recommendations and additional conclusions from the WJE inspections included:

- Chloride content was very low and not sufficient to promote corrosion of embedded metals
- The concrete had local areas of variable or low entrained air contents making it susceptible to cyclic freezing damage in localized areas. No evidence of cyclic freezing damage was noted however.
- Cracking in the roof slabs appeared to be primarily due to physical forces of freezing water trapped in the base module to roof anchor bolt hole voids.
- For the HSMs to remain serviceable for the designed service life, the long-term durability of the reinforced concrete required remediation. The repair efforts were to focus on:
    - Sealing the roof anchor bolt holes from water intrusion
    - Repair of deteriorated concrete cracking and spalling
    - Use preservation techniques to limit the moisture exposure of the concrete. This might include surface sealers, application of a membrane, or protective structures to control the water exposure of the HSMs.

Repair actions started in October 2009 by filling the HSM roof anchor bolt-through holes with polyurethane foam as recommended by WJE (Documented in FDC 6797 [3.11.118], WO 627046 [3.11.119], and EDF 9565 [3.11.120]). The HSMs were again inspected in September 2010 to assess their condition (documented in EDF 9897 [3.11.109]). Data providing crack location and severity was generated from the inspection.

Repair actions continued in June 2011 with installation of the HSM roof anchor bolt and through hole protective covers (FDC 7682 [3.11.121], FDC 7715 [3.11.122] and WO 635917 [3.11.123]). Cracks were repaired in September 2011 by capping and resin injection (FDC 7803 [3.11.124] and WO 636977 [3.11.26]). HSM concrete surfaces were sealed against moisture intrusion in October 2011 with application of a silane water repellent coating (FDC 7901 [3.11.125] and WO 637273 [3.11.19]).

3.2.3.2.2 Pre/Application Annual Inspections

The effectiveness of the concrete repairs has been confirmed by annual visual inspections. The intent of the repairs was to prevent moisture intrusion into the concrete to stop cracking from freeze thaw action. Based on the inspections, repairs have prevented moisture intrusion into the concrete and stopped cracking from freeze thaw action. Annual visual inspection of the TMI-2 ISFSI concrete is a commitment made to the NRC, as discussed in NRC Inspection Report 07200020/2012-001 [3.11.167]. During each of the annual inspections, starting with the 2012 pre-application inspection, all observed conditions from visual inspections were photographed for trending and monitored for deleterious aging of the HSM SSCs from previous inspections. Dimensioning was included in the photographs by inclusion of a tape measure or a crack comparator or both when applicable. All of the photographs taken are included in each of the annual inspection reports as part of the record.

Personnel who perform these inspections and evaluations meet the requirements of ACI 349.3R, Chapter 7, "Qualifications of Evaluation Team" [3.11.70] and these qualifications are documented via DOE-ID NLF contractor "Qualification Standard Checklists." Visual inspection of accessible HSM concrete surfaces in the outdoor environment are performed per ACI 349.3R, Section 3.5.1, *"Visual Inspection"* and ACI 201.1R, "Guide for Conducting a Visual Inspection of Concrete in Service" [3.11.71]. All inspection equipment used to photograph the HSMs or used in measurements is documented. Acceptance Criteria (AC) and disposition of identified findings is performed using the evaluation criteria in ACI-349.3R, Chapter 5, "Evaluation Criteria".

The following documentation provides the historical record of these inspections:

<u>2012</u>

- RPT-1193, 2012 pre-application inspection of the HSM Base and Roof Modules [3.11.186]
- RPT-1170, 2012 pre-application inspection of the HSM End Shield Walls [3.11.189]

<u>2013</u>

- RPT-1260, 2013 annual inspection of the HSM Base and Roof Modules [3.11.187]
- RPT-1259, 2013 annual inspection of the HSM End Shield Walls [3.11.190]

<u>2014</u>

- RPT-1401, 2014 annual inspection of the HSM Base, Roof Modules and End Shield Walls [3.11.188]

<u>2015</u>

- RPT-1443, 2015 annual inspection of the HSM Base, Roof Modules and End Shield Walls [3.11.138]

<u>2016</u>

- STI-NLF-RPT-034, 2016 annual inspection of the Horizontal Storage Modules and the End Shield Walls [3.11.214]

<u>2017</u>

- STI-NLF-RPT-057, 2017 annual inspection of the Horizontal Storage Modules and the End Shield Walls [3.11.227]

The following inspection results are described from the 2012 pre-application inspection of the HSM Base and Roof modules. No signs of concrete degradation from freezing and thawing (scaling or cracking in the concrete) were found. General surface conditions exhibited no cracking in excess of the ACI 349.3R first-tier criteria (less than 0.015-in. width). Less than first-tier *"map cracking"* was present on the front and rear vertical surfaces of the HSMs. Less than first-tier *"radial cracking"* was present on the front of the HSMs, originating from the circular opening for DSC insertion and in the HSM roof slabs around the through holes for the anchor bolts. Less than first-tier horizontal and vertical cracking was present on the front and rear vertical surfaces of the HSMs. In addition, some less than first-tier vertical cracking was found in the vertical surfaces of the HSM roof slabs. HSM roof and base unit corner cracks repaired using epoxy injection in September 2011 (WO 636977 [3.11.26]) were found to be in good condition based on visual inspection. No separation of bond between the cracked surfaces and the injected epoxy resin was observed. No new cracking adjacent to the repaired cracks was found. Power-washing cleaning techniques prepared the concrete HSM surfaces prior to crack repairs made in September 2011 and concrete surface sealing completed in October 2011. This cleaning removed efflorescence that had been identified in previous inspections. Therefore, any efflorescence found during the pre-application inspection was considered new.

Efflorescence was found in a few locations ranging in appearance from trace amounts to 4-in. long. Rust stains (approximately ¼-in. in diameter) were found in a few locations. They were attributed to tie wire end terminations at the concrete surface. The rusting caused no degradation to the concrete surface.

During construction of the HSMs, the roof slabs were lifted into place using embedded wire strand loops that protruded from four recessed pockets in the top surface of the roof slab. After the roof slab was assembled to the base unit, the lifting strands were then cut and the recessed pockets were filled with grout and finished to match. The condition of the grout surface is varied. Most roof slabs pockets showed no signs of degradation. The grout surfaces of some were partially to totally spalled, up to a depth of ¼-in. A few of the grouted pockets were spalled and have rust stains up to a ½-in. in diameter. The rust stains are from the cut ends of the remaining wire strand loop.

The coating treatment, a penetrating water-based silane water repellent was tested for water repellency by splashing water on the concrete surface to determine if it would bead. It was found not to prominently bead on the surfaces. Water repellency could not be adequately verified using this method, therefore, additional evaluation and testing was needed. This evaluation of the adequacy of the silane sealer to provide water repellency took place during the 2013 annual inspections [3.11.187]. Spraying water from a hand-held spray bottle on the concrete surface to determine if it would bead was the preferred method for demonstrating water repellency. The water was observed for evidence of beading. Inspection of the sprayed moisture consistently demonstrated a water beading effect. Photographs of the water beading effect were included in Appendix EE of RPT-1260 annual concrete inspection [3.11.187]. Based on the water beading effects observed during the inspection, it was concluded that the concrete is adequately protected from water intrusion.

Inspection findings from the 2012 pre-application inspection of the HSM End Shield Walls (RPT-1170) [3.11.189] included that the general surface conditions exhibited no cracking in excess of the ACI 349.3R first-tier criteria (width less than 0.015 in.). No efflorescence was observed. The grouted joint between the wall panels was found to be intact and in good condition. The coil insert holes in the tops of the walls exhibited minor cracking from freeze thaw action. The cracking widths were less than the ACI 349.3R first-tier criteria. Because water could fill the holes and cause freeze-thaw degradation, they were filled with silicone sealant per WO 642973 [3.11.27].

Several of the end shield walls exhibited significant spalling at their bases. The condition exceeded the ACI 349.3R second-tier criteria for spalling (less than ¾-in. depth and 8-in. in any direction). Additional evaluation was recommended to determine if repair of spalling was required. Subsequently, a repair plan was formulated and remediation actions were taken on the active spalling conditions. However, as detailed in Section 3.5.4.3.1, the progression of spalling along the base of the end shield walls was not halted after the active spalls were repaired in October 2015 (WO 656351) [3.11.28] and is documented in the 2016 inspection report [3.11.214].

3.2.3.2.3 Post 2012 Annual Inspection Findings/Observations

As stated in Section 3.2.3.2.2, there have been routine annual inspections of the HSM SSCs since the post/repair pre-application inspections of 2012. These inspections have occurred in 2013, 2014, 2015, 2016, and 2017 and will be continued on a routine basis into the PEO. The overall observations reported during these inspections are described below. These inspection findings from the 2013 visual inspections of the HSM End Shield Walls (RPT-1259) [3.11.190] and HSM SSCs (RPT-1260 [3.11.187]) along with the 2014, 2015, 2016 and 2017 HSM and End Shield Wall inspections [3.11.188], [3.11.138], [3.11.214], [3.11.227], included the following:

- No signs of concrete degradation from freezing and thawing were found.
- General surface conditions exhibited no cracking in excess of the ACI 349.3R [3.11.70] first-tier criteria (width less than 0.015-in.) with no change from the 2012 pre-application inspection.

- Efflorescence staining was found in a few locations ranging in appearance from trace amounts to 9-in. long. In 2015, small changes in the staining (less than 10 percent increase in size) were observed on two HSMs based on comparison to the 2012 pre-application inspection. New efflorescence staining was observed in two locations (RPT-1260, Appendix K, Figure 7 and Appendix L, Figure 3 [3.11.187]).
- Rust stains (approximately a quarter inch in diameter) were found in a few locations. No change to the size of the rust stains was noted based on comparison to the 2012 pre-application inspection.
- The condition of the grout surface of the recessed pockets in the top surface of the roof slab is varied. Most show no signs of degradation. The grout surfaces of some are partially to totally spalled up to a depth of a quarter of an inch. A few of the grouted pockets are spalled and have rust stains up to a half inch in diameter. No change from the 2012 pre-application inspection was observed.
- Radial cracking under first-tier criteria was present on the front of the HSMs originating from the circular opening for DSC insertion and in the HSM roof slabs around the through holes for the anchor bolts. During the 2017 inspection [3.11.227], HSM-7 showed radial cracking increasing in width to 0.030-in. (under second-tier criteria), originating from the perimeter of a core hole. No other changes from the 2012 pre-application inspection (RPT-1193 [3.11.186]) were observed.
- Horizontal and vertical cracking under first-tier criteria was present on the front and rear vertical surfaces of the HSMs. No change from the 2012 pre-application inspection was observed.
- Some vertical cracking under first-tier criteria was found in the vertical surfaces of the HSM roof slabs. No change from the 2012 pre-application inspection was observed.
- HSM roof and base unit corner cracks repaired using epoxy injection in September 2011 were found to be in good condition based on the visual inspections. No separation of bond between the cracked surfaces and the injected epoxy resin was observed. No new cracking adjacent to the repaired cracks was found with respect to the 2012 pre-application inspection.
- The grouted joints between the end shield walls panels were found to be intact and in good condition.
- Radial cracking under first-tier criteria around the end shield wall coil insert holes in the top of the walls was found to be passive based on comparison to the 2012 pre-application inspection.
- Nine large spalled areas in the bases of the end shield walls exceeded ACI 349.3R second-tier criteria (less than ¾-in. in depth and 8-in. in any direction). Five of the spalled areas are stable and four are active. The active spalls were repaired in October 2015. Several of the repaired areas are beginning to show signs of separation from the base material [3.11.214], [3.11.227]. The 2017 Inspection report recommends applying a fresh coating of epoxy to areas separating.
- It was recommended to benchmark (map) HSM roof micro-crack and monitor crack dimensions once a year for any changes. Mapping cracks is included in routine visual inspections of the HSM surfaces and is carried over into the HSM AMP in Appendix A2.

- As discussed in Section 3.2.3.2.2, the concrete coating treatment (a penetrating water-based silane water repellent) was tested for water repellency by spraying water from a hand-held spray bottle on the concrete surface to determine if it would bead. It was found to successfully bead on the surfaces. Since no tests were performed prior to the application of the coating treatment, comparisons to a before treated condition was not possible. It was recommended to start sealant monitoring in 2016, which would be 5 years after initial application. This is included in the HSM AMP in Appendix A2 and includes a manufacturer recommended testing protocol along with appropriate AC.

3.2.4 Generic Industry Experience

(NUREG-1927, Section 3.6.1.10)

3.2.4.1 NUHOMS Based System Operating Experience

The OE from other NUHOMS®-based systems were reviewed for applicability to the TMI-2 ISFSI. This information has previously been summarized in the 1004 CoC LRA [3.11.25] which covers both the OE from the Standardized NUHOMS® System as well as the site-specific systems such as the TMI-2 ISFSI. Due to the similarities of the systems, the OE for the TMI-2 ISFSI is also referenced in the Standardized NUHOMS® System OE. The main difference between the Standardized NUHOMS® System, site-specific NUHOMS® systems, and the TMI-2 ISFSI is the fact that the DSCs for the TMI-2 ISFSI are made from carbon steel, while all other NUHOMS® DSCs are fabricated from 300 series stainless steel. Hence, in this respect the OE is significantly different for the TMI-2 ISFSI. However, the concrete HSMs are very similar, with the main exception being that the TMI-2 ISFSI HSMs are not vented, since the TMI-2 core debris does not generate adequate decay heat in order to have justified them in the original design.

However, similar AMP elements in the DSC AMP are utilized from the 1004 LRA, Appendix 6A.4 [3.11.25]. Areas of the DSC subject to examination (i.e., detection) are similar since the general configuration of the DSC SSCs in both cases is similar. In addition, similarities between the Standard NUHOMS® DSC AMP and the TMI-2 ISFSI DSC AMP include the AC (See Appendix A1). The exception to the AC resemblance is that the ASME BPVC *"IWB-3514"* austenitic steel acceptance standards are replaced by ferritic steel [3.11.179] to match the DSC material.

This NUHOMS® OE for HSM SSCs is summarized in Table 3.2-1 of the 1004 LRA [3.11.25] and relates to conditions identified herein. The most common non-conforming conditions listed in the 1004 OE for HSMs are those involving loss of material (cracking and spalling) occurring on the exterior surfaces of the HSMs. The identified occurrences were primarily limited to surface and localized areas of HSMs. As appropriate, spalled areas and larger cracks were repaired using high strength cementitious grout (minimum 5000 psi compressive strength). Smaller cracks were sealed with various cementitious or chemical grouts or other sealants. Repairs made were consistent with qualified industry procedures and consensus standards such as ACI and Precast/Pre-stressed Concrete Institute (PCI) codes, including manufacturer's recommendations for particular products used. In general, the magnitude and extent of various cracking and spalling conditions were not considered significant relative to the overall size and dimensions of the HSM SSCs. The conditions did not constitute a threat to the structural integrity or shielding functions of the HSM, allowing SSCs to continue performing their intended functions. Any cracks which were not repaired met the criteria for no further evaluation required (i.e., width of passive surface cracks less than 0.015-in., consistent with ACI 349.3R [3.11.70]). This OE is similar to that for the NUHOMS®-12T DSS used at the TMI-2 ISFSI and is used as validation of the Appendix A2 AMP elements.

There were several OE instances that identified damage to the HSM concrete due to water trapped in the bolt hole penetrations located in the roof of the HSM. The water froze and, upon expanding, caused local cracking of the concrete. In all cases, the degraded concrete was repaired and restored allowing the HSM SSCs to be in a state to comply with all design criteria and to continue performing their intended functions. Preventive measures were taken and design changes were implemented to prevent recurrence. As described in Section 3.2.3.2.1, the TMI-2 ISFSI experienced this type of damage due to the roof attachment bolt holes not being properly sealed. The root cause was evaluated and determined, applying corrective actions consisting of both concrete repairs and preventive measures including filling the holes with foam and capping the holes with protective bolt hole covers. Continual monitoring of HSM concrete to prevent and detect water intrusion and freezing is addressed in the HSM AMP in Appendix A2.

Regarding basemat settlement of the NUHOMS® system, due to the loading patterns used when placing the HSMs on the pad during installation, the pad could settle unevenly causing a slight reduction of the HSM-to-HSM spacing between HSMs. In addition, differential settlement problems may theoretically affect retrievability (Page I.2-3 of [3.11.203]) of DSCs. The spacing of the TMI-2 ISFSI HSMs is nominally 6 inches and Section 8.2.10 of the UFSAR [3.11.2] evaluates an accident condition with consideration given to blockage of the space between adjacent HSMs. The UFSAR evaluates the thermal effects of this accident resulting from the increased temperatures of the DSC and the HSM due to blockage of the gap between HSMs. Although interesting, settling of the pad would have little effect on the non-vented TMI-2 ISFSI HSM design. Nonetheless, differential settlement of the Basemat and Approach Slab with respect to a retrievability function is addressed in Section 3.7.4.1.

3.2.4.2 VSC-24 Ventilated Storage Cask System Operating Experience

3.2.4.2.1 Background/AMR Elements

The Ventilated Storage Cask (VSC) system is a "canister-based" DSS that consists of a concrete storage overpack Ventilated Concrete Cask (VCC) and a plain carbon steel, seal-welded canister Multi-assembly Sealed Basket (MSB) to store SNF. The VSC System can be sized to hold from 4 to 24 PWR assemblies. The VSC-24 System was approved under 10 CFR 72 (Docket 72-1007) in May 1993. A 40-year CoC LRA for the VSC-24 System has been submitted to extend the CoC expiration date to May 2053 [3.11.205].

Currently, there are 58 VSC-24 casks loaded and put into storage at three different ISFSIs. These were loaded between May 1993 and June 2003 (18 casks at Palisades, 16 casks at Point Beach, and 24 casks at Arkansas Nuclear One) [3.11.203]. The SNF stored in the VSC-24 casks have low heat loads and low burnup similar to the TMI-2 ISFSI, albeit the TMI-2 core debris has even lower heat loads and lower burnup. The maximum initial heat load of the 58 loaded VSC-24 casks is less than 15 kW (kiloWatt). As extracted from [3.11.204], Figure 3-5 shows the major system components of the VSC-24 DSS.

The MSB assembly is constructed entirely from carbon steel (primarily SA-516, Grade 70), with the exception of the castable neutron shielding material. This is the same material that the TMI-2 DSC and DSC support structure is constructed from and therefore provides appropriate OE guidance for the AMR. In addition, the MSB carbon steel shell, bottom plate, top lids, and storage sleeve assembly are coated with a radiation-resistant, high-temperature, non-organic hard surface coating such as CARBOZINC® 11 (Table 1.2-2 of [3.11.204]). CARBOZINC® 11, in use for both the DSC and DSC support structure at the TMI-2 ISFSI, is one of the allowed VSC-24 MSB coating types, which was utilized at the Point Beach [3.11.206] VSC-24s.

The Sheltered Environment described in Section 3.3.1.2 is equivalent to the "Sheltered Environment" described in Section 3.1.2 of the VSC-24 LRA [3.11.205]. This is pertinent to the MSB shell on the VSC-24, correlating directly with the DSC outer shell and lid surfaces. Other similarities include the Encased Environment described in Section 3.3.1.2, which is equivalent to the "Sealed Air-Filled Environment" described in Section 3.1.2 of the VSC-24 LRA. This is pertinent to the MSB inner closure field weld and lids on the VSC-24 that correlates directly with the DSC volumes between bottom inner and outer plates and the top shield plug and top cover plate volume. The only characteristic exception is that the TMI-2 DSC environment is more benign (corrosion rates are lower) than that of the VSC-24 due to the lower decay heat loads mentioned previously.

3.2.4.2.2 Confirmatory Action Letter 97-7-001 and Closure Welds

As part of the TMI-2 ISFSI pre-submittal meeting with the NRC in June, 2016 [3.11.198], DOE-ID committed to review and evaluate Confirmatory Action Letter (CAL) 97-7-001 [3.11.195]. DOE-ID is including this assessment of CAL 97-7-001 and any potential implications on the TMI-2 ISFSI during the PEO. CAL 97-7-01 was issued on May 16, 1997 by the NRC to confirm Sierra Nuclear Corporation's (SNC's) commitments to resolve closure weld problems associated with the VSC-24. SNC was the CoC holder of the VSC-24 dry storage cask at the time. The problems were in the welds joining the cask shield lid to the MSB. On four occasions during loading operations at the commercial utilities using the VSC-24, cracks occurred in either the weld between the shield lid and the MSB shell or the weld between the structural lid and the MSB shell. The weld issues all occurred prior to issuance of the TMI-2 ISFSI initial license in 1999. In addition, ISG-15 [3.11.199], "Materials Evaluation" addressed this OE, but this ISG was issued in 2001 after the TMI-2 license was issued. The OE regarding these closure weld issues on the VSC-24 is discussed below.

SNC and the VSC-24 owners responded to the CAL and proposed corrective actions in numerous correspondences between July 30, 1997, and July 17, 1998 [3.11.196]. The general licensee determined that the Point Beach cracks on the root pass of the structural lid-to-shell weld were caused by wide fit-up gaps that were not properly filled by the welding technique. This resulted in a lack of fusion in the weld metal. The general licensee also concluded that the cracking and weld porosity found in the structural lid-to-shield lid seal weld were caused by moisture contamination of the weld. The moisture came from water forced out of the drain line during cask loading. The NRC staff concluded that the root causes presented by SNC for each of the weld cracking events were credible and accepted SNC's assessment on the susceptibility of the welds, on previously loaded casks, to Hydrogen-Induced Cracking (HIC). However, the NRC staff also concluded that SNC did not accurately assess the length of time in which delayed cracking of the shield and structural lid welds may have occurred. In response to this concern, the utilities with VSC-24s in use committed to performing volumetric Ultrasonic Testing (UT) of previously loaded cask welds. The UT data was then used to evaluate whether the casks met the design bases for the VSC-24 structural lid weld.

It was determined that HIC of the MSB closure welds was possible whenever a sufficient combined severity of the following three conditions were present during welding: (1) a concentration of diffusible hydrogen in the weld area; (2) a microstructure susceptible to embrittlement by hydrogen; and (3) high constraint (stresses) in the weld area.

Despite the fact that this issue occurred prior to the issuance of the TMI-2 ISFSI and that ISG-15 was issued after the license was issued, the circumstances regarding this issue were addressed during the original TMI-2 ISFSI license evaluation. On November 12, 1997, the NRC issued the first RAI for the TMI-2 ISFSI license [3.11.200]. This was 6 months after CAL 97-7-001 was issued, with at least one of the questions relating to the VSC-24 closure weld cracking issues. RAI question [4-1(a)] was as follows: "Provide the following information, necessary for the evaluation of the acceptability of the DSC closure welds and DSC coating: a) Welding specifications applied to the final closure seal welds on the DSC."

As part of the response to RAI 4-1(a) [3.11.197], DOE-ID indicated that a great deal of thought and effort had been expended to designing an adequate closure weld for the NUHOMS® DSCs to prevent such problems as HIC. It was mentioned that the final joint configuration and basic weld geometry is essentially the same as the original DSC designed, developed and tested as part of a demonstration project at the Robinson Station (EPRI NP-6941/PNL-7327) [3.11.201] in 1988-1989. This same closure weld design used with the NUHOMS® DSCs is a staple of the NUHOMS® design and is used at other ISFSIs including at the time Oconee, Calvert Cliffs, and Davis-Besse stations. In fact, the basic NUHOMS® closure welding program and joint design has not fundamentally changed since the EPRI demonstration project; with circa 30 years of OE, without such HIC weld issues as experienced by the VSC-24 DSS. The RAI 4-1(a) response by DOE-ID provided further substantiation why the specific NUHOMS®-12T DSC closure weld was not susceptible to the conditions outlined in the CAL.

The following statements are extracted from the RAI response:

> *"Key elements in satisfactory weld quality in the closure weld are basic joint design and geometry. Important attributes are joint restraint, weld volume, and cover-to-shell radial gap. The NUHOMS® closure design is not highly restrained and provides for displacement of the shell to mitigate the effects of residual weld stress caused by the weld metal solidification. The cylindrical shell, as depicted below, is drawn inward during inner cover welding. The shell is thin enough to act as the "weak link" in the joint to prevent stress relief in an undesired fashion (weld or shell plate lamellar tearing or cracking). Using classical formulas for determining the moment required to yield the shell, it can be shown that it requires approximately 2.5 times the stress (generated from the weld solidification) to deflect a 1" thick shell as it does for a 5/8" shell."*

It should be noted that the DSC shell is 5/8-in. thick while the VSC-24 MSB shell is 1-in. thick. This is noteworthy, because as stated above, the residual stresses are evaluated as 2.5 times less (40% lower) in the DSC shell than that of the MSB shell. Lower residual stresses indicate a lower chance that HIC could be induced in the weld's Heat Affected Zone (HAZ). The RAI response continues:

> *"The weld volume is minimized to reduce overall joint distortion during welding. The joint geometry preparation is specific and based on field experience to eliminate field grinding and fitting and to achieve excellent weld torch access for the tack and root pass operations. The radial gap between the inner top cover (top shield plug, plate 3) and shell is tightly controlled by a combination of rolling and forming and machining of the cover plate. A uniform, known and small inner cover radial gap allows for accurate prediction of the outer cover radial fit-up gap, minimizing the outer cover weld volume, and reducing the skill needed to achieve high quality flaw free outer cover weldments.*

> *"Appropriate specification of shell plate and selection of the welding process are essential. The shell material for such a corner joint should be free of gross laminations. The use of materials not susceptible to laminations or having been inspected to assure lamination free material is important to prevent lamellar tearing of the shell. Specification of ASME Section III, Subsection NB, for plate materials is adequate to detect extensive plate laminations. Additionally, the relatively thin shell plate thickness is less susceptible to laminations during manufacture. Low hydrogen filler material and welding processes will be used to prevent hydrogen embrittlement and cracking. It should be noted that the loading of the TMI-2 fuel is not done in a fuel pool, but, is done in a dry environment, eliminating a significant potential source of hydrogen contamination of the molten weld metal.*
>
> *"The root pass and final layer of the circumferential outer cover weld is liquid penetrant or magnetic particle tested. Ultrasonic examination (UT) was discussed during the RAI review meeting December 10, 1997. UT was discussed in reference to problems with closure welding cracking problems experienced by users of other non-NUHOMS® closure designs. Other welded closure designs do not have the key elements discussed above. These key elements were developed explicitly for the consistent production of high quality closure welds and with multiple surface examinations. UT examination is not appropriate for the closure design detail.*
>
> *"The closure detail will be demonstrated on a scale mock-up of the top end of the DSC prior to production DSC fabrication activities. The mock-up will be sectioned and could be examined for indications of unacceptable weld defects to further demonstrate the flaw-free nature of the closure weld design and welding process."*

DOE-ID did qualify both the manual and automated weld processes used for the DSC closure welds. Mock-ups were conducted and welders were qualified and certified to perform the welds [3.11.202]. In terms of UT of the closure welds, as addressed in the above RAI response, an ASME Code exception to this Non-Destructive Examination (NDE) method is identified in the TMI-2 ISFSI Technical Specifications (UFSAR ASME Code Exceptions Table 4-1) [3.11.148]. No evidence or indications of HIC or other anomalous failures or other unexpected degradation of either the closure welds or HAZs has occurred since the DSCs were closed and loaded into the HSMs. As a result, the initiation of problems as described in CAL-97-001 has not been experienced for the NUHOMS®-12T DSCs and no further action is necessitated in this LRA. Of note, the specific aging mechanism regarding Hydrogen Damage and HIC is addressed in Section 3.4.4.2.13.

3.2.4.2.3 Inspections/AMP Elements

In accordance with TS 1.3.3 of the VSC-24 LRA [3.11.205], the ventilation ducts and annulus of the first VSC-24 cask placed into service at each site are visually examined every 5 years. The primary purpose of these inspections is to check for blockage of the ventilation ducts. However, these periodic examinations also provide a visual indication of the condition of the MSB shell and VCC liner, inlet ducts, and outlet ducts, which are normally inaccessible. According to the LRA, "In general, none of the 5-year inspections showed any significant deterioration of the inspected surfaces."

In Section 3.2.2.2 of the VSC-24 LRA, titled "Condition of MSB Shell," OE experience regarding actual conditions of the MSB shell is provided, as follows:

> *"All 5-year inspections found some discoloration of the coating on the MSB shell, particularly in the region near the top end. In addition, the 5-year inspection of the 1st cask loaded at Palisades identified flaking of the top coat at the top end of the MSB shell, although no flaking of the base coat was observed. The flaking of the top coat and coating discoloration at the top end of the MSB shell resulted from high temperatures in the heat affected zone of the MSB closure welds...The results of the 5-year inspections do not show any evidence of significant corrosion of the MSB shell. Furthermore, as noted in the 5-year inspection reports, the degradation observed on the MSB shell was present in the first 5-year inspection and has not noticeably increased with subsequent inspections. This is consistent with the observations that the coating degradation observed on the MSB shell occurred during the loading operations and is not the result of aging effects during storage."*

In addition, a pre-application inspection was performed on Palisades Cask Number VSC-15 in May 2012. This cask, which was loaded in June 1999, was selected for the initial lead cask inspection primarily because it has the highest initial heat load (14.7 kW) of all loaded VSC-24 casks. The loading timeframe of June, 1999 corresponds well with the first TMI-2 DSC loaded (DOE12T-002) in March, 1999 that was also inspected in 2012 (See Section 3.2.3.1). The VSC-24 inspection included remote visual examination of the MSB shell, inlet air ducts, and outlet air ducts, and visual examination of the VCC cask lid, MSB structural lid, and closure weld. The remote visual examination used a borescope to identify blockage of airflow and degradation of the coated carbon steel surfaces.

Results from the inspections included that no coating degradation or other corrosion was identified on the MSB shell, VCC liner, inlet ducts, or outlet ducts. For the visual examinations, the coating on the MSB structural lid and closure weld was also found to be intact and adhered to the underlying steel, except for two small areas (i.e., a few square inches) of coating that appeared to be blistered or bubbled. The visual examination also did not identify any evidence of crevice corrosion occurring between the top end of the MSB assembly and the VCC shield ring. Upon removal of the temporary shielding used during the inspection, a small area (approximately ½-in. wide by 6-in. long) of coating adjacent to the closure weld was inadvertently scraped off. The coating in the areas that appeared to be blistered or bubbled and in the area that was inadvertently scraped when removing temporary shielding, were both removed to allow further examination of the underlying steel for corrosion. The steel surfaces underneath the small areas of coating that had blistered and underneath the coating that was scraped off did not show any signs of corrosion. The exposed steel surfaces were cleaned and recoated to return them to their original condition.

The conclusions from the inspections are that conditions were as expected and showed normal aging with no deleterious aging effects. Given the similarity in materials (Carbon steel with the zinc-rich coating) and environments (sheltered air ambient), a practical indicator of like conditions on the DSC and DSC support structure SSCs at the TMI-2 ISFSI can be asserted.

In terms of relevance to the DSC AMP, Section 3.4.2.3 of the VSC-24 LRA [3.11.205] describes the AMP for the DSC-equivalent carbon steel components of the VSC-24. In terms of examination frequency, the top end of one VSC-24 cask loaded at each site is visually examined on a 10-year frequency during the PEO, in order to manage loss of material (corrosion) on the coated steel surfaces. This inspection frequency described in Appendix A1 (on the directly accessible outer top cover plate) is more conservative at 5 years since it is coordinated with the 5-year routine seal leak testing. However, the 10-year frequency is applicable in the DSC AMP for the DSC shell and those areas of the DSC inside the HSM that are normally non-accessible, but may be visually examined by remote inspection.

The scope of the VSC-24 examination included a VT-3 visual inspection of all readily accessible surfaces: "VT-3 visual inspection of the steel components may be performed directly, or using long-handled tools and/or remote visual equipment (e.g., borescope/camera), if necessary." These detection techniques and methods are conducted similarly to the DSC inspection standard outlined in Appendix A1. In addition, as is described in the DSC AMP, the VSC-24 AMP uses available information from previous inspections performed during the initial storage period to inform the baseline inspection in the PEO. Other areas of similarity between the two AMPs include that AC in the DSC AMP are more conservative than those outlined in the VSC-24 AMP, and corrective actions in the DSC AMP may also include removing degraded coating, as is the case with the VSC-24 AMP.

3.2.4.3 Summary of Industry Records

In addition to DSS and ISFSI-specific information, relevant regulatory and industry information was reviewed. Relevant OE material was reviewed for any conditions that may address aging effects or AMAs of the TMI-2 ISFSI DSS and its SSCs. Applicable NRC Information Notices, NUREG Reports, and NRC Bulletins are listed in this section. This section provides a bulleted list of some of this industry and regulatory OE, which informed the LRA, including informing the TMI-2 ISFSI AMR portions of the LRA.

NUREGs

The following NUREGs provided fundamental bases to the aging effects discussions in Chapter 3 and were used to inform the AMR for the TMI-2 ISFSI and the in-scope SSCs:

- NUREG-1801, Final Report – GALL Report [3.11.126] was reviewed for concrete performance in a similar environment and function as the HSM Concrete. Typical aging effects identified from "Chapter XI, Aging Management Programs, Section XI.S6, Structures Monitoring", for concrete structures are loss of material, cracking, increase in porosity, and permeability. Typical aging effects identified for steel structures include loss of material due to corrosion.
- NUREG-, Draft Report – MAPS Report [3.11.76] was reviewed for aging effects for the various material and environmental combinations used at the TMI-2 ISFSI, including for the plain carbon steel DSCs, the Portland cement concrete used in the HSMs, and the 304L and 316L stainless steel used in the TMI-2 Canisters. The MAPS report was also used in part to justify exclusion of aging effects of the TMI-2 Canister neutron absorbers in Section 3.8.4.4.

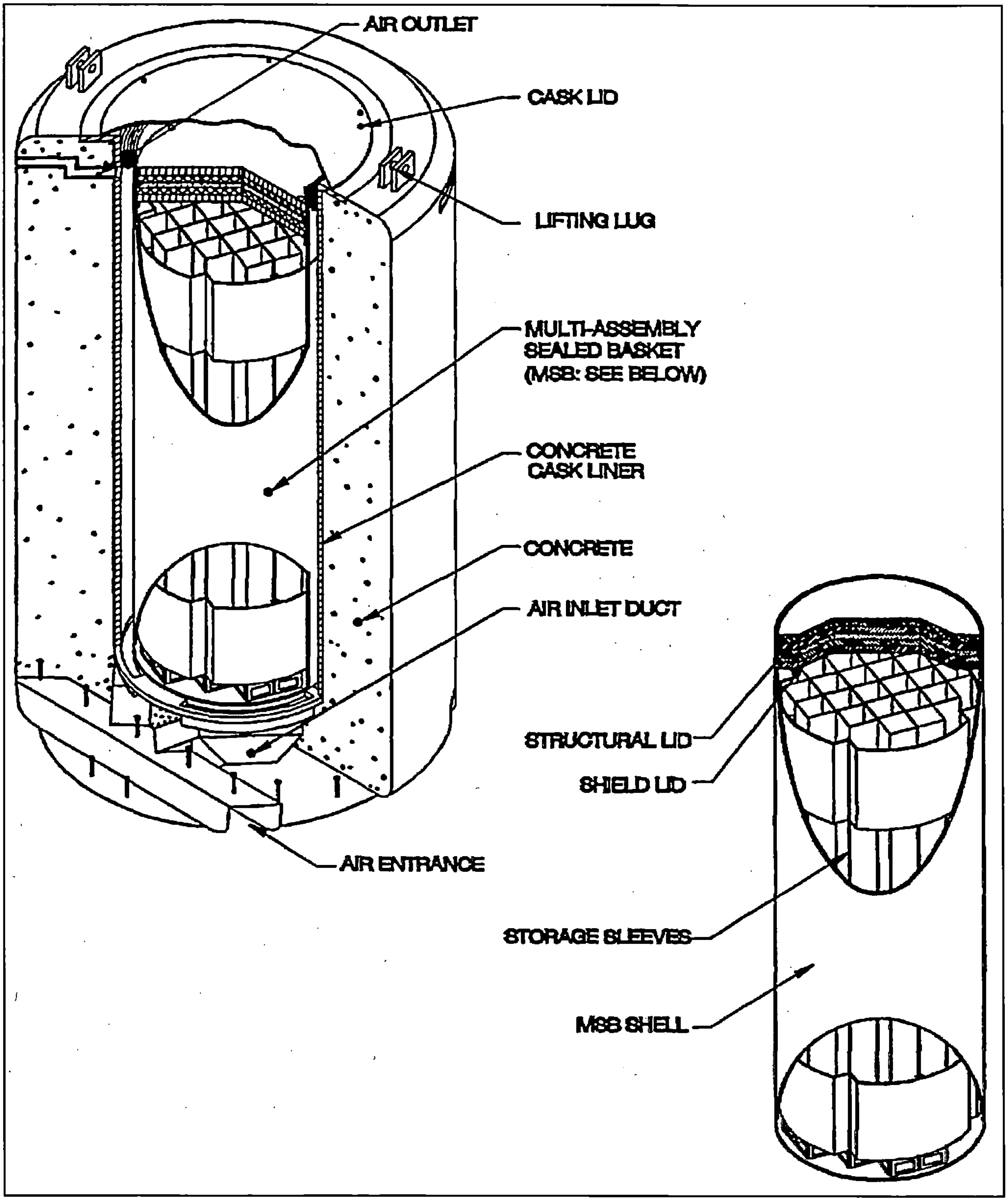

Figure 3-5: VSC-24 System Components [3.11.204]

NRC Information Notices

The following NRC INs were found to be directly related to the TMI-2 ISFSI and the in-scope SSCs:

- NRC Information Notice 2012-20: "Potential Chloride-Induced Stress Corrosion Cracking (CISCC) of Austenitic Stainless Steel and Maintenance of Dry Cask Storage System Canisters" [3.11.193]

  Several failures in austenitic stainless steels have been attributed to CISCC. The components that have failed at nuclear power plants because of this failure mechanism are made from the same types of austenitic stainless steels used to fabricate the TMI-2 Canisters. As described in the IN, this failure mechanism is reproducible in Type 304 and 304L stainless steels, as well as in 316L stainless steels. Failures mentioned in the IN at nuclear power plants occurred in components located near a saltwater body. Section 3.8.3.3 discusses the environmental conditions at the TMI-2 ISFSI and ranks the site conditions in Idaho for likelihood of CISCC initiation and growth and assesses the relationship between CISCC initiation and the proximity of the ISFSI to sources of chloride aerosols. Section 3.8.4.2.5 discusses SCC and specifically CISCC initiation as a postulated aging effect.

- NRC IN 2013-07: "Premature Degradation of Spent Fuel Storage Cask Structures and Components from Environmental Moisture" [3.11.194]

  This IN concerns OE on environmental moisture causing premature degradation of SSCs during storage operations. The instances described in this IN illustrate how the intrusion of water can potentially decrease the effective life of SSCs in a SNF storage system. In one instance, the presence of water not only caused chemical degradation through oxidation of one metal, but it also facilitated the formation of a galvanic cell between two dissimilar metals, which contributed to the degradation of the secondary confinement barrier of the DSS. The specific conditions cited in this case applied only to casks with bolted lids and mechanical seals. For the HSM, water intrusion to the interior is addressed by the installation of a drain for each HSM. Except for the previous freeze-thaw issues on HSM concrete, as detailed below, there has not been OE at the TMI-2 ISFSI to indicate water intrusion as an issue providing deleterious and unanticipated degradation of SSCs. However, visual inspections of the DSC, DSC support structure, HSM interior, and HSM exterior as specified by the AMPs in Appendix A would detect signs of water damage or resultant unexpected and adverse degradation of the TMI-2 ISFSI SSCs.

  IN 2013-07 also cites the OE at the TMI-2 ISFSI concerning freeze-thaw cracking of HSM concrete, indicating the contribution of water accelerating the aging process of the concrete HSMs. As a review of the condition, water entered roof bolt-through holes in the HSMs and when subjected to freezing temperatures, generated mechanical forces that produced cracks in the HSM concrete. These cracks provided additional and larger pathways for water to enter the interior of the concrete, which resulted in larger cracks from subsequent freezing temperatures. If the remedial actions discussed in Section 3.2.3.2.1 had been neglected, this accelerated aging process could have inhibited the ability of the HSM concrete SSCs from performing their intended function of protecting the DSC. The lessons learned from this OE are incorporated into the HSM AMP elements described in Appendix A2.

Industry OE

- MTI Publication No. 27: "Experience Survey Stress Corrosion Cracking of Austenitic Stainless Steels in Water" [3.11.94]

  Case histories of service experience with austenitic stainless steels in water with low levels of chloride ion were collected from interviews with Materials Technology Institute of the Chemical Process Industries, Inc. (MTI) members and from literature sources. Based on data from 273 case histories, service conditions under which CISCC was encountered were defined and several conclusions were made. For instance, the survey presents a CISCC service chart for 304 and 316 stainless steels, analogous to the National Association of Corrosion Engineers (NACE) caustic soda service chart, showing temperature and chloride concentration levels at which SCC was observed in the survey. The chart provides a guideline for a minimum temperature required for initiation of CISCC in austenitic stainless steels at various chloride concentration levels. Such stainless steels as 304L and 316L are used in the TMI-2 Canisters fabrication, in addition to being the material for a few SSCs of the DSC. This chart is similar to that presented in Figure 3-17, which is also noted as Figure 9 of [3.11.94]. An apparent temperature threshold of 60°C was observed for chloride SCC in near neutral waters regardless of chloride concentration, below which cracking probability becomes low. The data from this industry survey was used to help inform the AMR concerning the CISCC aging effect.

NRC Bulletins

- NRC Bulletin 82-02: "Degradation of Threaded Fasteners in the Reactor Coolant Pressure Boundary of PWR Plants" [3.11.135]

  The purpose of the bulletin was to apprise licensees about incidents of severe degradation of threaded fasteners (bolts and studs) in closures in the reactor coolant pressure boundary. The scope of action items in the bulletin was limited to the reactor coolant pressure boundary, but the description in the bulletin helped to inform the AMR in regards to SCC of high-strength bolting material, such as the quenched and tempered ASTM A194, Grade 2H nuts/coupling nuts used as part of the HSM SSCs. Since such extreme temperatures and environments as was the case for the conditions described in the bulletin are not experienced at the TMI-2 ISFSI, the aging effect was found to be non-credible in Section 3.5.4.3.3.

- NRC Bulletin 96-04: "Chemical, Galvanic or other Reactions in Spent Fuel Storage and Transportation Casks" [3.11.206]

  This bulletin addresses the generation of hydrogen due to the reaction of internal materials (including CARBOZINC® 11 steel coatings) with borated spent fuel pool water during loading operations at nuclear utilities (See also Section 3.4.3.4 of [3.11.205]). Although the CARBOZINC® 11 steel coating is used on both the DSC and DSC support structure, the issues in the bulletin regarding oxidation of the coating do not affect the aging conditions of the DSC. The circumstances outlined in the bulletin were a factor in the cracking issues described in Section 3.2.4.2.2 for the VSC-24 closure welds. The TMI-2 DSC SSCs are not impacted due to the TMI-2 Canisters being dried and loaded into the DSCs dry before being placed within the vented TMI-2 DSCs (See Section 3.3.1.2.1). Therefore, no further action is required as part of this LRA to address this industry OE.

3.3 AGING MANAGEMENT REVIEW METHODOLOGY

The AMR follows the methodology recommended in NUREG-1927 [3.11.1]. The AMR provides an assessment of the aging effects that could adversely affect the ability of the SSCs to perform their intended functions during the PEO.

The AMR process involves the following major steps:

- Identification of materials and environments
- Identification of aging effects and mechanisms requiring management
- Determination of the activities required to manage the effects and mechanisms of aging. This involves the identification of TLAAs or AMPs for managing the effects of aging

The scoping evaluation, documented in Chapter 2, identifies the in-scope SSCs for which potential aging effects must be identified and evaluated. The identification of materials and environments for the in-scope SSCs is presented in Section 3.3.1. For each SSC, the materials of construction and the environment to which each SSC is exposed are determined. The SSC environments are determined based on the location of the SSC within the DSS. Once the SSC material/environment combinations are determined, potential aging effects requiring management are determined (Section 3.3.2). Engineering literature, related research and industry information, and existing OE from Section 3.2 are reviewed to identify expected aging degradation mechanisms for different material and environmental combinations. As stated in Section 3.1, after the potential aging effects are identified, it is determined which activities (Section 3.3.3) the effects are addressed by, either by analysis (TLAA or other engineering evaluation), or by developing an AMP.

3.3.1 Identification of Materials and Environments

(NUREG-1927, Section 3.2 and Section 3.4.1.1)

The first step in the AMR process is to identify the materials of construction for each subcomponent of the in-scope SSCs and the environments to which those materials are exposed during normal storage conditions. The combinations of materials and environments are used to identify the potential aging effects that require management during the PEO, as covered in Section 3.3.2.

3.3.1.1 Materials

The TMI-2 ISFSI SSCs and associated subcomponent materials of construction are summarized in Table 3-4 on a component-by-component basis. The materials of construction were identified through a review of the drawings provided in the UFSAR and the design drawings identified in Chapter 2, along with other pertinent design information as necessary. Additional information regarding materials of the in-scope SSCs is included in Sections 3.4.2, 3.5.2, 3.7.2, and 3.8.2 for the DSC, HSM, Basemat and Approach Slab, and TMI-2 Canister, respectively.

3.3.1.2 Environments

The environments to which SSCs and associated subcomponents are exposed play a critical role in the determination of potential aging effects and mechanisms. A review of the information presented in Chapter 2 of the UFSAR [3.11.2] was performed to assess the environmental conditions to which the SSCs are normally exposed. The environments to which the TMI-2 SSCs are exposed are affected by the characteristics of the TMI-2 ISFSI site environment, as well as by the SSC location within the storage system. The SSC service environments are listed in Table 3-4. For any SSC subcomponents that were located partially in two or more environments, these are listed in Table 3-4 with each individual environment separated by a forward slash.

The environments considered in the AMR are the environments that the TMI-2 ISFSI SSCs and associated subcomponents normally experience. Environmental stressors that are conditions not normally experienced (such as extreme cold), or that may be caused by a design or fabrication condition, are considered event driven and are not aging related. Such event-driven situations would be evaluated and corrective actions, if any, implemented at the time of the event.

The geographic location of the TMI-2 ISFSI is north 43°-34'-13" latitude, west 112°-56'-56" longitude. The area where the ISFSI is located consists of the high, dry, and mostly flat Snake River Plain between mountain ranges in Southeastern Idaho. All air masses entering the Snake River Plain must first cross several mountain barriers, precipitating a large percentage of their moisture. Annual rainfall at the ISFSI is light, and the region has semiarid characteristics. Wind directions at INTEC (the TMI-2 ISFSI site) are mostly from the northeast or southwest quadrants due to airflow channeling by the bordering mountains. According to Section 2.3.1.2 of the UFSAR, the average wind speed for the 20-ft elevation is 7.5 miles per hour (mph), with greatest hourly average wind speed of 51 mph having occurred during the winter or early spring [3.11.2]. This relates to the total height of the HSM at 14-ft 6-in. The largest mean daily temperature range for the TMI-2 ISFSI is 38°F in July through August (Table 2.3.7 of the UFSAR [3.11.2]). Additional TMI-2 ISFSI site characteristics relative to the environmental conditions are summarized from UFSAR Sections 1.1.3 and 2.3.1, including:

- Average Monthly Temperature Extremes:
  - Maximum: 87°F (July)
  - Minimum: 4°F (January)
- Annual Precipitation:
  - Average: 8.71 in. (Note: < 10 in. rain/year classified as a desert [3.11.154])
  - Highest: 14.40 in.
  - Lowest: 4.50 in.
  - Average Yearly Snowfall: 26 in.
- Frost Depth: 5 ft
- Atmospheric Conditions (See Figure 3-7 for graph of typical year):
  - During January (the coldest month), the temperature averages 16.5°F and the dew point averages 7.4°F
  - During July (the hottest month), the temperature averages 69.0°F and the dew point averages 33.5°F
  - Average relative humidity ranges from 30% in July to 70% in February (Table E-3 of [3.11.74])

The INTEC facility shown in Figure 3-2 is designated as an exclusion area for SNF storage and high-level waste storage and processing. The ISFSI location is remote and away from major population centers, waterways, and interstate transportation routes. The shortest distance from the ISFSI to the INL Site boundary is 8.5 miles to the south. According to Section 2.1.3 of the UFSAR [3.11.2], the nearest populated area to the INL Site boundary is Atomic City, population about 30, located approximately 1 mile from the southern boundary of the INL Site, and about 11 miles from the TMI-2 ISFSI. The isolated ISFSI location was chosen to assure maximum public safety. The INL Site has no residents, and ingress and egress of site personnel for performance of their duties and visiting personnel on official business is strictly controlled. INTEC is a restricted area occupying 120 acres. Figure 3-2 shows the orientation of various buildings at INTEC along with the location of the TMI-2 ISFSI pad [3.11.2], although many of these buildings no longer exist.

The configuration of the TMI-2 ISFSI consists of an array of individual concrete monolith HSM storage modules, which provide protection against extreme seasonal weather conditions. This includes heavy precipitation, drifting snow, hail and ice storms, lightning strikes, strong winds, wind driven missiles, and blowing dust.

In accordance with Sections 2.4.2.2 and 2.7 of the UFSAR [3.11.2], the following summarizes environmental site conditions, which relate to the environmental conditions at the TMI-2 ISFSI:

- The TMI-2 ISFSI is designed to withstand temperature extremes of 103°F to -50°F.
- The TMI-2 ISFSI is designed for the maximum snow load of 30 psf.
- The TMI-2 ISFSI is designed to be at or above the PMF elevation of 4,917 feet.[2]
- The TMI-2 ISFSI is designed to withstand the Region III tornado (200 mph) with NUREG-0800 tornado generated missile [3.11.3].
- The TMI-2 ISFSI is designed to withstand a 0.36g horizontal seismic acceleration earthquake.

The TMI-2 ISFSI site atmosphere is within a remote environment that is not subject to potentially corrosive industrial gases. Processes in the surrounding areas of INTEC include ventilation systems exhausting through HEPA filters to minimize contamination, evaporators that utilize steam heat to concentrate liquid waste, and a planned high-level-waste treatment facility that will reduce liquid nitrates to elemental nitrogen. The area does not adjoin any roadways, although gas and diesel-powered vehicles occasionally pass nearby. No airborne contaminants are expected from the surrounding Snake River Plain except for windblown dust. The trivial amount of emissions released by vehicles occasionally passing near the ISFSI does not produce consistent levels of nitrogen or sulfur oxides to increase measurably corrosion rates within the HSMs.

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[2] The design basis maximum flood elevation for the TMI-2 ISFSI reported in Section 3.2.2 of the TMI-2 ISFSI FSAR is 4,917 feet. A Bureau of Reclamation (BOR) study performed in 2005 (Big Lost River Hazard Study) includes information that could change the ISFSI flood elevation previously analyzed in the TMI-2 ISFSI design and licensing basis. The flood elevation reported in the 2005 BOR study for a DOE regulated facility near the TMI-2 ISFSI is 4,917.48 feet. This calculated maximum flood level is approximately six inches higher than that reported in the TMI-2 ISFSI and the original TMI-2 ISFSI Environmental Report. A Deficiency Report has been initiated to identify the discrepancy in the corrective action program to 1) determine the purpose of the 2005 BOR report and 2) evaluate the need for actions pertaining to the TMI-2 ISFSI design and licensing basis. Any resulting impacts on the LRA and/or ER Supplement will be evaluated and communicated to the NRC, as appropriate.

Deicing compounds, such as road salt are disallowed within the ISFSI boundary. The nearby graveled areas are also not salted. The nearest paved area, approximately 50 yards west of the TMI-2 ISFSI, may be graveled and salted after being plowed. However, this is only performed in the winter when average wind speeds are low and snow and ice immobilize the salt, making windblown transmission to the ISFSI low. However, it should be noted that per the EPRI Report 3002005371 [3.11.37] wind conditions are an unranked factor in the ISFSI ranking for likelihood of CISCC initiation and growth on stainless steel casks. The reasons for this according to the EPRI report are: (1) that an investigation comparing the wind conditions at a National Oceanic and Atmospheric Administration (NOAA) monitoring site to the weekly chloride aerosol measurements for a co-located Clean Air Status and Trends Network (CASTNET) site did not reveal a strong correlation, and (2) the geographic criterion better captures the effects of infrequent but significant weather events (i.e., strong storms). Refer to Section 3.8.3.3 describing the above EPRI report regarding ranking of ISFSI sites with respect to CISCC susceptibility and how the TMI-2 ISFSI chloride environment is considered the lowest possible ranking (i.e., negligible effect).

Five basic environments apply for the TMI-2 NUHOMS®-12T System SSCs:

- Outdoor (ISFSI HSM exterior elements, Basemat and Approach Slab) – During storage, only the exterior surfaces of the HSM/End Shield Walls along with Basemat and Approach Slab are subjected to the INL Site ambient conditions. Exposure includes all weather conditions, including insolation, wind, rain, snow, ambient temperatures, and humidity. Specifically, elements of the HSM, including the outer portions of the Vent/Purge Port Rear Access Door, Front Shielded Door, and Roof Bolt Protective Covers are exposed to the Outdoor Environment.
- Sheltered (HSM interior, DSC exterior, DSC support structure) – The Sheltered Environment is a protected ambient environment with no direct exposure to sun, wind, or precipitation, although SSCs in the Sheltered Environment may receive these conditions intermittently during hydrogen sampling. The Sheltered Environment may receive small amounts of windblown rain through the vent holes in the rear access door of the HSM (See Section 3.5.3). Otherwise, the only moisture is from humidity brought in due to diffusion and diurnal pressure and temperature fluctuations. The temperature inside the HSM depends on the ambient air temperature and to a much lesser extent the heat load of the loaded DSC. The Sheltered Environment on the DSC shell exterior surface may range from ambient air temperature to just above ambient (as shown in Table 3-3). To a lesser magnitude than those of the Internal DSC Environment, SSCs exposed to the Sheltered Environment (interior side of the HSM walls, HSM steel, and DSC external shell assembly SSCs) are exposed to neutron and gamma radiation fields. However, radiation sources are stable or decreasing over the PEO and consequent decay heat loads remain low or decrease over the PEO. These are described in Sections 3.3.1.2.2 and 3.3.1.2.3, respectively.
- Internal DSC (DSC interior, TMI-2 Canister exterior) – The Internal DSC Environment is that located within the DSC annular cavity. The TMI-2 Canister exterior elements, the inside surfaces of the DSC shell, and interior shell assembly subcomponents (e.g., inner top and bottom cover plates and top shield plug) are exposed to the Internal DSC Environment. This environment communicates with the Sheltered Environment via a combination of four HEPA filters on the DSC Vent Port and the single HEPA filter on the DSC Purge Port. The ventilation and off gas system for the NUHOMS®-12T storage system is completely passive and is designed to allow diffusion of hydrogen from the DSC through the HEPA filter vents (source and history of hydrogen source discussed in greater detail in Section 3.3.1.2.1).

This environment experiences neutron and gamma fluence higher than the Sheltered Environment, as described in detail in Section 3.3.1.2.2. The environment within the DSCs is nearly ambient since it is vented and decay heats within are low (See Section 3.3.1.2.3). As indicated in Table 3-3, maximum temperatures are less than 90°F, and temperatures within some DSCs are considered equivalent to average outside temperatures due to their low decay heat. The main characterization of this environment is that for large swings in the site ambient temperature (e.g., case of several cold days followed by several warmer, humid days), the minimum DSC shell temperature may be below the dew point temperature because the DSC is slow to adjust to a rapid increase in air temperature, suggesting a mode for condensation formation. As shown in Figure 3-7, any condensation formation would be seasonally limited to approximately early December to the middle of March when the dew point temperature remains close to the air temperature, with a chance for the DSC shell temperature to drop below that of the dew point temperature. For this reason, DSCs with higher decay heat loads may not be as prone to condensation formation compared with DSCs with lower core debris decay heat loads. The effect of the decay heat load on the internal DSC temperatures is described in Section 3.3.1.2.3. A discussion regarding the hydrogen and oxygen concentrations is provided in Section 3.3.1.2.1. Annual hydrogen sampling measurements since 2004 indicate that on average, approximately 0.04% hydrogen is being observed within the DSC Internal Environment (See Figure 3-6). This is an order of magnitude less when compared with the LCO 3.2.3 limit of 0.5%.

- Internal TMI-2 Canister (i.e., TMI-2 Canister interior) – The Internal TMI-2 Canister Environment is that located within the TMI-2 Canister annular cavity and is described in more detail in Section 3.8.3.2. This environment is even more protected from outdoor ambient conditions than either the Sheltered or Internal DSC Environments. The TMI-2 Canister interior elements (i.e., the inside surfaces of the TMI-2 Canister shell and other internal TMI-2 Canister SSCs) are exposed to the Internal TMI-2 Canister Environment. It is a very similar environment to the Internal DSC Environment. Exceptions with the Internal DSC Environment are minor, but include that it is exposed to slightly higher temperatures (See Table 3-3) and higher neutron and gamma fluence. This is described in Sections 3.3.1.2.3 and 3.3.1.2.2, respectively. In addition, a more thorough discussion regarding the hydrogen and oxygen concentrations is included in Section 3.3.1.2.1.
- Embedded or Encased – This environment applies for materials that are embedded or encased (i.e., sealed) inside another material. These include rebar and anchorage embedded in the HSM concrete, DSC bottom shield plug encased between the inner and outer cover plates, BORAL® neutron poison material enclosed between the inner and outer skin on the TMI-2 Fuel Canister, and Boron Carbide pellets encased in the TMI-2 Knockout and TMI-2 Filter Canister poison rod tubes. Embedded or Encased Environments are exposed to radiation. The heat load from the TMI-2 core debris radioactive source decreases over the PEO.

Additional information regarding environments of the in-scope SSCs is included in Sections 3.4.3, 3.5.3, 3.7.3, and 3.8.3 for the DSC, HSM, Basemat and Approach Slab, and TMI-2 Canister, respectively.

3.3.1.2.1 Hydrogen and Oxygen Environment

The purpose of this section of the LRA is to elaborate on the gas composition conditions of the TMI-2 ISFSI given its design bases in the UFSAR [3.11.2]. This is necessary to clarify the internal gas composition within the DSC during the PEO. This is service conditions that the SSCs normally experience in their environments as defined in Section 3.3.1.2, specifically, Sheltered, Internal DSC, and Internal TMI-2 Canister Environments. This is to ensure conformity with Section 3.4.1.1 of NUREG-1927 [3.11.1], with respect to "gas compositions", expounding on the "pertinent environmental data…which has a direct bearing on aging and the proposed aging management approach."

The TMI-2 core debris is stored in three types of TMI-2 Canisters as described in the UFSAR [3.11.2] and Section 3.8 of this LRA. Besides the TMI-2 core debris fuel rubble, there is some filter material (diatomaceous earth in the TMI-2 Filter Canisters) and shoring materials in the TMI-2 Fuel canisters. In the TMI-2 Fuel Canisters, the shoring consists of a clad lightweight concrete termed Licon. During the original design considerations for the TMI-2 ISFSI, the internal TMI-2 core debris and other shoring material were considered to have the potential of trapping some water. Although water removal from undamaged material and other materials has been demonstrated by pulling and holding vacuums for a variety of times, the issue of water of hydration in the Licon left some uncertainty about the removal of all water from the TMI-2 Fuel Canister and the ability to control hydrogen in the DSC during dry storage. In addition, the TMI-2 reactor core was in its first cycle of operation and had operated for a short period at the time of the accident. As such, the residual decay heat of the TMI-2 core debris is relatively small and therefore the heat was considered unlikely to dry the TMI-2 Canisters adequately prior to dry storage. In addition, based on the low radiation fluence, the alpha and beta energy of the TMI-2 core debris is relatively small when compared to typical SNF, resulting in a reduced probability of water radiolysis. This was evaluated as shown by the equation on page C.4 of the UFSAR [3.11.2], and at PEO initiation, with reduced radioactive decay energy, will produce an even lower gas generation rate than the UFSAR values indicate.

Two approaches were taken to address the issue of potential hydrogen production within the DSC. The first approach was demonstrating removal of the water and the second was to design a DSC vent system to control the buildup of any hydrogen to be less than 10% of the explosive limit of 5% [3.11.148]. To be conservative, a DSC HEPA venting and filtration system with the capability of sampling releasable DSC gases was designed using bounding cases. For maximizing radiolysis, two assumptions were made: 1) Using TMI-2 Canisters containing the greatest amount of radioactive material and 2) Using the maximum expected void volume within the TMI-2 Canisters, sufficient water was available for absorbing all the energy. These assumptions were exceedingly conservative, since the TMI-2 Canisters were to be dewatered and dried. Shown in Appendix C of the UFSAR [3.11.2] is an evaluation of the vent system, demonstrating its ability to maintain low levels of hydrogen within the TMI-2 Canisters, using only diffusion as the driver for the hydrogen to outflow.

The TMI-2 Canisters were dewatered at TAN prior to drying. Dewatering was simply a blow down process that caused most of the bulk water to be forced out of the drain tubes [3.11.152]. A few pounds to several gallons or more of water may have remained after dewatering. In order to ensure that the water was near-completely removed from the TMI-2 Canisters prior to storage in the DSCs, a heated vacuum drying system was designed providing for vaporization of the remaining water within the TMI-2 Canister. Due to the low decay heat and the known presence of the Licon, a vacuum furnace was used for drying all of the TMI-2 Canisters. By pulling a low vacuum and holding the drying temperatures over 700°F for a period of time [3.11.155], it was demonstrated that not only were the TMI-2 Canisters dried, but also much of the bound water of hydration from the Licon could be driven off [3.11.5] (See Section 3.8.4.5).

With negligible water to act as a source for the radiolysis and, as stated earlier, minimal decay energy to produce hydrogen, detection of very little hydrogen was expected in the vents. This fact has been demonstrated via performance of the TS hydrogen sample-monitoring program, with measured hydrogen levels being low and constant, despite the decay of the radioactive source term. Hydrogen in the Internal DSC Environment is monitored according to TS LCO 3.2.3 [3.11.113]. Monitoring is performed using procedure TPR-7066 [3.11.48]. The procedure was written in accordance with the UFSAR and consistent with EDF-3736 [3.11.49], which describes how the sampling is to be performed. Hydrogen monitoring is performed using a combustible gas detector, which only operates in the presence of oxygen. The detector is therefore equipped with a sensor to measure the oxygen concentration as well. The oxygen concentration is documented to ensure the hydrogen measurement is valid. The detector is calibrated for hydrogen and oxygen prior to testing using hydrogen-air samples.

Sampling using the described equipment and procedures was performed from 2004 onwards, well after the DSCs were loaded into the HSMs in 1999-2001. Before 2004, a combustible gas monitor was also used, but the detector was not checked using hydrogen. The detector was calibrated using methane, which produces a different response for a given hydrogen concentration (EDF-2566) [3.11.50]. In 2002, hydrogen concentrations in S/N DOE12T-001 were measured above the allowable LCO 3.2.3 limit of 0.5%. Upon investigation, the detector sensor was found to have failed. For these reasons, the hydrogen concentration trends described in this LRA are represented only from 2004 onward.

Appendix C of the UFSAR [3.11.2] assumed that oxygen was also generated by radiolytic decomposition of water in stoichiometric quantities to the hydrogen. Therefore, the TMI-2 Canister oxygen concentration should be greater than its atmospheric concentration in the vented DSC, as is the case for hydrogen. If corrosion is the most important hydrogen generation mechanism, then the oxygen will be consumed as it oxidizes metal, instead of being generated from radiolysis. However, UFSAR Appendix C did not consider the effect of dewatering and drying the TMI-2 Canisters, which reduced the fuel water content from several thousand liters when the hydrogen generation rates were measured, to a maximum calculated value of 2.3 liters following drying [3.11.5]. As shown in Figure 3-6, the actual presence of hydrogen, as measured from annual samples of the DSCs, indicates a steady-state production of approximately 0.04% hydrogen from 2004-2014, with a very slight decline in the trend. Figure 3-6 shows the average DSC hydrogen concentrations obtained from annual monitoring performed according to [3.11.48]. The 3-year rolling average of these concentrations is trended, with the estimated average DSC hydrogen concentration obtained by performing least squares regression of the rolling average yearly values with year.

Given radioactive decay, the radiolysis portion goes down, and the corrosion portion is constant or unaffected. Appendix C of the UFSAR makes the following statement in this regard:

> *"The canisters were manufactured from stainless steel and will not be subjected to a corrosive environment while in dry storage. The core materials are not expected to significantly corrode when subjected to ambient atmospheric conditions. The fuel itself is uranium dioxide and is, thus, already oxidized. In summary, corrosion is not expected to provide a hydrogen source term that is significant relative to the hydrogen source term from radiolysis."*

However, this statement assumes that the DSC itself does not produce hydrogen from chemical processes such as sacrificial zinc coating oxidation in a conductive aqueous environment. Therefore, to be conservative for aging conditions, this LRA assumes all of the hydrogen coming from within the Internal DSC Environment is because of corrosion processes within the DSCs.

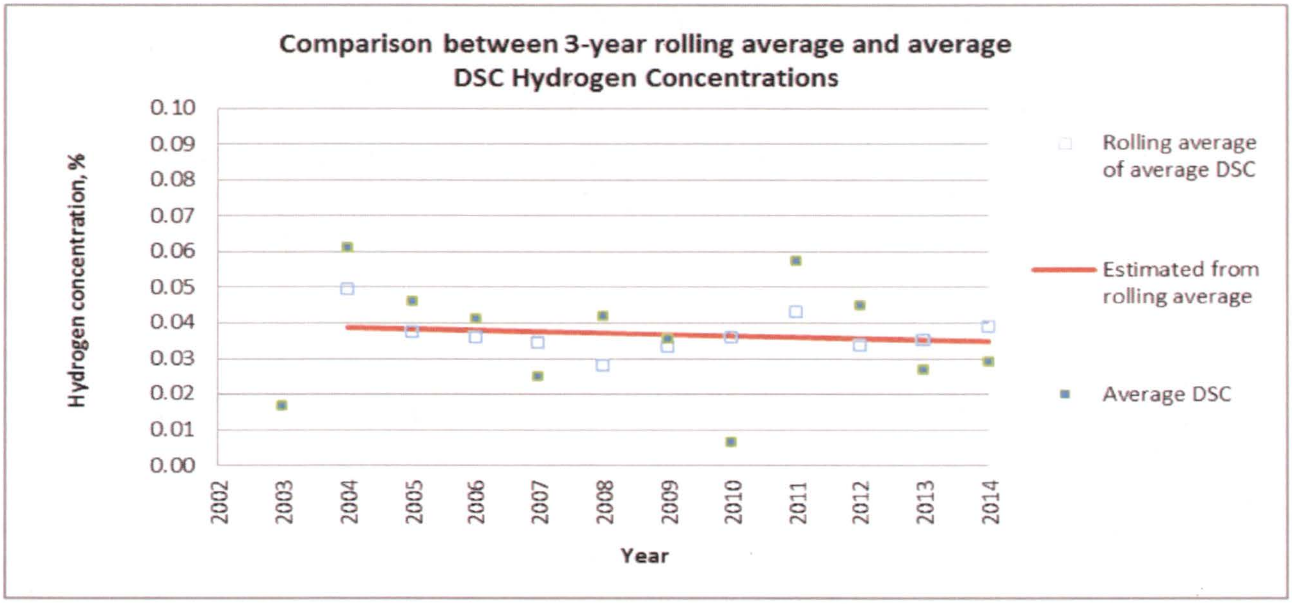

Figure 3-6: Comparison between 3-Year Rolling Average and Annual Average DSC Hydrogen Concentrations (2004-2014)

The maximum total amount of water available within the TMI-2 Canister interior is very small particularly when compared with the ~186 liter internal volume of the TMI-2 Canister. EDF-1466 predicted a maximum unbound moist air volume of 0.17 liters post heated-vacuum drying [3.11.5]. In addition, there is a possibility of water vapor being reintroduced into the TMI-2 Canister over the dry storage period. EDF-797 [3.11.104] predicted a maximum of 0.9 liters of water possibly reintroduced as unbound water vapor over the 40-year storage period. Not including the reacquired water content, as described in EDF-1466, 2.3 liters of water is considered the maximum allowed TMI-2 core debris water content (both bound and unbound). With the reacquired water content included, the total water volume within the TMI-2 Canister is 3.2 liters after the 40-year licensing period.

3.3.1.2.2 TMI-2 ISFSI Radiation Environment

The purpose of this section of the LRA is to elaborate on the radiological service conditions of the TMI-2 ISFSI given its design bases in the UFSAR [3.11.2]. This is necessary to clarify the PEO radiation conditions, both gamma and neutron, that the SSCs normally experience in their environments as defined in Section 3.3.1.2, specifically, Sheltered, Internal DSC, and Internal TMI-2 Canister Environments. This is to ensure conformity with Section 3.4.1.1 of NUREG-1927 [3.11.1], with respect to "radiation field (gamma and neutron)", expounding on the "pertinent environmental data...which has a direct bearing on aging and the proposed aging management approach."

The total irradiation time of the ISFSI SSCs will be 40 years at the end of the PEO (i.e., 20 years for the original license period plus 20 years for the PEO). Of note, as stated in Section 1.3.1, the ISFSI design basis lifetime according to the UFSAR is 50 years [3.11.2]. The reactor accident occurred in 1979; the first TMI-2 Canisters were loaded in November 1985; the first shipments to INL commencing in July 1986 [3.11.6]; with the first DSC loaded in March 1999. This is a gap of approximately 14 years since the TMI-2 Canisters were loaded with TMI-2 core debris and when they were first stored at the TMI-2 ISFSI. Therefore, the steel in the TMI-2 Canisters has experienced an additional 14 years of irradiation when compared to the DSC or HSM, yielding a total of 54 years (i.e., 14+40). To be conservative, an irradiation time of 60 years is used when analyzing all SSCs for adverse radiation effects except the TMI-2 Canisters, which are evaluated for a gamma irradiation time of 74 years, with source terms as described below.

A radial model of the TMI-2 Fuel Canisters within an HSM is developed using Monte Carlo N-Particle (MCNP) Transport Code, providing neutron and gamma energy depositions in the SSCs [3.11.24] integrated over a 60-year timeframe. Axial radiation effects are neglected in the model for simplicity because the maximum flux and radiation exposure is typically at the sides rather than the ends. Both gamma and neutron sources are considered and are obtained from Table 7.2-1 and 7.2-2 of the UFSAR [3.11.2]. Both source terms represent decay from the time of the Three Mile Island accident until the predicted date that the DSCs would be loaded into the ISFSI (March, 1979 to March, 1998), a 19-year timespan. As such, this decay time represents the approximate loading date of the HSMs to time of the accident. The design basis source term in UFSAR Section 7.2.1 uses the most bounding payload of any type of TMI-2 Canister and is indicative of the source terms in the TMI-2 Fuel, Filter, and Knockout Canisters. The design basis source term is based on core attributes such as burnup, initial enrichment, and specific power. In addition, a maximum bounding TMI-2 Canister payload mass of 1,908 pounds is assumed in the design basis source term determination.

The 1998 bounding source term includes a gamma source and two neutron sources as discussed in the reference calculation [3.11.24]. For the gamma source, an additional 14 years of gamma irradiation caused by exposure to an initially stronger source (1985 decayed source term) is calculated separately in [3.11.24] and is conservatively added to the cumulative gamma dose accrued over the entire 60 years for a total 74-year exposure period. This is an added level of conservatism for the gamma irradiation timeframe. Whereas, the neutron irradiation time of 60 years includes the initial 14-year TMI-2 Canister loading period and is used in the evaluation. As stated in Section 5.0 of [3.11.24], this is justified for both 1998 bounding neutron sources since the sources remains relatively constant with time from 1985 to 1998.

Material compositions for the TMI-2 core debris 'fuel', stainless steel, and concrete used in the MCNP models are obtained from the original UFSAR shielding calculation [3.11.157]. The DSC, HSM, and TMI-2 Canister are configured in the radiation effects calculation [3.11.24]. Analyses are conducted for the distributed design basis neutron and gamma sources and a localized Am-Be-Cm neutron source. From the analyses, the localized Am-Be-Cm neutron fluence is much higher than the fluence computed using the design basis distributed source model.

The radiation effects analysis [3.11.24] includes a second set of MCNP models created to include the internals (i.e., Licon and stainless steel BORAL® shroud) of the TMI-2 Fuel Canister. With the more detailed TMI-2 Fuel Canister, energy deposition/fluence in the TMI-2 Fuel Canister is computed. The model determines postulated radiation deposition in the stainless-steel BORAL® shroud and Licon. The energy deposition provided by the neutron fluence is updated for the DSC and HSM SSCs only with the localized Am-Be-Cm design basis source, because it bounds the results in the first MCNP model for the distributed design basis source. For simplicity, only the inner stainless steel shroud and Licon are explicitly modeled. The radiation damage of the inner shroud bounds the outer shroud because it is closer to the source material. The BORAL® plates are not explicitly modeled because, as stated in Section 1.3.4, radiation embrittlement of BORAL® is not a concern. However, in Section 3.8.4.4, the reported energy deposition/fluence on the inner shroud is compared with limits described in [3.11.76] for BORAL®. Because, as described in Section 3.8.2.2, the water composition of the Licon is not known precisely, the models are run for four different water compositions: (1) no water, (2) half of the nominal water content, (3) nominal water content, and (4) twice the nominal water content.

As was the case with the MCNP model without internals, a gamma source and two neutron source terms are considered in the analyses. Consistent with the results without internals, the TMI-2 Fuel Canisters located in the inner region of the DSC have greater energy deposition/fluence values than those in the outer region of the DSC. It is observed that the mass of water in the Licon has little effect on the gamma energy deposition.

For the gamma source in the second MCNP model (with internals), the maximum absorbed energy in the stainless-steel BORAL® shroud is 1.96×10^9 rad and for the Licon is 1.61×10^9 rad with the half nominal water content. The computed gamma energy deposition with the first MCNP model (without internals) is 1.98×10^8 rad for the HSM concrete, 4.42×10^8 rad for the DSC shell and 2.00×10^9 rad for the TMI-2 Canister shell. In addition, the dose rates at the beginning of the PEO are determined in Appendix B of [3.11.24] using a 40-year source term. For the gamma source in the first MCNP model (without internals), the computed energy disposition in the stainless-steel shell for the average TMI-2 Canister is 1520 rad/hr with the maximum individual TMI-2 Canister being 1745 rad/hr. For the gamma source in the second MCNP model (with internals), the computed energy disposition in the stainless-steel BORAL® shroud for the average TMI-2 Canister is 1566 rad/hr with the maximum individual TMI-2 Canister being 1693 rad/hr. Of note, the values for the TMI-2 Canister with internals are with no water content in the Licon, because no water in the Licon yields the highest dose rates.

For the neutron calculations with the distributed design basis source, the fluence shows a clear increase as the water density in the Licon is reduced. Because water acts as a neutron shield, less water may result in more neutron interactions between TMI-2 Fuel Canisters. As reported in [3.11.24] for the results with internals included, the total neutron fluence in the stainless-steel BORAL® shroud and Licon is 8.98×10^{11} neutrons/cm^2 and 8.92×10^{11} neutrons/cm^2, respectively. In addition, the total neutron fluence in the TMI-2 Canister and DSC shell exterior surfaces without internals are 9.23×10^{11} neutrons/cm^2 and 5.67×10^{11} neutrons/cm^2, respectively. The neutron fluence in the HSM concrete for the distributed source without internals is 5.49×10^{11} neutrons/cm^2.

However, the distributed design basis neutron source is bounded by the localized Am-Be-Cm design basis source. With the localized Am-Be-Cm design basis source, results are maximized with twice the nominal water density. As reported in [3.11.24], the total neutron fluence ($E > 0$ MeV) in the stainless-steel BORAL® shroud is 1.77×10^{15} neutrons/cm^2 while the total neutron fluence in the Licon is 9.83×10^{14} neutrons/cm^2. The total neutron fluence in the TMI-2 Canister and DSC shell exterior surfaces is 5.06×10^{14} neutrons/cm^2 and 1.98×10^{14} neutrons/cm^2, respectively. The neutron fluence in the HSM concrete for the localized source is 2.90×10^{13} neutrons/cm^2.

3.3.1.2.3 TMI-2 ISFSI Thermal Environment

The purpose of this section of the LRA is to elaborate on the thermal-based service condition of the TMI-2 ISFSI given its design bases in the UFSAR [3.11.2]. This is necessary to clarify the PEO temperature conditions that the SSCs normally experience in their environments as defined in Section 3.3.1.2, specifically, Sheltered, Internal DSC, and Internal TMI-2 Canister Environments. This is to ensure conformity with Section 3.4.1.1 of NUREG-1927 [3.11.1], with respect to "temperature," expounding on the "pertinent environmental data…which has a direct bearing on aging and the proposed aging management approach."

The thermal analysis described in Chapter 8 of the UFSAR is intended to estimate maximum temperatures for conservatively evaluating structural conditions during accidents. The purpose of the original thermal analysis is to maximize the internal DSC and TMI-2 Canister temperatures and temperature gradients by way of conservative modeling techniques. This approach is deemed valid since the solution to the coldest case, a steady-state analysis with no heat load, is trivial. It would leave the HSM and its contents at the lowest temperature possible and with no thermal gradient. As an example of a conservative modeling assumption and realizing the HSM cavity is not air-tight, air infiltration from the HSM access opening door and HEPA filter door is neglected in the thermal analysis and hence, any convection around the DSC shell is also ignored. Small insignificant factors, such as changes in emissivity due to corrosion, may be omitted from modeling. As the TMI-2 DSS ages, corrosion of the zinc-coated surfaces may gradually result in a small change in the emissivity, which results in a trivial effect on radiative heat transfer. The heat load of the TMI-2 DSS also decreases over time due to radioactive decay. Any negative effect on radiative heat transfer would be due to an increase in emissivity; but this increase will be countered by a reduction in the heat load, resulting in an overall negligible change in resultant temperatures.

The analyzed temperatures from this model are used to envelope normal, off-normal, and accident conditions in Chapter 8 of the UFSAR. From Table 1 of the GPU Calculation C-9000-915-E530-001 [3.11.30], the TMI-2 Knockout Canister identified as K506 had the highest TMI-2 Canister decay heat of any of the TMI-2 Canisters at 60 Watts in 1999 (with the peaking factor discussed below). The UFSAR thermal analysis added a 133% factor on the 60 Watts value to come to an 80-Watt maximum limiting TMI-2 Canister decay heat load. Based on the thermal load profiles of the 12 hottest TMI-2 Canisters in 1999, the UFSAR thermal analysis predicts a maximum heat load in a DSC at 649 Watts (Table 4-1 of [3.11.55]). A bounding heat load of 860 Watts was chosen for the thermal model for the NUHOMS®-12T design, bounding the 649 Watts DSC heat loading. From this decay heat loading, the bounding maximum predicted HSM concrete temperatures at the beginning of storage in 1999 are 128.7°F and 155.4°F for normal and off-normal conditions, respectively. These are considered acceptable bounding environmental limits for the HSM and its SSCs, noting temperatures will be substantially less than this due to the actual maximum decay heat loading described below. These temperatures will continue to decrease from PEO initiation through the end of the PEO.

In order to establish a bounding thermal environment for potential degradation mechanisms on the DSC and TMI-2 Canisters for the PEO, a thermal model that includes average decay heat loads is described based on the UFSAR source term input data. This is conservative because a lower decay heat reduces the material temperatures and, therefore, increases the likelihood that humidity will condense in or on the DSC, possibly leading to corrosion. The HSM, DSC, and TMI-2 Canisters have similar air environments. However, the temperature varies according to storage location. The stored TMI-2 core debris in the TMI-2 Canister generates heat by radioactive decay that is transferred passively from the HSM. Therefore, the TMI-2 core debris temperature is higher than the TMI-2 Canister temperature, which is higher than the DSC temperature, which is higher than the HSM temperature.

Temperatures are also affected by airflow due to temperature and pressure variations imposed by the surrounding Outdoor Environment. Due to the prevailing nature of winds from the Southwest, the Southwest HSMs are estimated to have more air infiltration than the more protected HSMs to the North and East (EDF-4550) [3.11.31]. As discussed below, a thermal model that incorporates conditions that are more realistic provides an assessment of bounding seasonal and diurnal temperatures for the TMI-2 Canister and DSC SSCs. These would be environmental stressors that the SSCs normally experience, that are not event driven or extreme environmental conditions. In addition, this thermal environment evaluation provides temperature conditions at the initiation of the PEO for both the Internal DSC Environment and that of the Internal TMI-2 Canister Environment.

In 2004, DOE-ID performed a thermal analysis (EDF-3908) [3.11.32] which provides a more detailed temperature calculation that included the daily temperature variation of the HSM, DSC, TMI-2 Canisters, and TMI-2 core debris, using monthly averaged daily weather conditions measured at the INL Site as input to the analysis. The [3.11.32] thermal analysis consists of two parts. In the first part, average weather conditions for each month of the year are used to calculate the daily variation in average temperature of the DSC, TMI-2 Canisters, and TMI-2 core debris. These results were used to estimate the extent of temperature fluctuations within the DSC and TMI-2 Canisters. In the second part, the same calculation is performed using a specific weather condition that is most likely to cause condensation: several cold days followed by several warmer, humid days. In this case, the daily variation in minimum temperature of the DSC and TMI-2 Canister is calculated and compared to the dew point temperature to assess the likelihood of condensation.

Finite Element heat transfer software was used as part of [3.11.32] to obtain detailed numerical calculations of transient temperatures in the HSM, DSC, and TMI-2 Canister. The effect of convection to the air inside and outside the HSM is modeled using empirical heat transfer correlations. This thermal analysis was used to establish relationships between the temperature of the DSC shell, TMI-2 Canister shell, TMI-2 core debris, and ambient air. Air infiltrates the HSM and heat transfer occurs by free convection between the air and DSC shell and by radiation between the DSC shell and HSM walls. Daily variations of ambient air temperature lead to fluctuations in the temperature of the DSC, TMI-2 Canister, and TMI-2 core debris.

EDF-3908 presents the results of the analysis as contour plots of temperature at various times during the day. EDF-3908 also contains tables of the average temperatures for: air, DSC shell, TMI-2 Canister shell, and TMI-2 core debris over selected months of the year. As part of the assumptions in [3.11.32], each TMI-2 Canister generates 12 Watts of heat. EDF-3908 applies this heat load uniformly over the DSC inner shell, similar to the original UFSAR, Section 8.1.3 thermal analysis. The results of the finite element simulation of DSC shell temperatures in [3.11.32] were used to calculate the TMI-2 Canister and core debris daily temperature variation. Using an average TMI-2 Canister decay heat of 12 Watts, the maximum steady-state TMI-2 Canister shell temperature in [3.11.32] is approximately 4°F - 5°F higher than the average DSC shell temperature.

In order to correlate and bound these heat loading results to the internal heat generated at the initiation of the PEO in 2019, a review of the decay heat generation in a TMI-2 Canister is compared to that used in [3.11.32] (i.e., 12 Watts /TMI-2 Canister). First, a review of the payload weights was undertaken. General Public Utilities (GPU) calculation C-9000-915-E530-001 [3.11.30] is used as a source for the TMI-2 Canister payload weights. This is the same source used for UFSAR, Section 8.1.3 "Thermal Hydraulic Analysis" and the hydrogen gas generation and transport evaluation in Appendix C of the UFSAR [3.11.2]. From Table 1 of [3.11.30] (except that TMI-2 Fuel Canister S/N D-153 is not stored at the ISFSI), each of the TMI-2 Canisters payload weights was determined. With this data and ISFSI loading forms for each of the TMI-2 Canisters identifying which DSC/HSM they were loaded into, the "Total Core Debris Weight" in Table 3-2 was determined. The lowest payload is in HSM-16 with 24 pounds of core debris, while the highest total payload is in HSM-24 with 18,439 pounds of core debris. As shown in Table 3-2, the total core debris weight stored at the ISFSI is 306,307 pounds. For clarity purposes, this is slightly lower than the 306,653 pounds of core debris shipped from TMI-2 to INL in the 1980s as was identified in Section 1.3 [3.11.33]. The difference of 346 pounds recognizes that INL used some of the TMI-2 core debris for research purposes [3.11.56] and was never stored at the ISFSI.

Next, an assessment of the decay heat load and activity levels for the various source term nuclides was conducted by reviewing the sources for the UFSAR thermal analyses. According to [3.11.30], each of the TMI-2 Canister decay heat loadings are based on a heat loading value of 0.017 Watts per pound TMI-2 core debris from GPU Nuclear Calculation 6612-96-021 [3.11.29]. From Attachment 5-1 of [3.11.29], the percentages of total energy available from all charged particle type radiations is calculated based on an average TMI-2 Fuel Canister weighing 1,100 pounds. This data is shown reproduced in Table 3-1, with the 1,100-pound payload TMI-2 Fuel Canister in 1996 generating approximately 18.64 Watts of decay heat. As shown in Table 3-1, through radioactive decay this average TMI-2 Canister heat loading reduces to approximately 11.47 Watts by 2019 at the initiation of the PEO. As a result, by 2019, the heat loading value is reduced to 0.010 Watts per pound core debris (or 61.55% of the original 18.64 Watts total as shown in Table 3-1).

From this data, Table 3-2 was generated based on the actual loading of the HSMs/DSCs, with decay heat loading in Watts reported. The TMI-2 Canister decay heat was multiplied by the same peaking factor of 1.9 used in the UFSAR Section 7.2.1, "Characterization of Sources", and Section 8.1.3.2 "Thermal Analyses of the DSC Inside the HSM." The peaking factor of 1.9 accounts for the variation between core average fuel assembly burnup and peak fuel assembly burnup. Because the payload core debris weight multiplied by 0.017 Watts /pound (for 1996) yields a TMI-2 Canister heat load for one containing 'average' core debris, this peaking factor is conservative in that it accounts for the hypothetical case where a TMI-2 Canister's contents consisted of the highest decay heat fuel debris. Table 3-2 indicates that theoretical DSC decay heat loads in 1996 could have ranged from zero Watts in HSM-16 to 594 Watts in HSM-24. This range has since declined due to radioactive decay and in 2019 at the beginning of the PEO; the DSC decay heat is estimated to range from zero Watts in HSM-16 to 365 Watts in HSM-24.

As stated earlier, the decay heat flux used in [3.11.32] was 12 Watts /TMI-2 Canister, or 144 Watts /DSC, which is greater than the estimated average DSC decay heat load of 11.47 Watts in 2019 (Table 3-1). The heat flux of 144 Watts in [3.11.32] was for 12 TMI-2 Canisters each weighing 843 pounds, which equates to a specific heat loading of 0.014 Watts /pound per DSC, which is higher than the 0.010 Watts /pound (for 2019). However, [3.11.32] did not include a peaking factor in the evaluation, which reduces the reported temperature results. Adjusting for the higher specific heat loading using the 1,100-pound average TMI-2 Canister payload, the 144 Watts average DSC decay heat flux equates to 185 Watts (1,100 pounds x 0.014 Watts /pound) which is comparable with the Table 3-2 average DSC heat loading with and without peak loading of 110 and 209 Watts, respectively. However, in all cases the DSC heat loading is low with the maximum DSC S/N DOE12T-011 (HSM-24) having a predicted heat load of 365 Watts in 2019 considering the maximum predicted peaking factor. Therefore, [3.11.32] is regarded as a representative assessment of the average DSC decay heat loads on resultant temperatures for the DSC shell, TMI-2 Canister shell, and TMI-2 core debris at the initiation of the PEO.

Temperatures of the DSC containing the maximum fuel content (HSM-24) were obtained from [3.11.32] values by using Newton's Law of cooling (Equation 2.34 of Reference [3.11.47]), which states that the (steady state) temperature rise in a given body emitting heat is proportional to the rate of heat dissipated for a given configuration ($\dot{Q}=h \times A \times \Delta T$), where $\dot{Q}$ is the net rate of heat transfer, h is the heat transfer coefficient, A is the surface area and ΔT is the change in temperature between the surface and ambient surrounding air. Newton's law is used because the ISFSI heat transfer configuration is the same and the resulting temperature is on par with the [3.11.32] values, thus correlating with the heat transfer properties used in [3.11.32]. Since the decay heat is proportional to the fuel load, maximum temperatures were calculated from the temperatures computed in [3.11.32] by multiplying the temperature increases (from ambient) given in Table 3-3 by the ratio of the maximum fuel content in HSM-24 (See Table 3-2) divided by the fuel content used in [3.11.32], or 1.82 (1537 pounds/843 pounds = 1.82). Average DSC shell, TMI-2 Canister shell and TMI-2 core debris temperatures in 1996 that were calculated in [3.11.32] are shown in Table 3-3. As an example, the DSC maximum shell temperature in January 1996 is determined as follows:

$$\Delta T \times 1.82 + T_{air} = (T_{DSC\_avg} - T_{air}) \times 1.82 + T_{air} = (23.4°F - 18.6°F) \times 1.82 + 18.6°F = 27.4°F$$

The same relation was used to estimate maximum storage temperatures in 2019. Radiological decay will reduce storage temperatures in 2019 to approximately 62% of the values in 1996 according to Table 3-1. As an example, the DSC maximum shell temperature in January 2019 is determined as follows:

$$\Delta T \times 0.62 + T_{air} = (T_{DSC\_max} - T_{air}) \times 0.62 + T_{air} = (27.4°F - 18.6°F) \times 0.62 + 18.6°F = 24.1°F$$

Shown in Table 3-3 are the projected temperatures for the TMI-2 core debris, TMI-2 Canisters, and DSC shell at the PEO initiation in 2019. These temperature estimates are based on the mean daily average air temperatures for January, April, July, and October per [3.11.32]. While maximum seasonal temperatures varied due to the difference in decay heats, the diurnal temperature variations do not, since they depend only on the heat transfer model and on the seasonal atmospheric temperatures.

3.3.2 Identification of Aging Effects Requiring Management

(NUREG-1927, Section 3.2 and Section 3.4.1.2)

After the SSC material/environment combinations are determined, potential aging management effects are determined. As was stated in Section 3.1, engineering literature, relevant OE, and other industry literature is reviewed to identify expected aging degradation mechanisms for different materials and environments.

Aging effects are the manifestation of aging mechanisms. In order to manage an aging effect directly, it is necessary to determine the aging mechanisms that are potentially at work for a given material and environment combination. Therefore, the AMR process identifies both the aging effects and the associated aging mechanisms that cause them. Some aging mechanisms are only applicable at certain conditions such as high temperature or moisture. Each identified aging mechanism is characterized by a set of applicable conditions that must be met for the mechanism to occur. Given this evaluation process, each SSC subcomponent was evaluated to determine if the potential aging effects and mechanisms were credible considering the various material/environment combinations.

The potential aging effects and mechanisms that were considered for the TMI-2 ISFSI were primarily based on DOE-ID OE, EPRI reports, NUREG documents, Standardized NUHOMS® OE, and nuclear industry OE. Each of the relevant aging effects and mechanisms evaluated and determined applicable for each of the in-scope SSCs for the DSC, HSM, Basemat and Approach Slab, and TMI-2 Canister are covered in Sections 3.4.4, 3.5.4, 3.7.4, and 3.8.4, respectively. A summary of applicable aging effects/mechanisms is shown in Table 3-5.

3.3.3 Identification of the AMAs Required to Manage the Effects of Aging

(NUREG-1927, Section 3.2, Section 3.4.1.3, Section 3.5 and Section 3.6)

A summary of the AMAs relevant to applicable aging effects and mechanisms for each of the in-scope SSCs for the DSC, HSM, Basemat and Approach Slab, and TMI-2 Canister are covered in Sections 3.4.5, 3.5.5, 3.7.5, and 3.8.5, respectively. TLAAs required for addressing the aging effects of in-scope SSCs at the TMI-2 ISFSI are summarized in Appendix B. Other analyses included within the context of the LRA are not TLAAs by definition but support the AMR (e.g., excluding an aging mechanism or effect or showing that an aging effect does not need to be managed). These are addressed on an individual basis for the in-scope SSCs for the DSC, HSM, Basemat and Approach Slab, and TMI-2 Canister in Sections 3.4.4, 3.5.4, 3.7.4, and 3.8.4, respectively. The TC is separately addressed in Section 3.6. Secondarily, for those SSCs not covered by a TLAA or another supporting engineering evaluation, AMPs are developed as required for managing the effects of aging on the in-scope SSCs affected. As appropriate, an AMP was created to summarize the activities implemented to monitor and manage the aging effects. The DSC AMP credited for managing the effects of aging degradation on impacted DSC SSCs is presented in Appendix A1. The HSM AMP credited for managing the effects of aging degradation on impacted HSM SSCs is presented in Appendix A2. A summary of applicable AMAs is shown in Table 3-5.

Table 3-1: Radioactive Decay for Average Loaded Canister (1,100 pounds fuel debris) with Corresponding Activity and Decay Energy Results (1996 to 2019)

Nuclides[1]	Activity- 1996 (Curies/ gram)[2]	Grams/ Canister (Average 1,100-pound fuel debris)[3]	Activity- 1996 (Curies)	Decay Heat Load per unit mass- 1996 (Watts/ gram)[4]	Decay Heat Load-1996 (Watts)	Activity- 2019 (Curies)	Decay Heat Load- 2019 (Watts)
Am-241	2.49E-05	498952	12.42	8.13E-07	4.08E-01	11.97	3.93E-01
Ba-137m	1.02E-03	498952	508.93	3.85E-07	1.98E+00	299.17	1.17E+00
C-14	1.34E-07	498952	0.07	3.93E-11	1.96E-05	0.07	1.96E-05
Cd-113m	1.01E-06	498952	0.50	1.11E-09	5.54E-04	0.17	1.86E-04
Co-60	1.37E-05	498952	6.84	7.78E-09	1.06E-01	0.33	5.14E-03
Cs-134	1.13E-06	498952	0.56	1.08E-09	5.72E-03	0.00	2.50E-06
Cs-137	1.07E-03	498952	533.88	1.06E-06	5.29E-01	313.84	3.11E-01
Eu-152	1.85E-07	498952	0.09	1.36E-10	6.99E-04	0.03	2.16E-04
Eu-154	1.29E-05	498952	6.44	2.09E-08	5.84E-02	1.01	9.16E-03
Eu-155	1.58E-05	498952	7.88	3.98E-08	2.27E-02	0.32	9.13E-04
Fe-55	9.75E-06	498952	4.86	1.82E-10	1.39E-04	0.01	3.02E-07
H-3	2.81E-05	498952	14.02	9.47E-10	4.73E-04	3.84	1.29E-04
Nb-94	1.08E-07	498952	0.05	9.40E-11	5.50E-04	0.05	5.49E-04
Ni-59	4.05E-07	498952	0.20	1.04E-11	8.03E-06	0.20	8.03E-06
Ni-63	4.47E-05	498952	22.30	4.54E-09	2.27E-03	18.76	1.90E-03
Pa-234m	1.93E-07	498952	0.10	9.42E-10	4.77E-04	0.00	0.00E+00
Pm-147	2.77E-04	498952	138.21	1.02E-07	5.09E-02	0.32	1.16E-04
Pu-238	6.03E-06	498952	3.01	1.96E-07	9.80E-02	2.51	8.17E-02
Pu-239	7.53E-05	498952	37.57	2.30E-06	1.15E+00	37.55	1.15E+00
Pu-240	2.00E-05	498952	9.98	6.12E-07	3.05E-01	9.95	3.05E-01
Pu-241	5.88E-04	498952	293.38	1.82E-08	9.08E-03	96.99	3.00E-03
Rh-106	1.30E-07	498952	0.06	1.09E-09	6.24E-04	0.00	0.00E+00
Ru-106	1.30E-07	498952	0.06	7.73E-12	3.86E-06	0.00	5.40E-13
Sb-125	4.96E-06	498952	2.47	2.87E-09	7.78E-03	0.01	2.47E-05
Sm-151	7.99E-05	498952	39.87	9.37E-09	4.68E-03	33.40	3.92E-03
Sr-90	4.15E-03	498952	2070.65	4.82E-06	2.40E+00	1197.37	1.39E+00
Tc-99	9.80E-07	498952	0.49	4.81E-10	2.40E-04	0.49	2.40E-04
Te-125m	1.22E-06	498952	0.61	8.99E-10	5.75E-04	0.00	1.67E-47
Th-234	1.93E-07	498952	0.10	6.82E-11	3.92E-05	0.00	5.14E-110
U-234	1.02E-06	498952	0.51	2.89E-08	1.44E-02	0.51	1.44E-02
U-238	1.93E-07	498952	0.10	4.81E-09	2.40E-03	0.10	2.40E-03
Y-90	4.16E-03	498952	2075.64	2.30E-05	1.15E+01	1200.26	6.64E+00
Zr-93	1.47E-07	498952	0.07	1.70E-11	8.48E-06	0.07	8.48E-06
Total					18.64		11.47
Fraction of original "remaining"							61.55%

1-Ba-137m is the daughter product of Cs-137, and Y-90 is the daughter product of Sr-90.
2-Taken from GPU Calc 6612-96-021 [3.11.29] Attachment 5-1 (# Curies/Gram)
3-Taken from GPU Calc 6612-96-021 [3.11.29] Attachment 9-1 (Gram/TMI-2 Canister)
4-Taken from GPU Calc 6612-96-021 [3.11.29] Attachment 5-1 (Alpha/beta/electron) and Attachment 15-1 (gamma/x-ray) (Watts/Gram)

Table 3-2: HSM TMI-2 Core Debris Weights and Decay Energy Reduction (1996 to 2019)

HSM No.	Number of TMI-2 Canisters Stored	Total Core Debris Weight (pounds)	Average Core Debris Weight (pounds/TMI-2 Canister)	Theoretical DSC Heat Load - 1996 (Watts)	Theoretical DSC Heat Load with Peaking Factor - 1996 (Watts)	DSC Heat Load - 2019 (Watts)	DSC Heat Load with Peaking Factor - 2019 (Watts)
HSM-1	9	12463	1385	211	401	130	247
HSM-2	12	7368	614	125	237	77	146
HSM-3	12	8758	730	148	282	91	174
HSM-4	12	6515	543	110	210	68	129
HSM-5	12	5306	442	90	171	55	105
HSM-6	12	12164	1014	206	392	127	241
HSM-7	12	7958	663	135	256	83	158
HSM-8	12	12882	1074	218	415	134	255
HSM-9	12	12508	1042	212	403	130	248
HSM-10	12	15568	1297	264	501	162	308
HSM-11	12	15058	1255	255	485	157	298
HSM-12	12	15044	1254	255	484	157	298
HSM-13	12	12781	1065	217	412	133	253
HSM-14	12	7714	643	131	248	80	153
HSM-16	8	24	3	0	1	0	0
HSM-17	12	8157	680	138	263	85	162
HSM-18	12	13235	1103	224	426	138	262
HSM-19	12	11459	955	194	369	120	227
HSM-20	12	11558	963	196	372	121	229
HSM-21	12	9708	809	165	313	101	192
HSM-22	12	11311	943	192	364	118	224
HSM-23	12	7155	596	121	230	75	142
HSM-24	12	18439	1537	312	594	192	365
HSM-25	12	12931	1078	219	416	135	256
HSM-26	12	14872	1239	252	479	155	295
HSM-27	12	10366	864	176	334	108	205
HSM-28	12	3734	311	63	120	39	74
HSM-29	12	9527	794	161	307	99	189
HSM-30	12	11744	979	199	378	122	233
Total	341	306307				Average = 110	Average = 209

Table 3-3: DSC Shell, TMI-2 Canister Shell and TMI-2 Core Debris Fuel Temperatures (estimated from [3.11.32])

Month	**Mean daily average air temperature (°F) [3.11.32]**	**DSC Shell**			
		Average temperature (°F) ([3.11.32], Table 7)	**Maximum temperature (°F) year 1996 (estimated from [3.11.32])**	**Maximum temperature (°F) year 2019**	**Average temperature °(F) year 2019**
January	18.6	23.4	27.4	24.1	21.6
April	42.6	47.8	52.1	48.5	45.9
July	69.2	73.20	76.5	73.8	71.7
October	42.3	47.70	52.2	48.5	45.7
Month	**Mean daily average air temperature (°F) [3.11.32]**	**TMI-2 Canister Shell**			
		Average temperature (°F) ([3.11.32], Table 8)	**Maximum temperature (°F) year 1996 (estimated from [3.11.32])**	**Maximum temperature (°F) year 2019**	**Average temperature (°F) year 2019**
January	18.6	27.4	34.7	28.6	24.1
April	42.6	51.1	58.1	52.2	47.9
July	69.2	76.2	82.0	77.1	73.6
October	42.3	51.0	58.2	52.2	47.7
Month	**Mean daily average air temperature (°F) [3.11.32]**	**TMI-2 Core Debris 'Fuel'**			
		Average temperature (°F) ([3.11.32], Table 8)	**Maximum temperature (°F) year 1996 (estimated from [3.11.32])**	**Maximum temperature (°F) year 2019**	**Average temperature (°F) year 2019**
January	18.6	28.3	36.3	29.6	24.6
April	42.6	52.0	59.8	53.3	48.4
July	69.2	77.0	83.4	78.0	74.1
October	42.3	51.9	59.8	53.1	48.3

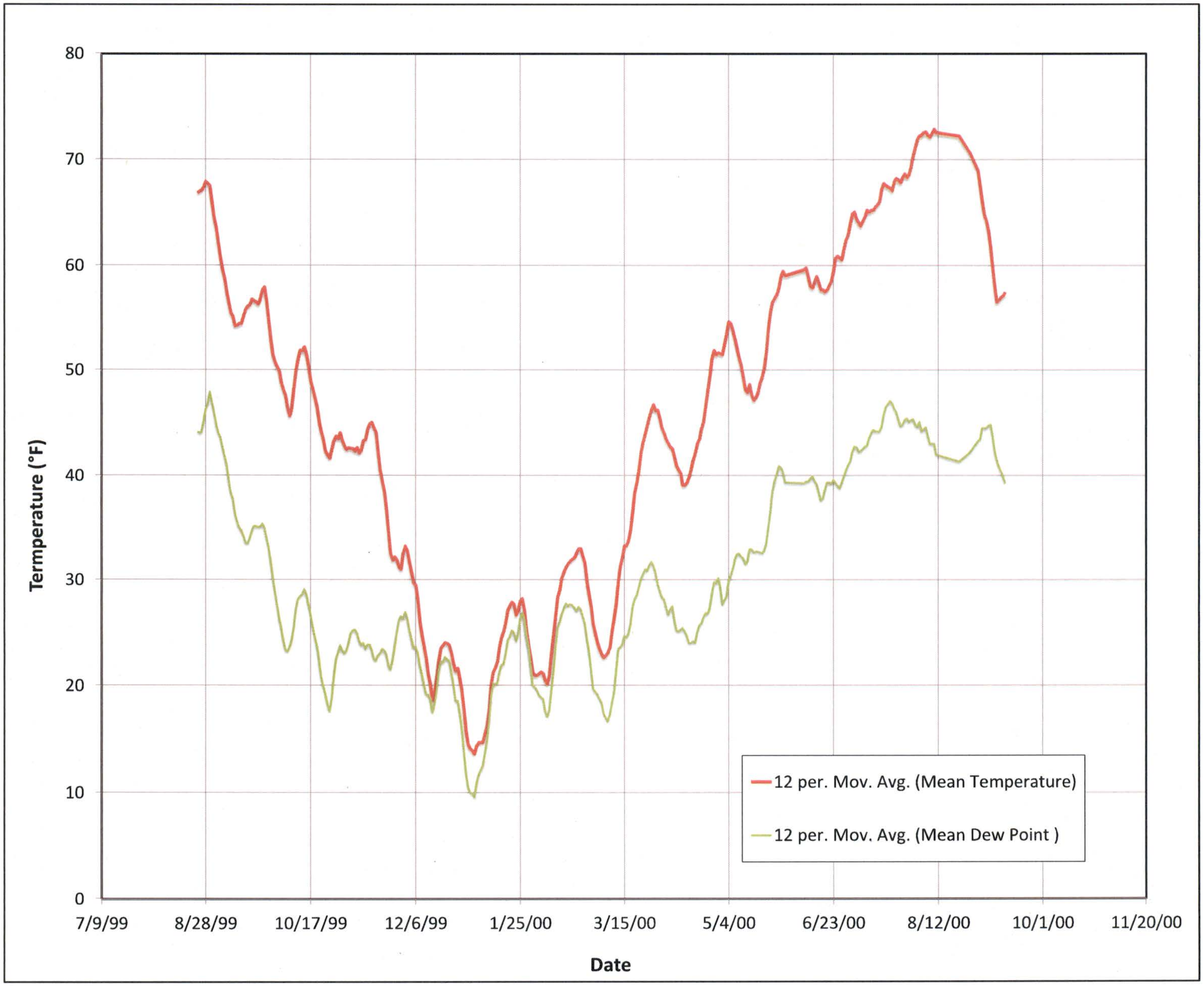

Figure 3-7: Graph of Typical Idaho Falls Average Temperatures and Dew Points during a Calendar Year from 1999-2000

Table 3-4: Identification of Materials and Environments for In-Scope SSC Components

Drawing Number	Component	Item Num.	Item Description	Drawing Material/ Item Identification Callout	Materials	Service Environments
DRY-SHIELDED CANISTER (DSC)						
219-02-1000	DSC BASKET ASSEMBLY	1	SPACER DISC, 1 1/4" PLATE	ASTM A516, GR 70	CARBON STEEL	INTERNAL DSC
219-02-1000	DSC BASKET ASSEMBLY	2	TOP SPACER DISC, 1 1/4" PLATE	ASTM A516, GR 70	CARBON STEEL	INTERNAL DSC
219-02-1000	DSC BASKET ASSEMBLY	3	SUPPORT ROD, Ø 1-1/2" ROD	ASTM A36	CARBON STEEL	INTERNAL DSC/ENCASED
219-02-1000	DSC BASKET ASSEMBLY	4	PIPE SLEEVE – LONG, 2.00 NPS SCHEDULE 80	ASTM A333, GR 1	CARBON STEEL	INTERNAL DSC
219-02-1000	DSC BASKET ASSEMBLY	5	PIPE SLEEVE – SHORT, 2.00 NPS SCHEDULE 80	ASTM A333, GR 1	CARBON STEEL	INTERNAL DSC
219-02-1000	DSC BASKET ASSEMBLY	6	END SLEEVE	ASTM A36	CARBON STEEL	INTERNAL DSC
219-02-1001	DSC SHELL ASSEMBLY	1	CYLINDRICAL SHELL, 5/8" PLATE	ASME SA-516, GR 70	CARBON STEEL	SHELTERED/ INTERNAL DSC
219-02-1001	DSC SHELL ASSEMBLY	2	OUTER BOTTOM COVER	ASME SA-516, GR 70	CARBON STEEL	SHELTERED/ ENCASED
219-02-1001	DSC SHELL ASSEMBLY	3	BOTTOM SHIELD PLUG	CARBON STEEL, 30,000 POUNDS/IN^2 (PSI) MINIMUM YIELD OR ASTM A36	CARBON STEEL	ENCASED
219-02-1001	DSC SHELL ASSEMBLY	4	GRAPPLE RING, 1" PLATE	ASME SA-516, GR 70	CARBON STEEL	SHELTERED
219-02-1001	DSC SHELL ASSEMBLY	5	GRAPPLE RING SUPPORT, 3/4" PLATE	ASME SA-516, GR 70	CARBON STEEL	SHELTERED
219-02-1001	DSC SHELL ASSEMBLY	6	INNER BOTTOM COVER 3/4" PLATE	ASME SA-516, GR 70	CARBON STEEL	INTERNAL DSC/ ENCASED
219-02-1002	DSC BASKET-SHELL ASSEMBLY	5	SUPPORT RING 3/4" PLATE	ASME SA-516, GR 70	CARBON STEEL	INTERNAL DSC
219-02-1002	DSC BASKET-SHELL ASSEMBLY	6	VENT PORT SHIELD BLOCK, 1-3/4" PLATE	ASME SA-516, GR 70	CARBON STEEL	INTERNAL DSC
219-02-1003	DSC MAIN ASSEMBLY	2	TOP SHIELD PLUG, PLATE 3 1-1/4" THICK PLATE	ASME SA-516, GR 70	CARBON STEEL	INTERNAL DSC/ ENCASED
219-02-1003	DSC MAIN ASSEMBLY	3	TOP COVER PLATE	ASME SA-516, GR 70	CARBON STEEL	SHELTERED/ ENCASED
219-02-1003	DSC MAIN ASSEMBLY	4	PURGE PORT BLOCK	CARBON STEEL, CARBON STEEL FY ≥30 KSI	CARBON STEEL	INTERNAL DSC
219-02-1003	DSC MAIN ASSEMBLY	9	TOP SHIELD PLUG PLATE 1 & 2	ASTM A516, GR 70 OR A36	CARBON STEEL	INTERNAL DSC
219-02-1010	DSC PURGE PORT FILTER ASSEMBLY	1	FILTER HOUSING	ASME SA-516, GR 70	CARBON STEEL	SHELTERED/ INTERNAL DSC
219-02-1010	DSC PURGE PORT FILTER ASSEMBLY	5	HEPA TYPE FILTER W/GASKET	"SUPPLIED BY OTHERS"	STAINLESS STEEL WITH ELASTOMERIC (NEOPRENE) SEAL	SHELTERED/ INTERNAL DSC
219-02-1010	DSC PURGE PORT FILTER ASSEMBLY	10	DUAL C-SEALS, EG & G PRESSURE SCIENCE (FILTER HOUSING)	METALLIC OR ELASTOMERIC	INCONEL X-750 OR EPDM ELASTOMER	INTERNAL DSC
219-02-1010	DSC PURGE PORT FILTER ASSEMBLY	14	SCREW, CAP SOCKET HD, 1/2 - 13 UNC - 2A X 0.75" LONG	ASME SA-193, GR B8	STAINLESS STEEL	ENCASED/ INTERNAL DSC
219-02-1010	DSC PURGE PORT FILTER ASSEMBLY	16	SCREW, CAP SOCKET HD, 1 – 8 UNC – 2A X 3.00" LONG	ASME SA-193, GR B8	STAINLESS STEEL	SHELTERED
219-02-1010	DSC PURGE PORT FILTER ASSEMBLY	20	DUAL C-SEALS, EG&G PRESSURE SCIENCE	METALLIC	INCONEL X-750	INTERNAL DSC
219-02-1010	DSC PURGE PORT FILTER ASSEMBLY	22	LOCK WASHER	CARBON STEEL OR STAINLESS STEEL	CARBON STEEL OR STAINLESS STEEL	SHELTERED/ INTERNAL DSC

Table 3-4: Identification of Materials and Environments for In-Scope SSC Components

Drawing Number	Component	Item Num.	Item Description	Drawing Material/ Item Identification Callout	Materials	Service Environments
219-02-1011	DSC VENT PORT FILTER ASSEMBLY	1	FILTER HOUSING	ASME SA-516, GR 70	CARBON STEEL	SHELTERED/ INTERNAL DSC
219-02-1011	DSC VENT PORT FILTER ASSEMBLY	5	HEPA TYPE FILTER W/GASKET	"SUPPLIED BY OTHERS"	STAINLESS STEEL WITH ELASTOMERIC (NEOPRENE) SEAL	SHELTERED/ INTERNAL DSC
219-02-1011	DSC VENT PORT FILTER ASSEMBLY	10	DUAL C-SEALS, EG & G PRESSURE SCIENCE (FILTER HOUSING)	METALLIC OR ELASTOMERIC	INCONEL X-750 OR EPDM ELASTOMER	INTERNAL DSC
219-02-1011	DSC VENT PORT FILTER ASSEMBLY	14	SCREW, CAP SOCKET HD, 1/2 - 13 UNC - 2A X 0.75" LONG	ASME SA-193, GR B8	STAINLESS STEEL	ENCASED/ INTERNAL DSC
219-02-1011	DSC VENT PORT FILTER ASSEMBLY	16	SCREW, CAP SOCKET HD, 1 – 8 UNC – 2A X 3.00" LONG	ASME SA-193, GR B8	STAINLESS STEEL	SHELTERED
219-02-1011	DSC VENT PORT FILTER ASSEMBLY	20	DUAL C-SEALS, EG&G PRESSURE SCIENCE	METALLIC	INCONEL X-750	INTERNAL DSC
219-02-1011	DSC VENT PORT FILTER ASSEMBLY	22	LOCK WASHER	CARBON STEEL OR STAINLESS STEEL	CARBON STEEL OR STAINLESS STEEL	SHELTERED/ INTERNAL DSC
Fabrication Specification 219-02-107 [3.11.35]	DSC ASSEMBLY	N/A	WELD FILLER METAL	WELD FILLER METAL COMPATIBLE WITH SA-516, GRADE 70	CARBON STEEL	SHELTERED/ INTERNAL DSC
Fabrication Specification 219-02-107 [3.11.35]	DSC ASSEMBLY	N/A	INORGANIC ZINC-RICH COATING	CARBOZINC® 11 OR CARBOZINC® 11 HS	ZINC-RICH INORGANIC COATING	SHELTERED/ INTERNAL DSC
HORIZONTAL STORAGE MODULE (HSM)						
219-02-5100	HSM ISFSI GENERAL ARRANGEMENT	5100-203	BOLT, 3/4-10 UNC-2A X 2" LONG	ASTM A193 GRADE B7, ASTM A325, OR ASTM A490; HEX OR HEAVY HEX PER ANSI B18.2.1; ZINC-COATED	CARBON, CARBON/BORON, OR ALLOY STEEL	OUTDOOR
219-02-5100	HSM ISFSI GENERAL ARRANGEMENT	5100-301	NUT, 1 1/8-7 UNC-2B	ASTM A194 GRADE 2H OR ASTM A563 GRADE A; HEX OR HEAVY HEX PER ANSI B18.2.2; ZINC-COATED	CARBON STEEL	OUTDOOR
219-02-5100	HSM ISFSI GENERAL ARRANGEMENT	5100-305	NUT, 1 1/2-6 UNC-2B	ASTM A194 GRADE 2H OR ASTM A563 GRADE A; HEX OR HEAVY HEX PER ANSI B18.2.2; ZINC-COATED	CARBON STEEL	OUTDOOR
219-02-5100	HSM ISFSI GENERAL ARRANGEMENT	NOTE 10	GROUT - SHIELD WALL PANELS	SONOGROUT® 10K [3.11.161]	CEMENTITIOUS GROUT	OUTDOOR
219-02-5100/ WO 642973 [3.11.27]	HSM ISFSI GENERAL ARRANGEMENT	NOTE 8	LIFTING STRAND LOOP POCKET FILL	DOW CORNING® 890-SL SILICONE JOINT SEALANT [3.11.164]	SILICONE SEALANT (CHEMICAL GROUT)	OUTDOOR
219-02-5101	STANDARD MODULE MAIN ASSEMBLY	5101-204	BOLT, 3/4 – 10 UNC – 2A X 2-3/4" LONG	ASTM A193 GRADE B7, ASTM A325, OR ASTM A490; HEX OR HEAVY HEX PER ANSI B18.2.1; ZINC-COATED	CARBON, CARBON/BORON, OR ALLOY STEEL	OUTDOOR
219-02-5101	STANDARD MODULE MAIN ASSEMBLY	5101-206	BOLT, 3/4 – 10 UNC – 2A X 3-1/4" LONG	ASTM A193 GRADE B7, ASTM A325, OR ASTM A490; HEX OR HEAVY HEX PER ANSI B18.2.1; ZINC-COATED	CARBON, CARBON/BORON, OR ALLOY STEEL	OUTDOOR
219-02-5101	STANDARD MODULE MAIN ASSEMBLY	5101-208	BOLT, 1 1/4 – 7 UNC – 2A X 3-1/2" LONG	ASTM A193 GRADE B7, ASTM A325, OR ASTM A490; HEX OR HEAVY HEX PER ANSI B18.2.1; ZINC-COATED	CARBON, CARBON/BORON, OR ALLOY STEEL	SHELTERED

Table 3-4: Identification of Materials and Environments for In-Scope SSC Components

Drawing Number	Component	Item Num.	Item Description	Drawing Material/ Item Identification Callout	Materials	Service Environments
219-02-5101	STANDARD MODULE MAIN ASSEMBLY	5101-210	BOLT, 1-1/4 – 7 UNC – 2A X 4-1/4" LONG	ASTM A193 GRADE B7, ASTM A325, OR ASTM A490; HEX OR HEAVY HEX PER ANSI B18.2.1; ZINC-COATED	CARBON, CARBON/BORON, OR ALLOY STEEL	SHELTERED
219-02-5101	STANDARD MODULE MAIN ASSEMBLY	5101-307	NUT, 1-5/8 –5 ½ UNC–2B	ASTM A194 GRADE 2H OR ASTM A563 GRADE A; HEX OR HEAVY HEX PER ANSI B18.2.2; ZINC-COATED	CARBON STEEL	SHELTERED
219-02-5101	STANDARD MODULE MAIN ASSEMBLY	5101-311	NUT, 1-1/4 –7 UNC – 2B	ASTM A194 GRADE 2H OR ASTM A563 GRADE A; HEX OR HEAVY HEX PER ANSI B18.2.2; ZINC-COATED	CARBON STEEL	SHELTERED
219-02-5101	STANDARD MODULE MAIN ASSEMBLY	NOTE 16	GROUT - LIFTING STRAND LOOP POCKET FILL	SONOGROUT® 10K [3.11.161]	CEMENTITIOUS GROUT	OUTDOOR
219-02-5101	STANDARD MODULE MAIN ASSEMBLY	NOTE 2B	WELD FILLER MATERIAL (CATEGORY B COMPONENTS)	E70XX ELECTRODE	E70XX ELECTRODE (WELD FILLER COMPATIBLE WITH CARBON STEEL)	SHELTERED
219-02-5101/ WO 635917 [3.11.123]	STANDARD MODULE MAIN ASSEMBLY	FDC 7682, FDC 7715	TMI-2 ISFSI HSM ROOF BOLT PROTECTIVE COVER	TWO PIECE STAINLESS STEEL COVER FASTENED TOGETHER WITH FOUR STAINLESS STEEL, PROTECTIVE GRAY OR ZINC-PLATED HEX HEAD SELF-DRILLING SCREWS. EDGES OF COVER HEMMED, SEAMS OF COVER SEAL WELDED.	STAINLESS STEEL	OUTDOOR
219-02-5103	HSM STANDARD MODULE BASE UNIT	NOTE 5	REINFORCEMENT BARS, OTHER THAN #4	ACI 318-95 ASTM A615 OR A706, GRADE 60 (TN WEST SPECIFICATION 219-02-114)	CARBON STEEL	EMBEDDED
219-02-5103	HSM STANDARD MODULE BASE UNIT	NOTES 1&14	CONCRETE	ACI 318-95 & TN WEST SPECIFICATION 219-02-114 (SECTION 5)	CONCRETE	OUTDOOR
219-02-5103	HSM STANDARD MODULE BASE UNIT	NOTES 8&18	GROUT – MOUNTING HOLES & EMBEDMENT VOIDS	SONOGROUT® 10K [3.11.161]	CEMENTITIOUS GROUT	OUTDOOR
219-02-5104	HSM ROOF SLAB	NOTE 15	SLOW-RISE POLYURETHANE FOAM FORMULA SPRAY FOAM	TIGER FOAM® SLOW-RISE POLYURETHANE FOAM FORMULA SPRAY FOAM [3.11.158]	POLYURETHANE (PLASTIC)	EMBEDDED
219-02-5104	HSM ROOF SLAB	NOTE 15 / FDC 7715	WATER RESISTANT POLYURETHANE FOAM MATERIAL, 6-1/2" X 6-1/2" X 1/8" THICK (NOT ADHESIVE)	WATER RESISTANT POLYURETHANE FOAM MATERIAL: McMASTER CARR® PART NUMBER 86225K43 [3.11.122] & [3.11.207]	POLYURETHANE (PLASTIC)	EMBEDDED
219-02-5104	HSM ROOF SLAB	NOTE 5	REINFORCEMENT BARS, OTHER THAN #4	ACI 318-95, ASTM A615 OR A706, GRADE 60 (TN WEST SPECIFICATION 219-02-114)	CARBON STEEL	EMBEDDED
219-02-5104	HSM ROOF SLAB	NOTES 1&11	CONCRETE	ACI 318-95, TN WEST SPECIFICATION 219-02-114 (SECTION 5)	CONCRETE	OUTDOOR
219-02-5105	HSM DSC SUPPORT STRUCTURE	5105-101	FRONT MOUNTING PLATE, 1" THICK	ASTM A36	CARBON STEEL	SHELTERED
219-02-5105	HSM DSC SUPPORT STRUCTURE	5105-102	REAR MOUNTING PLATE, 1" THICK	ASTM A36	CARBON STEEL	SHELTERED
219-02-5105	HSM DSC SUPPORT STRUCTURE	5105-103	STIFFENER PLATE, 1/2" THICK	ASTM A36	CARBON STEEL	SHELTERED
219-02-5105	HSM DSC SUPPORT STRUCTURE	5105-104	STIFFENER PLATE, 1/2" THICK	ASTM A36	CARBON STEEL	SHELTERED
219-02-5105	HSM DSC SUPPORT STRUCTURE	5105-105	SUPPORT PLATE, 1-1/2" THICK X 7" LONG	ASTM A36	CARBON STEEL	SHELTERED
219-02-5105	HSM DSC SUPPORT STRUCTURE	5105-106	CANISTER STOP PLATE, 1-1/8" THICK	ASTM A36	CARBON STEEL	SHELTERED
219-02-5105	HSM DSC SUPPORT STRUCTURE	5105-107	SUPPORT RAIL, W12 X 96	ASTM A36	CARBON STEEL	SHELTERED
219-02-5105	HSM DSC SUPPORT STRUCTURE	5105-109	STIFFENER PLATE, 1/2" THICK	ASTM A36	CARBON STEEL	SHELTERED
219-02-5105	HSM DSC SUPPORT STRUCTURE	5105-110	RAIL EXTENSION PLATE, 3/4" THICK	ASTM A36	CARBON STEEL	SHELTERED
219-02-5105	HSM DSC SUPPORT STRUCTURE	5105-111	CROSS BEAM, W6 X 25	ASTM A36	CARBON STEEL	SHELTERED

Table 3-4: Identification of Materials and Environments for In-Scope SSC Components

Drawing Number	Component	Item Num.	Item Description	Drawing Material/ Item Identification Callout	Materials	Service Environments
219-02-5105	HSM DSC SUPPORT STRUCTURE	NOTE 2	WELD FILLER MATERIAL	AMERICAN WELDING SOCIETY (AWS) D1.1-96, AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC) A3.6, 70,000 PSI MINIMUM SPECIFIED TENSILE STRENGTH (TN WEST SPECIFICATION 219-02-115)	E70XX ELECTRODE (WELD FILLER COMPATIBLE WITH CARBON STEEL)	SHELTERED
219-02-5105/ Fabrication Specification 219-02-115 [3.11.17]	HSM DSC SUPPORT STRUCTURE	NOTE 5	COATING	TN WEST SPECIFICATION 219-02-115 (SECTION 6.4 & APPENDIX A) PRIME COAT: CARBOZINC® 11 INORGANIC ZINC-RICH PRIMER AT 2.0 TO 6.0 MILS DRY FILM THICKNESS (DFT), FINISH COAT: CARBOLINE® 890 HIGH BUILD EPOXY ENAMEL AT 5.0 MILS TO 7.0 MILS DFT	INORGANIC ZINC PRIMER WITH EPOXY ENAMEL TOP COAT	SHELTERED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-101	PLATE ½" THICK	ASTM A36	CARBON STEEL	OUTDOOR
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-102	ROLLED PLATE 3/8" THICK	ASTM A36	CARBON STEEL	OUTDOOR
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-103	PLATE 1-½" THICK	ASTM A36	CARBON STEEL	OUTDOOR
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-105	MOUNTING PLATE 1" THICK	ASTM A36	CARBON STEEL	OUTDOOR
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-118	PLATE ¾" THICK	ASTM A36	CARBON STEEL	EMBEDDED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-120	PLATE ½" THICK	ASTM A36	CARBON STEEL	SHELTERED/ EMBEDDED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-121	PLATE ½" THICK	ASTM A36	CARBON STEEL	SHELTERED/ EMBEDDED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-125	DOOR, PLATE 1-1/2" THICK	ASTM A36	CARBON STEEL	OUTDOOR
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-126	SPACER, PLATE 1-1/2" THICK	ASTM A36	CARBON STEEL	OUTDOOR
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-127	HEAVY DUTY HINGE (REAR ACCESS DOOR)	MCMASTER-CARR® #10855A44 [3.11.208]	CARBON STEEL	OUTDOOR
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-130	ANGLE, L8" X 8" X 1" THICK	ASTM A36	CARBON STEEL	SHELTERED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-131	STIFFENER PLATE, ½" THICK	ASTM A36	CARBON STEEL	SHELTERED

Table 3-4: Identification of Materials and Environments for In-Scope SSC Components

Drawing Number	Component	Item Num.	Item Description	Drawing Material/ Item Identification Callout	Materials	Service Environments
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-135	PLATE, ¾" THICK	ASTM A36	CARBON STEEL	OUTDOOR/ EMBEDDED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-137	PLATE, ¾" THICK	ASTM A36	CARBON STEEL	SHELTERED/ EMBEDDED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-139	TUBE STEEL, 5" X 5" X 3/8" THICK	ASTM A500, GRADE B	CARBON STEEL	EMBEDDED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-140	PLATE, 4-½" SQUARE X 1/4" THICK	ASTM A36	CARBON STEEL	EMBEDDED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-141	SEISMIC RETAINER, TUBE STEEL, 4" X 4" X ½" THICK X 1'-0" LONG	ASTM A500, GRADE B	CARBON STEEL	SHELTERED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-148	REAR DSC SUPPORT STRUCTURE LUG PLATE, 2" X 4" X 1" THICK	ASTM A36	CARBON STEEL	SHELTERED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-149	SHIELD WALL TIE PLATE, 3/4" THICK	ASTM A36	CARBON STEEL	OUTDOOR
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-154	RICHMOND DOWEL BAR SPLICER (DB-SAE) WITH 1-9/16–8 UN THREAD AND #11 BAR	RICHMOND, ASTM A615 PLAIN CARBON STEEL; ZINC-COATED[1]	CARBON STEEL	EMBEDDED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-155	WASHER PLATE, 1/2" THICK	ASTM A36	CARBON STEEL	OUTDOOR
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-157	WASHER PLATE, 1/2" THICK	ASTM A36	CARBON STEEL	OUTDOOR
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-158	RICHMOND DOWEL BAR SPLICER (DB-SAE) WITH 1-9/16–8 UN THREAD AND # 11 BAR	RICHMOND, ASTM A615 PLAIN CARBON STEEL; ZINC-COATED[1]	CARBON STEEL	EMBEDDED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-251	SHIELD WALL CAST-IN-PLACE BOLT, 1 1/8–7UNC – 2A X 1' – 0" LONG	ASTM A193 GRADE B7, ASTM A325, OR ASTM A490; HEX OR HEAVY HEX PER ANSI B18.2.2; ZINC-COATED	CARBON, CARBON/BORON, OR ALLOY STEEL	OUTDOOR/ EMBEDDED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-307	NUT, 1 ½" – 6 UNC – 2B	ASTM A193 GRADE B7, ASTM A325, OR ASTM A490; HEX OR HEAVY HEX PER ANSI B18.2.2; ZINC-COATED	CARBON STEEL	EMBEDDED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-308	COUPLING NUT, 1 ½" – 6 UNC – 2B	ASTM A193 GRADE B7, ASTM A325, OR ASTM A490; HEX OR HEAVY HEX PER ANSI B18.2.2; ZINC-COATED	QUENCHED CARBON STEEL	EMBEDDED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-310	NUT, 1 ¼" – 7 UNC – 2B	ASTM A193 GRADE B7, ASTM A325, OR ASTM A490; HEX OR HEAVY HEX PER ANSI B18.2.2; ZINC-COATED	CARBON STEEL	EMBEDDED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-311	COUPLING NUT, 1 ¼" – 7 UNC – 2B	ASTM A193 GRADE B7, ASTM A325, OR ASTM A490; HEX OR HEAVY HEX PER ANSI B18.2.2; ZINC-COATED	QUENCHED CARBON STEEL	EMBEDDED

Table 3-4: Identification of Materials and Environments for In-Scope SSC Components

Drawing Number	Component	Item Num.	Item Description	Drawing Material/ Item Identification Callout	Materials	Service Environments
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-313	NUT, 2 – 4 ½ UNC – 2B	ASTM A193 GRADE B7, ASTM A325, OR ASTM A490; HEX OR HEAVY HEX PER ANSI B18.2.2; ZINC-COATED	CARBON STEEL	EMBEDDED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-314	COUPLING NUT, 2 – 4 ½ – 7 UNC – 2B	ASTM A193 GRADE B7, ASTM A325, OR ASTM A490; HEX OR HEAVY HEX PER ANSI B18.2.2; ZINC-COATED	QUENCHED CARBON STEEL	EMBEDDED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-316	NUT, ¾ - 10 UNC – 2B	ASTM A193 GRADE B7, ASTM A325, OR ASTM A490; HEX OR HEAVY HEX PER ANSI B18.2.2; ZINC-COATED	CARBON STEEL	EMBEDDED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-317	COUPLING NUT, ¾ - 10 UNC – 2B	ASTM A193 GRADE B7, ASTM A325, OR ASTM A490; HEX OR HEAVY HEX PER ANSI B18.2.2; ZINC-COATED	QUENCHED CARBON STEEL	EMBEDDED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-452	WASHER PLATE 6” SQ X 1” THICK	ASTM A36	CARBON STEEL	SHELTERED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-506	STUD, 1 ½” – 6 UNC – 2A	ASTM A193 GRADE B7, ASTM A325, OR ASTM A490; ZINC-COATED	FERRITIC STEEL	EMBEDDED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-509	STUD, 1 ¼” – 7 UNC – 2A	ASTM A193 GRADE B7, ASTM A325, OR ASTM A490; ZINC-COATED	FERRITIC STEEL	EMBEDDED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-512	STUD, 2 – 4 ½ UNC – 2A	ASTM A193 GRADE B7, ASTM A325, OR ASTM A490; ZINC-COATED	FERRITIC STEEL	EMBEDDED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-515	STUD, ¾ - 10 UNC – 2A	ASTM A193 GRADE B7, ASTM A325, OR ASTM A490; ZINC-COATED	FERRITIC STEEL	EMBEDDED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-544	SHIELD WALL SUPPORT STUD, 1 1/2–6UNC–2A	ASTM A193 GRADE B7, ASTM A325, OR ASTM A490; ZINC-COATED	FERRITIC STEEL	EMBEDDED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-553	ROOF ATTACHMENT BOLT, ROD Ø 1–5/8”	ASTM A193 GRADE B7, ASTM A325, OR ASTM A490; HEX OR HEAVY HEX PER ANSI B18.2.1; ZINC-COATED	CARBON, CARBON/BORON, OR ALLOY STEEL	SHELTERED/ EMBEDDED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-619	NELSON STUD, TYPE S3L, Ø ¾” X 3–3/16” LONG	CARBON STEEL; ZINC-COATED	CARBON STEEL	EMBEDDED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-643	NELSON STUD, TYPE H4L Ø 1/2” X 4–1/8” LONG	CARBON STEEL; ZINC-COATED	CARBON STEEL	EMBEDDED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	NOTE 1/ NOTE 18	WELD FILLER MATERIAL (ATTACHES DSC SUPPORT STRUCTURE)	ALL WELDING SHALL CONFORM TO AWS D1.1-96 AND TN WEST SPECIFICATION 219-02-115	E70XX ELECTRODE (WELD FILLER COMPATIBLE WITH CARBON STEEL)	SHELTERED
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	NOTE 11	CONCRETE FILL	TN WEST SPECIFICATION 219-02-114 (SECTION 5) AND ACI 318-95	CONCRETE	EMBEDDED

Table 3-4: Identification of Materials and Environments for In-Scope SSC Components

Drawing Number	Component	Item Num.	Item Description	Drawing Material/ Item Identification Callout	Materials	Service Environments
219-02-5107/ Fabrication Specification 219-02-115 [3.11.17]	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	NOTES 2-3, 9-10, 13	COATING	TN WEST SPECIFICATION 219-02-115 (SECTION 6.4 & APPENDIX A) PRIME COAT: CARBOZINC® 11 INORGANIC ZINC-RICH PRIMER AT 2.0 TO 6.0 MILS DFT, FINISH COAT: CARBOLINE® 890 HIGH BUILD EPOXY ENAMEL AT 5.0 MILS TO 7.0 MILS DFT	INORGANIC ZINC PRIMER WITH EPOXY ENAMEL TOP COAT	SHELTERED
219-02-5108	HSM END MODULE SHIELD WALL	NOTE 1/ NOTE 9	REINFORCEMENT BARS	ACI 318-95 & TN WEST SPECIFICATION 219-02-114 (SECTION 5.3) ASTM A615 OR A706, GRADE 60	CARBON STEEL	EMBEDDED
219-02-5108	HSM END MODULE SHIELD WALL	NOTE 1/ NOTE 9	CONCRETE	TN WEST SPECIFICATION 219-02-114 (SECTION 5) AND ACI 318-95	CONCRETE	OUTDOOR
TMI-2 KNOCKOUT CANISTER						
02-1150946-C	KNOCKOUT CANISTER UPPER HEAD WELDMENT	1	1150946C POISON TUBE ASSEMBLY	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL TMI-2 CANISTER/ ENCASED
02-1150946-C	KNOCKOUT CANISTER UPPER HEAD WELDMENT	2	1150946C TOP END CAP	ASTM A479 TYPE 316L STAINLESS STEEL BAR	STAINLESS STEEL	INTERNAL TMI-2 CANISTER/ ENCASED
02-1150946-C	KNOCKOUT CANISTER UPPER HEAD WELDMENT	3	1150946C BOTTOM END CAP	ASTM A479 TYPE 316L STAINLESS STEEL BAR	STAINLESS STEEL	INTERNAL TMI-2 CANISTER/ ENCASED
02-1150946-C	KNOCKOUT CANISTER UPPER HEAD WELDMENT	4	1150946C PIPE 1" ∅ SCHEDULE 160	ASTM A312 TYPE 316L STAINLESS STEEL PIPE	STAINLESS STEEL	INTERNAL TMI-2 CANISTER/ ENCASED
02-1150946-C	KNOCKOUT CANISTER UPPER HEAD WELDMENT	5	1150946C B_4C PELLET	ASTM C-750 BORON CARBIDE POWDER (TYPE 2). PELLETS STACKED IN THE TUBE TO PRODUCE A MINIMUM LINEAR DENSITY OF 1.66 GRAMS OF B^{10} PER INCH. (≥ 1500 GRAMS LOADED INTO TUBE)	BORON CARBIDE	ENCASED
02-1150968-D	KNOCKOUT CANISTER BOTTOM SUPPORT PLATE ASSEMBLY	1	1150968D BOTTOM SUPPORT PLATE ASSEMBLY	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL TMI-2 CANISTER
02-1150968-D	KNOCKOUT CANISTER BOTTOM SUPPORT PLATE ASSEMBLY	2	1150950E BOTTOM SUPPORT PLATE	ASTM A240 GRADE 304L OR ASTM A240 GRADE 316L STAINLESS STEEL PLATE	STAINLESS STEEL	INTERNAL TMI-2 CANISTER
02-1154027-F	KNOCKOUT CANISTER INTERNALS ASSEMBLY	1	1154027F KNOCKOUT CANISTER INTERNALS ASSEMBLY	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL TMI-2 CANISTER
02-1154027-F	KNOCKOUT CANISTER INTERNALS ASSEMBLY	2	1155233D POISON TUBE A	SEE BOM COMPONENTS	STAINLESS STEEL	ENCASED
02-1154027-F	KNOCKOUT CANISTER INTERNALS ASSEMBLY	3	1150946C POISON TUBE B	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL TMI-2 CANISTER
02-1154027-F	KNOCKOUT CANISTER INTERNALS ASSEMBLY	4	1150968D BOTTOM SUPPORT PLATE ASSEMBLY	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL TMI-2 CANISTER
02-1154027-F	KNOCKOUT CANISTER INTERNALS ASSEMBLY	5	1150939D INTERMEDIATE SUPPORT PLATE A	ASTM A240 TYPE 304L OR TYPE 316L STAINLESS STEEL PLATE	STAINLESS STEEL	INTERNAL TMI-2 CANISTER
02-1154027-F	KNOCKOUT CANISTER INTERNALS ASSEMBLY	7	1150937D SUPPORT RING	ASTM A240 TYPE 304L OR TYPE 316L STAINLESS STEEL PLATE	STAINLESS STEEL	INTERNAL TMI-2 CANISTER
02-1154027-F	KNOCKOUT CANISTER INTERNALS ASSEMBLY	9	1150954D SEAL PLATE	ASTM A240 GRADE 304L OR GRADE 316L STAINLESS STEEL PLATE	STAINLESS STEEL	INTERNAL TMI-2 CANISTER/ ENCASED

Table 3-4: Identification of Materials and Environments for In-Scope SSC Components

Drawing Number	Component	Item Num.	Item Description	Drawing Material/ Item Identification Callout	Materials	Service Environments
02-1154027-F	KNOCKOUT CANISTER INTERNALS ASSEMBLY	14	1154090C CENTER TUBE	ASTM A269, TYPE 304L OR TYPE 316L STAINLESS STEEL TUBE	STAINLESS STEEL	INTERNAL TMI-2 CANISTER/ ENCASED
02-1154034-F	KNOCKOUT CANISTER INTERNALS & SHELL ASSEMBLY	1	1154034F INTERNALS & SHELL ASSEMBLY	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL DSC/ INTERNAL TMI-2 CANISTER
02-1154034-F	KNOCKOUT CANISTER INTERNALS & SHELL ASSEMBLY	2	1150945C SHELL (KNOCKOUT & FILTER CANISTER)	WELDED OR SEAMLESS/ASME SA-312 TYPE 304L OR 316L STAINLESS STEEL PIPE	STAINLESS STEEL	INTERNAL DSC/ INTERNAL TMI-2 CANISTER
02-1154034-F	KNOCKOUT CANISTER INTERNALS & SHELL ASSEMBLY	3	1154027F KNOCKOUT CANISTER INTERNALS ASSEMBLY	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL TMI-2 CANISTER
02-1154041-F	KNOCKOUT CANISTER ASSEMBLY	1	1154041F KNOCKOUT CANISTER ASSEMBLY	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL DSC/ INTERNAL TMI-2 CANISTER
02-1154041-F	KNOCKOUT CANISTER ASSEMBLY	2	1154045D BOTTOM HEAD ASSEMBLY	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL DSC/ INTERNAL TMI-2 CANISTER
02-1154041-F	KNOCKOUT CANISTER ASSEMBLY	3	1154046F KNOCKOUT CANISTER UPPER HEAD WELDMENT	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL DSC/ INTERNAL TMI-2 CANISTER
02-1154045-D	KNOCKOUT & FILTER CANISTER LOWER HEAD ASSEMBLY	1	1154045D CANISTER LOWER HEAD ASSEMBLY	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL DSC/ INTERNAL TMI-2 CANISTER
02-1154045-D	KNOCKOUT & FILTER CANISTER LOWER HEAD ASSEMBLY	2	1150917D CANISTER LOWER HEAD (KNOCKOUT & FILTER CANISTER)	ASME SA-479 OR SA-240 TYPE 304L OR TYPE 316L STAINLESS STEEL	STAINLESS STEEL	INTERNAL DSC/ INTERNAL TMI-2 CANISTER
02-1154046-F	FILTER & KNOCKOUT CANISTER SKIRT	1	1154046F KNOCKOUT CANISTER HEAD WELDMENT	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL DSC/ INTERNAL TMI-2 CANISTER
02-1154046-F	FILTER & KNOCKOUT CANISTER SKIRT	3	1150943E KNOCKOUT CANISTER UPPER HEAD	ASME SA-240 TYPE 316L OR 304L STAINLESS STEEL	STAINLESS STEEL	INTERNAL DSC/ INTERNAL TMI-2 CANISTER
02-1155233-D	KNOCKOUT CANISTER POISON TUBE ASSEMBLY	1	1155233D KNOCKOUT CANISTER POISON TUBE ASSEMBLY	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL TMI-2 CANISTER/ ENCASED
02-1155233-D	KNOCKOUT CANISTER POISON TUBE ASSEMBLY	2	1155233D TUBE 2-1/8" OD X 0.065" THICK WALL	ASTM A269 TYPE 316L STAINLESS STEEL	STAINLESS STEEL	INTERNAL TMI-2 CANISTER/ ENCASED
02-1155233-D	KNOCKOUT CANISTER POISON TUBE ASSEMBLY	3	1155233D BOTTOM END PLUG	ASTM A479 OR A276, TYPE 316L STAINLESS STEEL BAR	STAINLESS STEEL	INTERNAL TMI-2 CANISTER/ ENCASED
02-1155233-D	KNOCKOUT CANISTER POISON TUBE ASSEMBLY	4	1155233D TOP END PLUG	ASTM A479 OR A276, TYPE 316L STAINLESS STEEL BAR	STAINLESS STEEL	INTERNAL TMI-2 CANISTER/ ENCASED
02-1155233-D	KNOCKOUT CANISTER POISON TUBE ASSEMBLY	5	1155233D B_4C PELLET	ASTM C-750, TYPE 2 BORON CARBIDE POWDER PELLETS SHALL BE PACKED INTO THE TUBE TO PRODUCE A MINIMUM LINEAR DENSITY OF 10.00 GRAMS OF B^{10} PER INCH ($\geq$ 9115 GRAMS OF B_4C LOADED INTO TUBE)	BORON CARBIDE	ENCASED

Table 3-4: Identification of Materials and Environments for In-Scope SSC Components

Drawing Number	Component	Item Num.	Item Description	Drawing Material/ Item Identification Callout	Materials	Service Environments
02-1161301-D	KNOCKOUT CANISTER ASSEMBLY SAR	UFSAR	NOTE 3: WELD FILLER METAL	WELD WIRE PER AWS 5.4 OR 5.9 TYPE 316L OR 308L	STAINLESS STEEL	INTERNAL DSC/ INTERNAL TMI-2 CANISTER
TMI-2 FILTER CANISTER						
02-1150949-D	FILTER CANISTER POISON TUBE ASSEMBLY	1	1150949D POISON TUBE ASSEMBLY	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL TMI-2 CANISTER/ ENCASED
02-1150949-D	FILTER CANISTER POISON TUBE ASSEMBLY	2	1150949D; TUBE 2-1/8" OD X 0.065" THICK WALL	ASTM A-269 TYPE 316L STAINLESS STEEL TUBE	STAINLESS STEEL	INTERNAL TMI-2 CANISTER/ ENCASED
02-1150949-D	FILTER CANISTER POISON TUBE ASSEMBLY	3	1150949D; BOTTOM END PLUG	ASTM A-479 OR ASTM A-276, TYPE 316L STAINLESS STEEL BAR	STAINLESS STEEL	INTERNAL TMI-2 CANISTER/ ENCASED
02-1150949-D	FILTER CANISTER POISON TUBE ASSEMBLY	4	1150949D; TOP END PLUG	ASTM A-479 OR ASTM A-276, TYPE 316L STAINLESS STEEL BAR	STAINLESS STEEL	INTERNAL TMI-2 CANISTER/ ENCASED
02-1150949-D	FILTER CANISTER POISON TUBE ASSEMBLY	5	1150949D; B_4C PELLET	ASTM C-750 TYPE 2 BORON CARBIDE POWDER PELLETS SHALL BE PACKED INTO THE TUBE TO PRODUCE A MINIMUM LINEAR DENSITY OF 10.00 GRAMS OF B^{10} PER INCH. ($\geq$ 9465 GRAMS OF B_4C LOADED INTO TUBE)	BORON CARBIDE	ENCASED
02-1150959-D	FILTER CANISTER UPPER HEAD WELDMENT	1	1150959D UPPER HEAD WELDMENT	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL DSC/ INTERNAL TMI-2 CANISTER
02-1150959-D	FILTER CANISTER UPPER HEAD WELDMENT	5	1150958D FILTER CANISTER UPPER HEAD	ASME SA-240 TYPE 316L OR TYPE 304L STAINLESS STEEL PLATE	STAINLESS STEEL	INTERNAL DSC/ INTERNAL TMI-2 CANISTER
02-1154018-F	FILTER CANISTER ASSEMBLY	1	1154018F FILTER CANISTER ASSEMBLY	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL DSC/ INTERNAL TMI-2 CANISTER
02-1154018-F	FILTER CANISTER ASSEMBLY	2	1150959D UPPER HEAD WELDMENT	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL DSC/ INTERNAL TMI-2 CANISTER
02-1154018-F	FILTER CANISTER ASSEMBLY	3	1154045D BOTTOM HEAD ASSEMBLY	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL DSC/ INTERNAL TMI-2 CANISTER
02-1154020-E	FILTER CANISTER SUB-ASSEMBLY	1	1154020E FILTER CANISTER SUB-ASSEMBLY	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL DSC/ INTERNAL TMI-2 CANISTER
02-1154020-E	FILTER CANISTER SUB-ASSEMBLY	3	1150945C SHELL	WELDED OR SEAMLESS/ASME SA-312 TYPE 304L OR 316L STAINLESS STEEL PIPE	STAINLESS STEEL	INTERNAL DSC/ INTERNAL TMI-2 CANISTER
02-1154020-E	FILTER CANISTER SUB-ASSEMBLY	6	1150949D POISON TUBE ASSEMBLY	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL TMI-2 CANISTER
02-1161299-D	FILTER CANISTER ASSEMBLY SAR	UFSAR	NOTE 3: WELD FILLER METAL	WELD WIRE PER AWS 5.4 OR 5.9 TYPE 316L OR 308L	STAINLESS STEEL	INTERNAL DSC/ INTERNAL TMI-2 CANISTER

Table 3-4: Identification of Materials and Environments for In-Scope SSC Components

Drawing Number	Component	Item Num.	Item Description	Drawing Material/ Item Identification Callout	Materials	Service Environments
TMI-2 FUEL CANISTER						
02-1095753-E	FUEL CANISTER NEUTRON POISON SHROUD	1	18163E100 TUBE ASSEMBLY	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL TMI-2 CANISTER/ ENCASED
02-1095753-E	FUEL CANISTER NEUTRON POISON SHROUD	2	18163E100-1 OUTER SKIN	ASME SA-240 304L OR 316L STAINLESS STEEL (SOLUTION ANNEALED AND QUENCHED, NO. 2D FINISH PER ASME SA-480 OR EQUIVALENT)	STAINLESS STEEL	INTERNAL TMI-2 CANISTER/ ENCASED
02-1095753-E	FUEL CANISTER NEUTRON POISON SHROUD	3	18163E100-2 INNER SKIN	ASME SA-240 304L OR 316L STAINLESS STEEL (SOLUTION ANNEALED AND QUENCHED, NO.2D FINISH PER ASME SA-480 OR EQUIVALENT)	STAINLESS STEEL	INTERNAL TMI-2 CANISTER/ ENCASED
02-1095753-E	FUEL CANISTER NEUTRON POISON SHROUD	4	18163E100-3 BORAL®	ASTM C750-1980, TYPE 3 BORON CARBIDE PARTICLES (B ≥ 76%) IN AN ALUMINUM MATRIX, B^{10} LOADING ≥ 0.040 GRAM/CM^2	BORAL®	ENCASED
02-1150998-E	FUEL CANISTER BOTTOM PLATE ASSEMBLY	1	1150998E FUEL CANISTER BOTTOM PLATE ASSEMBLY	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL TMI-2 CANISTER
02-1150998-E	FUEL CANISTER BOTTOM PLATE ASSEMBLY	2	1150992E BOTTOM PLATE	ASTM A240 GRADE 304L OR 316L STAINLESS STEEL PLATE	STAINLESS STEEL	INTERNAL TMI-2 CANISTER
02-1150999-F	FUEL CANISTER LOWER ASSEMBLY	1	1150999F FUEL CANISTER LOWER ASSEMBLY	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL TMI-2 CANISTER
02-1150999-F	FUEL CANISTER LOWER ASSEMBLY	2	1095753E BORAL® SHROUD ASSEMBLY	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL TMI-2 CANISTER/ ENCASED
02-1150999-F	FUEL CANISTER LOWER ASSEMBLY	3	1154014F FUEL CANISTER BULKHEAD	ASME SA-240 TYPE 316L OR 304L STAINLESS STEEL PLATE	STAINLESS STEEL	INTERNAL DSC/ INTERNAL TMI-2 CANISTER
02-1150999-F	FUEL CANISTER LOWER ASSEMBLY	5	1150983C FUEL CANISTER SHELL	WELDED OR SEAMLESS/ASME SA-312 TYPE 304L OR 316L STAINLESS STEEL PIPE	STAINLESS STEEL	INTERNAL DSC/ INTERNAL TMI-2 CANISTER/ ENCASED
02-1150999-F	FUEL CANISTER LOWER ASSEMBLY	6	1154045D LOWER HEAD ASSEMBLY	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL DSC/ INTERNAL TMI-2 CANISTER
02-1150999-F	FUEL CANISTER LOWER ASSEMBLY	7	1150998E BOTTOM PLATE ASSEMBLY	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL TMI-2 CANISTER
02-1150999-F	FUEL CANISTER LOWER ASSEMBLY	9	1150999F CONCRETE MIX	HOMOGENEOUS MIXTURE COMPOSED OF: 60 WEIGHT % CA-25C REFRACTORY CEMENT (ALCO CORP.) 11 WEIGHT % GLASS BUBBLES (3M CORP. PRODUCT 828-750) 29 WEIGHT % DEIONIZED WATER	LICON	INTERNAL TMI-2 CANISTER/ ENCASED
02-1154026-F	FUEL CANISTER HEAD WELDMENT	1	1154026F FUEL CANISTER HEAD WELDMENT	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL DSC/ INTERNAL TMI-2 CANISTER
02-1154026-F	FUEL CANISTER HEAD WELDMENT	2	1150989F FUEL CANISTER UPPER HEAD	ASME SA-240 TYPE 316L OR TYPE 304L STAINLESS STEEL PLATE	STAINLESS STEEL	INTERNAL DSC/ INTERNAL TMI-2 CANISTER
02-1154026-F	FUEL CANISTER HEAD WELDMENT	4	1150993C SHOCK ABSORBER SUPPORT	ASTM A312 TYPE 304L OR TYPE 316L STAINLESS STEEL PIPE	STAINLESS STEEL	INTERNAL TMI-2 CANISTER

Table 3-4: Identification of Materials and Environments for In-Scope SSC Components

Drawing Number	Component	Item Num.	Item Description	Drawing Material/ Item Identification Callout	Materials	Service Environments
02-1154026-F	FUEL CANISTER HEAD WELDMENT	5	1150995C IMPACT PLATE "D"	ASTM A240 GRADE 304L OR 316L STAINLESS STEEL PLATE	STAINLESS STEEL	INTERNAL TMI-2 CANISTER
02-1154026-F	FUEL CANISTER HEAD WELDMENT	7	1150994C IMPACT PLATE "C"	ASTM A240 GRADE 304L OR 316L STAINLESS STEEL PLATE	STAINLESS STEEL	INTERNAL TMI-2 CANISTER
02-1154026-F	FUEL CANISTER HEAD WELDMENT	12	1154021C FUEL CANISTER BOLT	ASME SB 446, GRADE 1 NICKEL ALLOY	INCONEL 625	INTERNAL DSC/ INTERNAL TMI-2 CANISTER
02-1154070-F	FUEL CANISTER ASSEMBLY	1	1154070F FUEL CANISTER ASSEMBLY	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL DSC/ INTERNAL TMI-2 CANISTER
02-1154070-F	FUEL CANISTER ASSEMBLY	2	1150999E FUEL CANISTER LOWER ASSEMBLY	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL DSC/ INTERNAL TMI-2 CANISTER
02-1154070-F	FUEL CANISTER ASSEMBLY	3	1154026F FUEL CANISTER UPPER HEAD WELDMENT	SEE BOM COMPONENTS	STAINLESS STEEL	INTERNAL DSC /INTERNAL TMI-2 CANISTER
02-1161300-D	FUEL CANISTER ASSEMBLY SAR	UFSAR	NOTE 3: WELD FILLER METAL	WELD WIRE PER AWS 5.4 OR 5.9 TYPE 316L OR 308L	STAINLESS STEEL	INTERNAL DSC/ INTERNAL TMI-2 CANISTER

Table Footnotes:

[1]-Material Type identified in HSM Documentation Package [3.11.87] with coating of dowel splicer coupling end identified in Diamond Note 10 on drawing 219-02-5107 as CARBOZINC® 11 or ZINC-RICH COLD GALVANIZING COMPOUND.

Table 3-5: Applicable Aging Effects and Mechanisms with Aging Management Activities

Drawing Number	Component	Item Num.	Item Description	Applicable Aging Effects	Applicable Aging Mechanisms	AMAs
DRY-SHIELDED CANISTER (DSC)						
219-02-1000	DSC BASKET ASSEMBLY	1	SPACER DISC, 1 1/4" PLATE	Loss of material[1]	Corrosion (General, Crevice, Pitting)	Bounded by DSC AMP[1]
219-02-1000	DSC BASKET ASSEMBLY	2	TOP SPACER DISC, 1 1/4" PLATE	Loss of material[1]	Corrosion (General, Crevice, Pitting)	Bounded by DSC AMP[1]
219-02-1000	DSC BASKET ASSEMBLY	3	SUPPORT ROD, Ø 1 1/2" ROD	Loss of material[1]	Corrosion (General, Crevice, Pitting)	Bounded by DSC AMP[1]
219-02-1000	DSC BASKET ASSEMBLY	4	PIPE SLEEVE – LONG, 2.00 NPS SCHEDULE 80	Loss of material[1]	Corrosion (General, Crevice, Pitting)	Bounded by DSC AMP[1]
219-02-1000	DSC BASKET ASSEMBLY	5	PIPE SLEEVE – SHORT, 2.00 NPS SCHEDULE 80	Loss of material[1]	Corrosion (General, Crevice, Pitting)	Bounded by DSC AMP[1]
219-02-1000	DSC BASKET ASSEMBLY	6	END SLEEVE	Loss of material[1]	Corrosion (General, Crevice, Pitting)	Bounded by DSC AMP[1]
219-02-1001	DSC SHELL ASSEMBLY	1	CYLINDRICAL SHELL, 5/8" PLATE	Loss of material	Corrosion (General, Crevice, Pitting) – includes Galvanic, Wear (Adhesive)	DSC AMP
219-02-1001	DSC SHELL ASSEMBLY	2	OUTER BOTTOM COVER	Loss of material	Corrosion (General, Crevice, Pitting)	DSC AMP
219-02-1001	DSC SHELL ASSEMBLY	3	BOTTOM SHIELD PLUG	None Identified	None Identified	None Required
219-02-1001	DSC SHELL ASSEMBLY	4	GRAPPLE RING, 1" PLATE	Loss of material	Corrosion (General, Crevice, Pitting)	DSC AMP

Table 3-5: Applicable Aging Effects and Mechanisms with Aging Management Activities

Drawing Number	Component	Item Num.	Item Description	Applicable Aging Effects	Applicable Aging Mechanisms	AMAs
219-02-1001	DSC SHELL ASSEMBLY	5	GRAPPLE RING SUPPORT, 3/4" PLATE	Loss of material	Corrosion (General, Crevice, Pitting)	DSC AMP
219-02-1001	DSC SHELL ASSEMBLY	6	INNER BOTTOM COVER 3/4" PLATE	Loss of material[1]	Corrosion (General, Crevice, Pitting)	Bounded by DSC AMP[1]
219-02-1002	DSC BASKET-SHELL ASSEMBLY	5	SUPPORT RING 3/4" PLATE	Loss of material[1]	Corrosion (General, Crevice, Pitting)	Bounded by DSC AMP[1]
219-02-1002	DSC BASKET-SHELL ASSEMBLY	6	VENT PORT SHIELD BLOCK, 1-3/4" PLATE	Loss of material[1]	Corrosion (General, Crevice, Pitting)	Bounded by DSC AMP[1]
219-02-1003	DSC MAIN ASSEMBLY	2	TOP SHIELD PLUG, PLATE 3 1-1/4" THICK PLATE	Loss of material[1]	Corrosion (General, Crevice, Pitting)	Bounded by DSC AMP[1]
219-02-1003	DSC MAIN ASSEMBLY	3	TOP COVER PLATE	Loss of material	Corrosion (General, Crevice, Pitting)	DSC AMP
219-02-1003	DSC MAIN ASSEMBLY	4	PURGE PORT BLOCK	Loss of material[1]	Corrosion (General, Crevice, Pitting)	Bounded by DSC AMP[1]
219-02-1003	DSC MAIN ASSEMBLY	9	TOP SHIELD PLUG PLATE 1 & 2	Loss of material[1]	Corrosion (General, Crevice, Pitting)	Bounded by DSC AMP[1]
219-02-1010	DSC PURGE PORT FILTER ASSEMBLY	1	FILTER HOUSING	Loss of material	Corrosion (General, Crevice, Pitting)	DSC AMP
219-02-1010	DSC PURGE PORT FILTER ASSEMBLY	5	HEPA TYPE FILTER W/GASKET	Loss of material[2]	Corrosion (General, Crevice, Pitting, Galvanic)	DSC AMP[2]
219-02-1010	DSC PURGE PORT FILTER ASSEMBLY	10	DUAL C-SEALS, EG & G PRESSURE SCIENCE (FILTER HOUSING	Loss of material[1]	Corrosion (General, Crevice, Pitting, Galvanic)	Bounded by DSC AMP[1]
219-02-1010	DSC PURGE PORT FILTER ASSEMBLY	14	SCREW, CAP SOCKET HD, 1/2 - 13 UNC - 2A X 0.75" LONG	Loss of material[1]	Corrosion (General, Crevice, Pitting)	Bounded by DSC AMP[1]
219-02-1010	DSC PURGE PORT FILTER ASSEMBLY	16	SCREW, CAP SOCKET HD, 1 – 8 UNC – 2A X 3.00" LONG	Loss of material[2]	Corrosion (General, Crevice, Pitting, Galvanic)	DSC AMP[2]
219-02-1010	DSC PURGE PORT FILTER ASSEMBLY	20	DUAL C-SEALS, EG&G PRESSURE SCIENCE	Loss of material[1]	Corrosion (General, Crevice, Pitting, Galvanic)	Bounded by DSC AMP[1]
219-02-1010	DSC PURGE PORT FILTER ASSEMBLY	22	LOCK WASHER	Loss of material[2]	Corrosion (General, Crevice, Pitting, Galvanic)	DSC AMP[2]
219-02-1011	DSC VENT PORT FILTER ASSEMBLY	1	FILTER HOUSING	Loss of material	Corrosion (General, Crevice, Pitting)	DSC AMP
219-02-1011	DSC VENT PORT FILTER ASSEMBLY	5	HEPA TYPE FILTER W/GASKET	Loss of material[2]	Corrosion (General, Crevice, Pitting, Galvanic)	DSC AMP[2]
219-02-1011	DSC VENT PORT FILTER ASSEMBLY	10	DUAL C-SEALS, EG & G PRESSURE SCIENCE (FILTER HOUSING	Loss of material[1]	Corrosion (General, Crevice, Pitting, Galvanic)	Bounded by DSC AMP[1]
219-02-1011	DSC VENT PORT FILTER ASSEMBLY	14	SCREW, CAP SOCKET HD, 1/2 - 13 UNC - 2A X 0.75" LONG	Loss of material[1]	Corrosion (General, Crevice, Pitting)	Bounded by DSC AMP[1]
219-02-1011	DSC VENT PORT FILTER ASSEMBLY	16	SCREW, CAP SOCKET HD, 1 – 8 UNC – 2A X 3.00" LONG	Loss of material[2]	Corrosion (General, Crevice, Pitting, Galvanic)	DSC AMP[2]
219-02-1011	DSC VENT PORT FILTER ASSEMBLY	20	DUAL C-SEALS, EG&G PRESSURE SCIENCE	Loss of material[1]	Corrosion (General, Crevice, Pitting, Galvanic)	Bounded by DSC AMP[1]
219-02-1011	DSC VENT PORT FILTER ASSEMBLY	22	LOCK WASHER	Loss of material[2]	Corrosion (General, Crevice, Pitting, Galvanic)	DSC AMP[2]
Fabrication Specification 219-02-107 [3.11.35]	DSC ASSEMBLY	N/A	WELD FILLER METAL	Loss of material	Corrosion (General, Crevice, Pitting)	DSC AMP

Table 3-5: Applicable Aging Effects and Mechanisms with Aging Management Activities

Drawing Number	Component	Item Num.	Item Description	Applicable Aging Effects	Applicable Aging Mechanisms	AMAs
Fabrication Specification 219-02-107 [3.11.35]	DSC ASSEMBLY	N/A	INORGANIC ZINC-RICH COATING	Loss of Coating Integrity	Blistering, Cracking, Flaking, Peeling, Physical damage	DSC AMP
[1]-These inaccessible area components are located in the Internal DSC Environment and are not explicitly managed as discussed in Sections 3.4.3.2 and 3.4.4.1. [2]-Aging effects management in these areas consists of a defense-in-depth opportunistic inspection only as discussed in Section 3.4.4.4.						
HORIZONTAL STORAGE MODULE (HSM)						
219-02-5100	HSM ISFSI GENERAL ARRANGEMENT	5100-203	BOLT, 3/4-10 UNC-2A X 2" LONG	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5100	HSM ISFSI GENERAL ARRANGEMENT	5100-301	NUT, 1 1/8-7 UNC-2B	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5100	HSM ISFSI GENERAL ARRANGEMENT	5100-305	NUT, 1 1/2-6 UNC-2B	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5100	HSM ISFSI GENERAL ARRANGEMENT	NOTE 10	GROUT - SHIELD WALL PANELS	Spalling, scaling cracking, and Increase in porosity and permeability	Freeze-thaw, Shrinkage	HSM AMP
				-Reduction of concrete strength, modulus and pH -Increase in concrete porosity and permeability	Leaching of Calcium Hydroxide	
219-02-5100/ WO 642973 [3.11.27]	HSM ISFSI GENERAL ARRANGEMENT	NOTE 8	LIFTING STRAND LOOP POCKET FILL	Adhesive Failure Between Chemical Grout and Substrate and Cohesive Failure within Chemical Grout	Premature Degradation (Various)	HSM AMP
219-02-5101	STANDARD MODULE MAIN ASSEMBLY	5101-204	BOLT, 3/4 – 10 UNC – 2A X 2-3/4" LONG	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5101	STANDARD MODULE MAIN ASSEMBLY	5101-206	BOLT, 3/4 – 10 UNC – 2A X 3-1/4" LONG	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5101	STANDARD MODULE MAIN ASSEMBLY	5101-208	BOLT, 1 1/4 – 7 UNC – 2A X 3-1/2" LONG	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5101	STANDARD MODULE MAIN ASSEMBLY	5101-210	BOLT, 1-1/4 – 7 UNC – 2A X 4-1/4" LONG	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5101	STANDARD MODULE MAIN ASSEMBLY	5101-307	NUT, 1-5/8 –5 ½ UNC–2B	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5101	STANDARD MODULE MAIN ASSEMBLY	5101-311	NUT, 1-1/4 –7 UNC – 2B	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5101	STANDARD MODULE MAIN ASSEMBLY	NOTE 16	GROUT - LIFTING STRAND LOOP POCKET FILL	Spalling, scaling cracking, and Increase in porosity and permeability	Freeze-thaw, Shrinkage	HSM AMP
				-Reduction of concrete strength, modulus and pH -Increase in concrete porosity and permeability	Leaching of Calcium Hydroxide	
219-02-5101	STANDARD MODULE MAIN ASSEMBLY	NOTE 2B	WELD FILLER MATERIAL (CATEGORY B COMPONENTS)	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5101/ WO 635917 [3.11.123]	STANDARD MODULE MAIN ASSEMBLY	FDC 7682, FDC 7715	TMI-2 ISFSI HSM ROOF BOLT PROTECTIVE COVER	Loss of Material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5103	HSM STANDARD MODULE BASE UNIT	NOTE 5	REINFORCEMENT BARS, OTHER THAN #4	Loss of material	Corrosion	HSM AMP

Table 3-5: Applicable Aging Effects and Mechanisms with Aging Management Activities

Drawing Number	Component	Item Num.	Item Description	Applicable Aging Effects	Applicable Aging Mechanisms	AMAs
219-02-5103	HSM STANDARD MODULE BASE UNIT	NOTES 1&14	CONCRETE	Spalling, scaling cracking, and Increase in porosity and permeability -Reduction of concrete strength, modulus and pH -Increase in concrete porosity and permeability	Freeze-thaw, Shrinkage Leaching of Calcium Hydroxide	HSM AMP
219-02-5103	HSM STANDARD MODULE BASE UNIT	NOTES 8&18	GROUT – MOUNTING HOLES & EMBEDMENT VOIDS	Spalling, scaling cracking, and Increase in porosity and permeability -Reduction of concrete strength, modulus and pH -Increase in concrete porosity and permeability	Freeze-thaw, Shrinkage Leaching of Calcium Hydroxide	HSM AMP
219-02-5104	HSM ROOF SLAB	NOTE 15	SLOW-RISE POLYURETHANE FOAM FORMULA SPRAY FOAM	Adhesive Failure Between Chemical Grout and Substrate and Cohesive Failure within Chemical Grout	Premature Degradation (Various)	HSM AMP
219-02-5104	HSM ROOF SLAB	NOTE 15	WATER RESISTANT POLYURETHANE FOAM MATERIAL, 6-1/2" X 6-1/2" X 1/8" THICK (NOT ADHESIVE)	Loss of material/Reduction of Material Elasticity	Premature Degradation (Various)	HSM AMP
219-02-5104	HSM ROOF SLAB	NOTE 5	REINFORCEMENT BARS, OTHER THAN #4	Loss of material	Corrosion	HSM AMP
219-02-5104	HSM ROOF SLAB	NOTES 1&11	CONCRETE	Spalling, scaling cracking, and Increase in porosity and permeability -Reduction of concrete strength, modulus and pH -Increase in concrete porosity and permeability	Freeze-thaw, Shrinkage Leaching of Calcium Hydroxide	HSM AMP
219-02-5105	HSM DSC SUPPORT STRUCTURE	5105-101	FRONT MOUNTING PLATE, 1" THICK	Loss of Material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5105	HSM DSC SUPPORT STRUCTURE	5105-102	REAR MOUNTING PLATE, 1" THICK	Loss of Material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5105	HSM DSC SUPPORT STRUCTURE	5105-103	STIFFENER PLATE, 1/2" THICK	Loss of Material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5105	HSM DSC SUPPORT STRUCTURE	5105-104	STIFFENER PLATE, 1/2" THICK	Loss of Material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5105	HSM DSC SUPPORT STRUCTURE	5105-105	SUPPORT PLATE, 1-1/2" THICK X 7" LONG	Loss of Material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5105	HSM DSC SUPPORT STRUCTURE	5105-106	CANISTER STOP PLATE, 1-1/8" THICK	Loss of Material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5105	HSM DSC SUPPORT STRUCTURE	5105-107	SUPPORT RAIL, W12 X 96	Loss of Material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5105	HSM DSC SUPPORT STRUCTURE	5105-109	STIFFENER PLATE, 1/2" THICK	Loss of Material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5105	HSM DSC SUPPORT STRUCTURE	5105-110	RAIL EXTENSION PLATE, 3/4" THICK	Loss of Material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5105	HSM DSC SUPPORT STRUCTURE	5105-111	CROSS BEAM, W6 X 25	Loss of Material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5105	HSM DSC SUPPORT STRUCTURE	NOTE 2	WELD FILLER MATERIAL	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP

Table 3-5: Applicable Aging Effects and Mechanisms with Aging Management Activities

Drawing Number	Component	Item Num.	Item Description	Applicable Aging Effects	Applicable Aging Mechanisms	AMAs
219-02-5105/ Fabrication Specification 219-02-115 [3.11.17]	HSM DSC SUPPORT STRUCTURE	NOTE 5	COATING	Loss of Coating Integrity	Blistering, Cracking, Flaking, Peeling, Physical damage	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-101	PLATE ½" THICK	Loss of Material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-102	ROLLED PLATE 3/8" THICK	Loss of Material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-103	PLATE 1-½" THICK	Loss of Material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-105	MOUNTING PLATE 1" THICK	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-118	PLATE ¾" THICK	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-120	PLATE ½" THICK	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-121	PLATE ½" THICK	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-125	DOOR, PLATE 1-1/2" THICK	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-126	SPACER, PLATE 1-1/2" THICK	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-127	HEAVY DUTY HINGE (REAR ACCESS DOOR)	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-130	ANGLE, L8" X 8" X 1" THICK	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-131	STIFFENER PLATE, ½" THICK	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-135	PLATE, ¾" THICK	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-137	PLATE, ¾" THICK	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-139	TUBE STEEL, 5" X 5" X 3/8" THICK	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP

Table 3-5: Applicable Aging Effects and Mechanisms with Aging Management Activities

Drawing Number	Component	Item Num.	Item Description	Applicable Aging Effects	Applicable Aging Mechanisms	AMAs
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-140	PLATE, 4-½” SQUARE X 1/4” THICK	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-141	SEISMIC RETAINER, TUBE STEEL, 4” X 4” X ½” THICK X 1’-0” LONG	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-148	REAR DSC SUPPORT STRUCTURE LUG PLATE, 2” X 4” X 1” THICK	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-149	SHIELD WALL TIE PLATE, 3/4” THICK	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-154	RICHMOND DOWEL BAR SPLICER (DB-SAE) WITH 1-9/16–8 UN THREAD AND #11 BAR	Loss of material	Corrosion	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-155	WASHER PLATE, 1/2” THICK	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-157	WASHER PLATE, 1/2” THICK	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-158	RICHMOND DOWEL BAR SPLICER (DB-SAE) WITH 1-9/16–8 UN THREAD AND # 11 BAR	Loss of material	Corrosion	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-251	SHIELD WALL CAST-IN-PLACE BOLT, 1 1/8–7UNC – 2A X 1’ – 0” LONG	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-307	NUT, 1 ½” – 6 UNC – 2B	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-308	COUPLING NUT, 1 ½” – 6 UNC – 2B	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-310	NUT, 1 ¼” – 7 UNC – 2B	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-311	COUPLING NUT, 1 ¼” – 7 UNC – 2B	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-313	NUT, 2 – 4 ½ UNC – 2B	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-314	COUPLING NUT, 2 – 4 ½ – 7 UNC – 2B	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-316	NUT, ¾ - 10 UNC – 2B	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP

Table 3-5: Applicable Aging Effects and Mechanisms with Aging Management Activities

Drawing Number	Component	Item Num.	Item Description	Applicable Aging Effects	Applicable Aging Mechanisms	AMAs
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-317	COUPLING NUT, ¾ - 10 UNC – 2B	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-452	WASHER PLATE 6" SQ X 1" THICK	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-506	STUD, 1 ½" – 6 UNC – 2A	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-509	STUD, 1 ¼" – 7 UNC – 2A	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-512	STUD, 2 – 4 ½ UNC – 2A	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-515	STUD, ¾ - 10 UNC – 2A	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-544	SHIELD WALL SUPPORT STUD, 1 1/2–6UNC–2A	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-553	ROOF ATTACHMENT BOLT, ROD Ø 1–5/8"	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-619	NELSON STUD, TYPE S3L, Ø ¾" X 3–3/16" LONG	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	5107-643	NELSON STUD, TYPE H4L Ø 1/2" X 4–1/8" LONG.	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	NOTE 1/ NOTE 18	WELD FILLER MATERIAL (ATTACHES DSC SUPPORT STRUCTURE)	Loss of material	Corrosion (General, Crevice, Pitting)	HSM AMP
219-02-5107	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	NOTE 11	CONCRETE FILL	Spalling, scaling cracking, and Increase in porosity and permeability	Freeze-thaw, Shrinkage	HSM AMP
				-Reduction of concrete strength, modulus and pH -Increase in concrete porosity and permeability	Leaching of Calcium Hydroxide	
219-02-5107/ Fabrication Specification 219-02-115 [3.11.17]	HSM ERECTION HARDWARE AND MISCELLANEOUS STEEL DOORS & FABRICATED FASTENERS	NOTES 2-3, 9-10, 13	COATING	Loss of Coating Integrity	Blistering, Cracking, Flaking, Peeling, Physical damage	HSM AMP
219-02-5108	HSM END MODULE SHIELD WALL	NOTE 1/ NOTE 9	REINFORCEMENT BARS	Loss of material	Corrosion	HSM AMP

Table 3-5: Applicable Aging Effects and Mechanisms with Aging Management Activities

Drawing Number	Component	Item Num.	Item Description	Applicable Aging Effects	Applicable Aging Mechanisms	AMAs
219-02-5108	HSM END MODULE SHIELD WALL	NOTE 1/ NOTE 9	CONCRETE	Spalling, scaling cracking, and Increase in porosity and permeability	Freeze-thaw, Shrinkage	HSM AMP
				-Reduction of concrete strength, modulus and pH -Increase in concrete porosity and permeability	Leaching of Calcium Hydroxide	
TMI-2 KNOCKOUT CANISTER						
02-1150946-C	KNOCKOUT CANISTER UPPER HEAD WELDMENT	1	1150946C POISON TUBE ASSEMBLY	None Identified	None Identified	None Required
02-1150946-C	KNOCKOUT CANISTER UPPER HEAD WELDMENT	2	1150946C TOP END CAP	None Identified	None Identified	None Required
02-1150946-C	KNOCKOUT CANISTER UPPER HEAD WELDMENT	3	1150946C BOTTOM END CAP	None Identified	None Identified	None Required
02-1150946-C	KNOCKOUT CANISTER UPPER HEAD WELDMENT	4	1150946C PIPE 1" ∅ SCHEDULE 160	None Identified	None Identified	None Required
02-1150946-C	KNOCKOUT CANISTER UPPER HEAD WELDMENT	5	1150946C B_4C PELLET	None Identified	None Identified	None Required
02-1150968-D	KNOCKOUT CANISTER BOTTOM SUPPORT PLATE ASSEMBLY	1	1150968D BOTTOM SUPPORT PLATE ASSEMBLY	None Identified	None Identified	None Required
02-1150968-D	KNOCKOUT CANISTER BOTTOM SUPPORT PLATE ASSEMBLY	2	1150950E BOTTOM SUPPORT PLATE	None Identified	None Identified	None Required
02-1154027-F	KNOCKOUT CANISTER INTERNALS ASSEMBLY	1	1154027F KNOCKOUT CANISTER INTERNALS ASSEMBLY	None Identified	None Identified	None Required
02-1154027-F	KNOCKOUT CANISTER INTERNALS ASSEMBLY	2	1155233D POISON TUBE A	None Identified	None Identified	None Required
02-1154027-F	KNOCKOUT CANISTER INTERNALS ASSEMBLY	3	1150946C POISON TUBE B	None Identified	None Identified	None Required
02-1154027-F	KNOCKOUT CANISTER INTERNALS ASSEMBLY	4	1150968D BOTTOM SUPPORT PLATE ASSEMBLY	None Identified	None Identified	None Required
02-1154027-F	KNOCKOUT CANISTER INTERNALS ASSEMBLY	5	1150939D INTERMEDIATE SUPPORT PLATE A	None Identified	None Identified	None Required
02-1154027-F	KNOCKOUT CANISTER INTERNALS ASSEMBLY	7	1150937D SUPPORT RING	None Identified	None Identified	None Required
02-1154027-F	KNOCKOUT CANISTER INTERNALS ASSEMBLY	9	1150954D SEAL PLATE	None Identified	None Identified	None Required
02-1154027-F	KNOCKOUT CANISTER INTERNALS ASSEMBLY	14	1154090C CENTER TUBE	None Identified	None Identified	None Required
02-1154034-F	KNOCKOUT CANISTER INTERNALS & SHELL ASSEMBLY	1	1154034F INTERNALS & SHELL ASSEMBLY	None Identified	None Identified	None Required
02-1154034-F	KNOCKOUT CANISTER INTERNALS & SHELL ASSEMBLY	2	1150945C SHELL (KNOCKOUT & FILTER CANISTER)	None Identified	None Identified	None Required
02-1154034-F	KNOCKOUT CANISTER INTERNALS & SHELL ASSEMBLY	3	1154027F KNOCKOUT CANISTER INTERNALS ASSEMBLY	None Identified	None Identified	None Required
02-1154041-F	KNOCKOUT CANISTER ASSEMBLY	1	1154041F KNOCKOUT CANISTER ASSEMBLY	None Identified	None Identified	None Required
02-1154041-F	KNOCKOUT CANISTER ASSEMBLY	2	1154045D BOTTOM HEAD ASSEMBLY	None Identified	None Identified	None Required
02-1154041-F	KNOCKOUT CANISTER ASSEMBLY	3	1154046F KNOCKOUT CANISTER UPPER HEAD WELDMENT	None Identified	None Identified	None Required

Table 3-5: Applicable Aging Effects and Mechanisms with Aging Management Activities

Drawing Number	Component	Item Num.	Item Description	Applicable Aging Effects	Applicable Aging Mechanisms	AMAs
02-1154045-D	KNOCKOUT & FILTER CANISTER LOWER HEAD ASSEMBLY	1	1154045D CANISTER LOWER HEAD ASSEMBLY	None Identified	None Identified	None Required
02-1154045-D	KNOCKOUT & FILTER CANISTER LOWER HEAD ASSEMBLY	2	1150917D CANISTER LOWER HEAD (KNOCKOUT & FILTER CANISTER)	None Identified	None Identified	None Required
02-1154046-F	FILTER & KNOCKOUT CANISTER SKIRT	1	1154046F KNOCKOUT CANISTER HEAD WELDMENT	None Identified	None Identified	None Required
02-1154046-F	FILTER & KNOCKOUT CANISTER SKIRT	3	1150943E KNOCKOUT CANISTER UPPER HEAD	None Identified	None Identified	None Required
02-1155233-D	KNOCKOUT CANISTER POISON TUBE ASSEMBLY	1	1155233D KNOCKOUT CANISTER POISON TUBE ASSEMBLY	None Identified	None Identified	None Required
02-1155233-D	KNOCKOUT CANISTER POISON TUBE ASSEMBLY	2	1155233D TUBE 2-1/8" OD X 0.065" THICK WALL	None Identified	None Identified	None Required
02-1155233-D	KNOCKOUT CANISTER POISON TUBE ASSEMBLY	3	1155233D BOTTOM END PLUG	None Identified	None Identified	None Required
02-1155233-D	KNOCKOUT CANISTER POISON TUBE ASSEMBLY	4	1155233D TOP END PLUG	None Identified	None Identified	None Required
02-1155233-D	KNOCKOUT CANISTER POISON TUBE ASSEMBLY	5	1155233D B_4C PELLET	None Identified	None Identified	None Required
02-1161301-D	KNOCKOUT CANISTER ASSEMBLY SAR	UFSAR	NOTE 3: WELD FILLER METAL	None Identified	None Identified	None Required
TMI-2 FILTER CANISTER						
02-1150949-D	FILTER CANISTER POISON TUBE ASSEMBLY	1	1150949D POISON TUBE ASSEMBLY	None Identified	None Identified	None Required
02-1150949-D	FILTER CANISTER POISON TUBE ASSEMBLY	2	1150949D; TUBE 2-1/8" OD X 0.065" THICK WALL	None Identified	None Identified	None Required
02-1150949-D	FILTER CANISTER POISON TUBE ASSEMBLY	3	1150949D; BOTTOM END PLUG	None Identified	None Identified	None Required
02-1150949-D	FILTER CANISTER POISON TUBE ASSEMBLY	4	1150949D; TOP END PLUG	None Identified	None Identified	None Required
02-1150949-D	FILTER CANISTER POISON TUBE ASSEMBLY	5	1150949D; B_4C PELLET	None Identified	None Identified	None Required
02-1150959-D	FILTER CANISTER UPPER HEAD WELDMENT	1	1150959D UPPER HEAD WELDMENT	None Identified	None Identified	None Required
02-1150959-D	FILTER CANISTER UPPER HEAD WELDMENT	5	1150958D FILTER CANISTER UPPER HEAD	None Identified	None Identified	None Required
02-1154018-F	FILTER CANISTER ASSEMBLY	1	1154018F FILTER CANISTER ASSEMBLY	None Identified	None Identified	None Required
02-1154018-F	FILTER CANISTER ASSEMBLY	2	1150959D UPPER HEAD WELDMENT	None Identified	None Identified	None Required
02-1154018-F	FILTER CANISTER ASSEMBLY	3	1154045D BOTTOM HEAD ASSEMBLY	None Identified	None Identified	None Required
02-1154020-E	FILTER CANISTER SUB-ASSEMBLY	1	1154020E FILTER CANISTER SUB-ASSEMBLY	None Identified	None Identified	None Required
02-1154020-E	FILTER CANISTER SUB-ASSEMBLY	3	1150945C SHELL	None Identified	None Identified	None Required
02-1154020-E	FILTER CANISTER SUB-ASSEMBLY	6	1150949D POISON TUBE ASSEMBLY	None Identified	None Identified	None Required
02-1161299-D	FILTER CANISTER ASSEMBLY SAR	UFSAR	NOTE 3: WELD FILLER METAL	None Identified	None Identified	None Required

Table 3-5: Applicable Aging Effects and Mechanisms with Aging Management Activities

Drawing Number	Component	Item Num.	Item Description	Applicable Aging Effects	Applicable Aging Mechanisms	AMAs
			TMI-2 FUEL CANISTER			
02-1095753-E	FUEL CANISTER NEUTRON POISON SHROUD	1	18163E100 TUBE ASSEMBLY	None Identified	None Identified	None Required
02-1095753-E	FUEL CANISTER NEUTRON POISON SHROUD	2	18163E100-1 OUTER SKIN	None Identified	None Identified	None Required
02-1095753-E	FUEL CANISTER NEUTRON POISON SHROUD	3	18163E100-2 INNER SKIN	None Identified	None Identified	None Required
02-1095753-E	FUEL CANISTER NEUTRON POISON SHROUD	4	18163E100-3 BORAL®	None Identified	None Identified	None Required
02-1150998-E	FUEL CANISTER BOTTOM PLATE ASSEMBLY	1	1150998E FUEL CANISTER BOTTOM PLATE ASSEMBLY	None Identified	None Identified	None Required
02-1150998-E	FUEL CANISTER BOTTOM PLATE ASSEMBLY	2	1150992E BOTTOM PLATE	None Identified	None Identified	None Required
02-1150999-F	FUEL CANISTER LOWER ASSEMBLY	1	1150999F FUEL CANISTER LOWER ASSEMBLY	None Identified	None Identified	None Required
02-1150999-F	FUEL CANISTER LOWER ASSEMBLY	2	1095753E BORAL® SHROUD ASSEMBLY	None Identified	None Identified	None Required
02-1150999-F	FUEL CANISTER LOWER ASSEMBLY	3	1154014F FUEL CANISTER BULKHEAD	None Identified	None Identified	None Required
02-1150999-F	FUEL CANISTER LOWER ASSEMBLY	5	1150983C FUEL CANISTER SHELL	None Identified	None Identified	None Required
02-1150999-F	FUEL CANISTER LOWER ASSEMBLY	6	1154045D LOWER HEAD ASSEMBLY	None Identified	None Identified	None Required
02-1150999-F	FUEL CANISTER LOWER ASSEMBLY	7	1150998E BOTTOM PLATE ASSEMBLY	None Identified	None Identified	None Required
02-1150999-F	FUEL CANISTER LOWER ASSEMBLY	9	1150999F CONCRETE MIX	None Identified	None Identified	None Required
02-1154026-F	FUEL CANISTER HEAD WELDMENT	1	1154026F FUEL CANISTER HEAD WELDMENT	None Identified	None Identified	None Required
02-1154026-F	FUEL CANISTER HEAD WELDMENT	2	1150989F FUEL CANISTER UPPER HEAD	None Identified	None Identified	None Required
02-1154026-F	FUEL CANISTER HEAD WELDMENT	4	1150993C SHOCK ABSORBER SUPPORT	None Identified	None Identified	None Required
02-1154026-F	FUEL CANISTER HEAD WELDMENT	5	1150995C IMPACT PLATE "D"	None Identified	None Identified	None Required
02-1154026-F	FUEL CANISTER HEAD WELDMENT	7	1150994C IMPACT PLATE "C"	None Identified	None Identified	None Required
02-1154026-F	FUEL CANISTER HEAD WELDMENT	12	1154021C FUEL CANISTER BOLT	None Identified	None Identified	None Required
02-1154070-F	FUEL CANISTER ASSEMBLY	1	1154070F FUEL CANISTER ASSEMBLY	None Identified	None Identified	None Required
02-1154070-F	FUEL CANISTER ASSEMBLY	2	1150999E FUEL CANISTER LOWER ASSEMBLY	None Identified	None Identified	None Required
02-1154070-F	FUEL CANISTER ASSEMBLY	3	1154026F FUEL CANISTER UPPER HEAD WELDMENT	None Identified	None Identified	None Required
02-1161300-D	FUEL CANISTER ASSEMBLY SAR	UFSAR	NOTE 3: WELD FILLER METAL	None Identified	None Identified	None Required

3.4 AMR RESULTS – DSC

This section summarizes the results of the AMR for the DSCs. The DSC and its SSCs, along with the license renewal intended functions for these SSCs, are described in the scoping evaluation summarized in Section 2.3.2.1.

3.4.1 Description of DSC

The DSC is a high integrity welded pressure vessel that consists of a 5/8-in. thick cylindrical shell with top and bottom end assemblies. The top and bottom end assemblies include a shield plug, with the bottom including an inner cover plate. The DSC contains the TMI-2 Canisters. The NUHOMS®-12T DSC design is illustrated in Figure 4.2-4 through Figure 4.2-7 of the UFSAR [3.11.2].

The main component of construction of each DSC is the cylindrical shell. The DSC cylindrical shell serves as a portion of the confinement boundary and consists of a rolled and welded plate. The DSC cylindrical shell is constructed using two pieces of rolled plate, with either two full-length longitudinal seams, or two half-length longitudinal welds and a circumferential weld. The circumferential and longitudinal shell plate weld seams are fabricated using multi-pass, full penetration butt welds compliant with ASME Code, Section III, Subsection NB [3.11.81] with exceptions noted in Table 4-1 of the UFSAR TS [3.11.2].

The DSC shell, and top and bottom end assemblies enclose a non-structural basket assembly. The DSC basket is considered a nonstructural, non-load bearing system of plates that is included in the DSC for operational convenience in the loading of the TMI-2 Canisters. The basket assembly is not designed to provide structural support to the TMI-2 Canisters during off-normal or accident loading conditions. However, the DSC basket is credited during license renewal with indirectly providing locational support for the TMI-2 Canisters in their shielding function. The shield plugs at each end of the DSC provide radiological shielding when the DSC is in the TC or HSM.

The top shield plug is placed into the DSC after the TMI-2 Canisters are loaded and then using the AWS, the plug is welded to the DSC shell completing the inner confinement boundary. The top shield plug rests on a support ring, which is welded to the interior circumference of the DSC shell. The top cover plate is placed on top of the top shield plug and is welded to the DSC shell to form a redundant seal. The plates are seal welded together at the purge and vent ports to provide redundant closures. Both welded joints for the top shield plug and the top cover plate act as barriers for confining all radioactive material within the DSC throughout the service life of the DSC.

The top shield plug and top cover plate includes vent and purge access ports. The vent penetration is terminated at the bottom of the shield plug assembly. The vent port accesses the DSC in the headspace immediately above the top of the TMI-2 Canisters. This allows for direct removal of any gases emitted by the TMI-2 Canisters. The purge port is attached to a tube, which continues to the bottom of the DSC cavity. The purge port tube allows for gas circulation in the system and for complete purging of the DSC if, as discussed in Section 4.3 of the UFSAR and per the requirements in TS LCO 3.2.3, any hydrogen build-up greater than the LCO limit is measured [3.11.113]. The vent and purge ports include offsets to prevent radiation streaming with the vent port shield block providing a shielding function and the purge port block offering locational support to the TMI-2 Canisters in their shielding role. The vent and purge ports terminate in double-gasketed sealed heads that contain the HEPA grade filters. This HEPA filter design was originally developed for long-term hydrogen gas venting of radiological waste containers and is completely passive.

The bottom end assembly consists of the inner bottom cover plate, the bottom shield plug, and the outer bottom cover plate. The bottom shield plug is placed into the bottom end of the DSC during fabrication. It is encased between the inner bottom and outer bottom cover plates.

Following DSC fabrication, leak tests of the DSC shell assembly were performed consistent with the provisions of ANSI N14.5, "American National Standard for Radioactive Materials - Leakage Tests on Packages for Shipment" [3.11.23] [3.11.12]. In addition, according to Section 4.7.3.1 of the UFSAR [3.11.2], a leak test was performed prior to transportation from the TAN facility. After the DSC was sealed, the DSC cavity was evacuated and backfilled with helium to perform leak testing of the closure welds. The seal welds were inspected and leak tested to ensure that any flow of gases in or out of the DSC during storage is through the HEPA filters (Section 3.1.2 of [3.11.2]).

Extraction and insertion of the DSC from the HSM and into the TC and vice versa is performed by grappling the ring plate with the HRS. The grapple ring assembly is composed of a ring and an end plate with a hole and is welded to the bottom cover plate of the DSC. This grapple assembly prevents significant deformation and bending stresses in the DSC bottom cover plate and shell during handling and is necessary for DSC retrieval.

3.4.2 DSC Materials Evaluated

(NUREG-1927, Section 3.2 and Section 3.4.1.1)

The materials of construction for the DSC's subcomponents are summarized in Table 3-4 and described in detail below.

Consistent with the DSC documentation package [3.11.68], the in-scope structural SSCs of the DSCs are primarily constructed from ASME SA-516, Grade 70 carbon steel [3.11.67]. In addition, non-structural SSCs (e.g., shield plugs, filter housings) are designated as plain carbon steel. The in-scope attachment hardware on the purge and vent filter housings securing the filter housings to the DSC are austenitic stainless steel (ASME SA-193, Grade B8, Class 1A) [3.11.69], [3.11.68] consistent with Section 5.2.1.B of the DSC fabrication specification [3.11.35]. Except as described in Section 3.4.2.1, the carbon steel SSCs of the DSCs are coated with an inorganic zinc-rich primer coating (CARBOZINC® 11 or CARBOZINC® 11 HS) for corrosion protection [3.11.35]. The materials and coatings are the same for DSC SSCs on both the exterior as well as on the interior. The thickness of the zinc primer coating ranges from 2-6 mils with a single coat and 4-12 mils with two coats, giving a minimum acceptable thickness of 2 mils [3.11.36].

On the other hand, the HEPA filters which are screwed into the filter housings consist of sintered stainless steel filter media encased in stainless steel bodies. The filter media is certified to have an efficiency of greater than 99.97% for particulate down to 0.3 microns (UFSAR Section 3.1.2) [3.11.2]. This filter media material is welded into the threaded stainless steel filter body, which in turn is threaded into the filter housings. Using a single elastomeric gasket under the flange of the HEPA filter body and situated against the filter housing, the gasket seal is made of neoprene [3.11.51].

3.4.2.1 Extent of Zinc-Rich Primer Coating

By design, several areas of the DSC SSC surfaces are not coated with the zinc primer coating. Section 5.6.2 of the DSC Fabrication Specification [3.11.35] states that the, "field weld closure end preparations and the surfaces to be field fillet welded (plus ½" margin on both sides of the minimum specified weld sizes) shall not be coated" with the zinc primer. The exposed surfaces include the field-welded area of the top of the shell, Top Shield Plug Plate, and edge of the Top Cover Plate. Based on photographs of the external shell, this zone was estimated to be 6 inches in length. This zone begins at the lid end, starting from the shield plug weld and extending to the front edge of the shell. However, these surfaces were blast cleaned and covered with a "readily strippable material" to prevent corrosion prior to welding [3.11.35]. This was necessary to protect the surfaces prior to DSC storage such as during fabrication, shipping, and preliminary operations. The readily strippable material specified is Plastisol (a PVC resin dispersed within a plasticizer to make it conformable). Consistent with the American Boiler Works (ABW) Visual Testing Procedure, the minimum specified thickness of the Plastisol coating was 1 mil [3.11.36], making it demonstrable as being "readily strippable". The three DSC SSC field-welded locations that had the Plastisol applied were:

1. Top edge of the DSC shell (Item 1 on FSAR Drawing 219-02-2001)
2. Edge of the DSC top shield plug plate (Item 2 on FSAR Drawing 219-02-2003)
3. Edge of the DSC top cover plate (Item 3 on FSAR Drawing 219-02-2003)

A review of all the DSC seal welding records (e.g., TPR-6477 [3.11.202]) indicates the Plastisol was completely removed during field weld preparation cleaning. Other intentionally uncoated surfaces include threaded surfaces and interior surfaces of the vent and purge lines and the axial basket supports that cannot be coated by the zinc-rich primer. Finally, machined sealing surfaces were not coated with the zinc-based coating or Plastisol. This would include locations around the vent and purge port seals. Rather, these areas were protected immediately after leak testing with a thin film of vacuum grease.

In addition, after installation of the DSC into the HSM, there were a few areas identified in the pre-application inspections where the coating had been scraped off (See Section 3.2.3.1). Therefore, compromised coating areas may include any scratches or marring occurring during fabrication or operations such as when the basket and TMI-2 Canisters were lowered into the DSC or when the DSC was pushed into the HSM.

3.4.3 Environments for the DSC

(NUREG-1927, Section 3.2 and Section 3.4.1.1)

The environments that affect the DSC subcomponents, both externally and internally, are those that are normally (i.e., continuously) experienced by the DSCs and are summarized in Section 3.3.1.2 and Table 3-4 and are described in detail below.

3.4.3.1 External

Each DSC is positioned for long-term storage inside an HSM. As such, the external surfaces of the DSC (shell, top and bottom outer cover plates, grapple assembly, and associated welds) are exposed to the HSM interior (i.e., Sheltered Environment of Sections 3.3.1.2 and 3.5.3). This is a protected environment with no direct exposure to sun, wind, or precipitation. The Sheltered Environment may contain moisture and other contaminants from the external ambient air.

The maximum initial (at the beginning of storage) temperature, using the 45°F and 87°F normal ambient temperatures for the thermal model described in Section 8.1.1.1.D of the UFSAR, on the exterior of the DSC shell, from UFSAR Table 8.1-9 [3.11.2] is 134°F at the top outer surface of the DSC. As discussed in Section 3.3.1.2.3, the minimum temperature for DSC S/N DOE12T-002, containing eight TMI-2 Filter Canisters with negligible decay heat load is the ambient temperature. As shown in Table 3-3 and discussed in Section 3.3.1.2.3 (at initiation of PEO in 2019), using 12 average decay heat load TMI-2 Fuel Canisters with convective effects included in the HSM interior, maximum surface temperatures on the DSC shell exterior in July are just under 74°F, with average DSC shell temperatures ranging from 21.6°F in January to 71.7°F in July. The minimum average temperature of a DSC with negligible heat (i.e., DSC S/N DOE12T-002) are considered identical to the minimum average monthly temperature of the ambient air indicated as 4°F in January (listed in Section 3.3.1.2). All of these reported surface temperatures continuously decrease from the beginning of PEO through the end of the PEO.

The DSC shell is exposed to neutron and gamma radiation. Section 3.3.1.2.2 discusses the analyses performed to evaluate the effects of neutron fluence and gamma radiation on the mechanical properties of the TMI-2 NUHOMS®-12T System SSCs. Bounding sources and bounding MCNP models are used in order to envelop the DSC with or without the neutron startup sources [3.11.24]. The total irradiation time (service life) of the DSC shell is assumed integrated over 60 years (See Section 3.3.1.2.2) with no credit taken for source strength decay over the period. The calculated maximum neutron fluence on the DSC shell assembly is 1.98×10^{14} neutrons/cm^2 with the Am-Be-Cm startup neutron source, while the computed gamma energy deposition is 4.42×10^8 rad with the distributed gamma radiation source.

3.4.3.2 Internal

There are two environments applicable to the interior of the DSC. The first interior environment is the "Encased Environment" identified in Section 3.3.1.2. This environment is limited to four specific locations on the SSCs:

1. The volume between the bottom inner and outer plates (the entirety of the bottom shield plug occupies this volume).
2. The volume between the top shield plug 3/16-in. bevel field weld and the top cover plate and its V-groove field weld to the shell. Two boundaries of this volume are the all-around seal welds at the vent and purge port locations. The circumferential top shield plug weld, top cover plate weld, and the two seal weld joints bound this sealed air volume.
3. Item 14 on the Vent and Purge Port Assemblies ([3.11.77] & [3.11.78]) is a sample port bolt that is sealed off (except for the bottom bolt shank surface) by the Filter Housing Body and the Item 7, Sample Tube Plug.
4. The 1-1/2-in. diameter internal support rods for the basket which are encased within an outer pipe sleeve.

The Encased Environment is characterized as a dry, air-filled environment. The moisture in these volumes is limited to that present when the welds were applied at the fabricator or in the field in case of the top cover plate field welds. As such, the moisture content consists of that volume retained in the zones when they were welded in place. However, the sample port bolt Encased Environment is limited to the moisture concentration present in the sample port cavity air after hydrogen sampling through the port ended circa 2003 (See Section 3.3.1.2.1).

The second and higher volume environment for the interior of the DSC is defined as the "Internal DSC Environment" as identified in Section 3.3.1.2. The internal SSCs and surfaces of the DSC (shell, HEPA filter and housing, inner bottom cover plate, top shield plug plates, vent port shield block, basket, purge port block, sample port bolt, and associated welds) are exposed to the Internal DSC Environment inside the DSC cavity. The interior environment is the product of the exchange of air and moisture between the exterior Sheltered Environment and of radiolysis and chemical processes within the DSC. Any radiolytic production of hydrogen is due to interactions within the TMI-2 Canisters between any remaining bound water and the core debris radiation. The chemical aging processes within the DSC are due to oxidation of the sacrificial zinc coating applied to the interior DSC SSCs, in addition to any limited corrosion processes of the TMI-2 Canisters, including their contents.

The thermal and radiological environments of the Internal DSC Environment are conjoined by that of the Sheltered Environment in Section 3.4.3.1 and the Internal TMI-2 Canister environment in Section 3.8.3.1. In terms of conditions required for aging, the Internal DSC Environment is similar to, but less severe than the exterior DSC Sheltered Environment. This is due to the following reasons:

1. There is a lag between changes in the Sheltered and Internal DSC Environments due to the required diffusion through the HEPA filters.
2. Any corrosion of interior materials, especially the sacrificial zinc primer coating will reduce the Internal DSC Environment moisture and oxygen concentration, reducing the oxidation of the remaining SSCs.
3. The slight increase in heat loads in the Internal DSC Environment due to radioactive decay of the core debris will cause the internal surfaces of the DSC to be at a neutral to slightly positive temperature gradient with respect to the exterior surfaces (See Table 3-3), resulting in a net neutral to slightly negative differential in likelihood of condensation formation with respect to internal and external surfaces of the DSC.

The Internal DSC Environment is therefore a more benign environment with respect to exposure to external effects, including condensation and thus potential for degradation effects than the "Sheltered Environment", which the exterior elements of the DSC are exposed. Therefore, the conditions on the Sheltered Environment DSC SSC surfaces bound those conditions occurring on the Internal DSC Environment SSC surfaces.

3.4.4 DSC Aging Effects

(NUREG-1927, Section 3.2 and Section 3.4.4)

This section describes the aging effects that could, if left unmanaged, cause degradation of DSC SSCs and result in loss of SSC intended functions. As such, applicable unmanaged aging effects could result in loss of intended functions for the DSC SSCs. Aging mechanisms that could lead to aging effects for DSC SSCs were determined using technical literature, related industry research, and existing OE. Aging mechanisms were evaluated to determine if the mechanisms could lead to an aging effect requiring management. Applicable aging effects and aging mechanisms for DSC SSCs are summarized in Section 3.4.4.6 and are listed in Table 3-5.

3.4.4.1 Identification of Aging Effects/Mechanisms

As discussed in Section 3.4.2, the DSC is constructed almost entirely of carbon steel. The DSC SSCs are constructed of ASME SA-516, Grade 70 plain carbon steel (with the exception being the HEPA filters and Purge/Vent Filter Housing Attachment Bolts, which are fabricated from stainless steel). The environments of the DSC subcomponents are described in Section 3.4.3 with the exterior surfaces of the DSC shell, Top Cover Plate, and Outer Bottom Cover Plate and the entirety of the Grapple Ring SSCs exposed to the Sheltered Environment of the HSM. The Basket, Purge Port Block, Vent Port Shield Block and interior surfaces of: DSC shell, Inner Bottom Cover Plate, HEPA Filter, HEPA Filter Housings, and Sample Port Bolt are exposed to the Internal DSC Environment. In addition, the Top Shield Plug plates 1 & 2 and the interior side of the Top Shield Plug Plate 3 are exposed to the Internal DSC Environment.

The majority of the applicable aging mechanisms discussed in Section 3.4.4.2 will affect all of these DSC SSCs to some extent. Therefore, the applicable aging mechanisms discussed are operative on both the internal and external surfaces of the DSC albeit to either an equivalent or lesser degree on the internal as stated in Section 3.4.3.2. As a result, aging effects representative of those portions of DSC SSCs in the Sheltered Environment bounds those portions of DSC SSCs in the Internal DSC Environment. This is due to the nature of the Internal DSC Environment being equal to or more benign than the Sheltered Environment (as described in Section 3.4.3). Therefore, the exposed surfaces of the Sheltered Environment are considered representative of degradation processes within the Internal DSC Environment. This indicates that the rate of corrosion on the DSC interior is less than or equal to the rate of corrosion on the DSC exterior.

Exceptions to aging effects on particular SSC surfaces bounded by the Encased Environment are as described in Section 3.4.4.3. In addition, aging effects management for those SSCs providing exclusively a confinement function for the vent/purge filter assemblies, is discounted in Section 3.4.4.4.

The aging effects that could cause loss of intended functions are:

- Loss of Material
- Cracking
- Change in Material Properties

Each aging effect and causative mechanism is summarized in the following subsections: 3.4.4.1.1, 3.4.4.1.2, and 3.4.4.1.3. Aging mechanisms are then each evaluated in Section 3.4.4.2 to determine if the mechanisms could lead to an aging effect requiring management.

3.4.4.1.1 Loss of Material Aging Effects Assessment

- Loss of Material due to General Corrosion
- Loss of Material due to Crevice Corrosion
- Loss of Material due to Pitting Corrosion
- Loss of Material due to Galvanic Corrosion
- Loss of Material due to Microbiologically Induced Corrosion
- Loss of Material due to Wear

3.4.4.1.2 Cracking Aging Effects Assessment

- Cracking due to SCC
- Cracking due to Thermal Fatigue
- Cracking due to Hydrogen Damage

3.4.4.1.3 Change in Material Properties Aging Effects Assessment

- Change in material properties due to Intergranular Corrosion
- Change in material properties due to Creep
- Change in material properties due to Thermal Aging
- Change in material properties due to Irradiation Embrittlement
- Change in material properties due to Hydrogen Damage

3.4.4.2 Discussion of Aging Mechanisms

3.4.4.2.1 General Corrosion

DSC carbon steel surfaces in contact with moist air or condensed water vapor are subject to general corrosion. The majority of the DSC carbon steel parts are exposed to both the Sheltered Environment of the HSM and the Internal DSC Environment. The exceptions are the Bottom Shield Plug and the Shield Plug facing sides of the Inner and Outer Bottom Cover Plates (exposed to the Encased Environment as discussed in Section 3.4.4.3) and the Grapple Ring SSCs (exposed only to the Sheltered Environment). In addition, the only SSCs exposed exclusively to the Internal DSC Environment are the Basket (with exception to the radial surfaces of the Basket Support Rods which are encased within the basket pipe sleeve tube), Purge Port Block and Vent Port Shield Block.

The IFSF dry storage facility described in Section 3.2.2.2 has a similar environment to the TMI-2 ISFSI. The protected SNF containers in both facilities (DSC for the TMI-2 ISFSI) are shielded from the elements (rain, snow, etc.) with both facilities' containers being exposed to ambient outside air. Therefore, both facilities are expected to have similar corrosion rates due to the moisture brought in by the air. Based on corrosion coupon data [3.11.91] discussed in Section 3.2.2.2.4, the maximum carbon steel general corrosion rate measured for the IFSF was 0.0365 mpy on coupon "CS-168." The average uniform carbon steel corrosion rate associated with a 95% confidence level for the IFSF corrosion coupons was 0.0356 ± 0.0121 mpy (Table A-2 of [3.11.91]). This average rate was based on two ASTM A36 corrosion coupons with corrosion evaluated over a 4-year period from 2011 – 2015. A uniform corrosion allowance over the 50-year design basis period is provided in the DSC structural evaluations (See Section 1.3.1). For the DSC shell, the allowance is 75 mils, while for both the top and bottom outer cover plates it is 10 mils on each (Section 2.2 of [3.11.92]). This equates to an averaged design basis allowance of 1.87 mpy and 0.25 mpy on each of these DSC SSCs over the combined initial license period plus the PEO, respectively. The IFSF general corrosion rates are both less than the allowed rate in the DSC SSC design basis. In addition, as described in Section 3.2.2.2.3, the highest corrosion rate measurements on actual samples of carbon steel canisters from the IFSF stored 31 years in a similar environment was 0.060 mpy, which is lower than the minimum 0.25 mpy design basis allowance indicated above.

The rate of general corrosion on the DSC SSCs is governed by several factors, such as the moisture of the air, the salinity level of the air, the temperature of the metal surface, and the specific type of metal involved. As described in Section 3.8.3.3, atmospheric chlorides for the TMI-2 ISFSI site are categorized as very low. Based on borescope inspections described in Section 3.2.2.2.4, the overall rate of uniform corrosion on the DSC SSCs has been low, as expected. The rate is limited by sacrificial cathodic protection provided by the zinc-rich inorganic corrosion coating. The exposed DSC surfaces (to either the Sheltered or Internal DSC Environments) are coated with the zinc-rich inorganic corrosion protection coating with exceptions as indicated in Section 3.4.2.1. Since iron is cathodic to zinc, uniform general corrosion has occurred for the most part on the carbon steel DSC surface areas unprotected by the zinc-rich coating. Despite the observed IFSF corrosion rates being less than the allowed design basis rates, general corrosion has been observed on DSC surfaces. Therefore, loss of material due to general corrosion of DSC SSCs in the Sheltered Environment is an aging mechanism that will be managed during the PEO.

3.4.4.2.2 Crevice Corrosion

Crevice corrosion occurs when a corroding metal is in close contact with anything that makes a tight crevice. Crevice corrosion is an intense, localized corrosion within crevices or shielded areas. It occurs most frequently in connections, lap joints, splice plates, bolt threads, under bolt heads, or points of contact between metals and non-metals, and it is associated with a stagnant or low flow solution (an electrolyte). To function as a corrosion site, the crevice must be wide enough to permit liquid entry and narrow enough to maintain a stagnant zone, typically a few thousandths of an inch or less [3.11.72].

Crevice corrosion is strongly dependent on the presence of dissolved oxygen. Any surface exposed to atmospheric conditions will be saturated in oxygen above the threshold levels for crevice corrosion to occur (0.1 parts per million (ppm)). This form of corrosion, as the name implies, requires a crevice in which contaminants and corrosion products can concentrate. In addition to oxygen, moisture is required for the mechanism to operate. Typically, atmospheric pollutants and contaminants, both indoors and outdoors, are insufficient to concentrate and thereby promote crevice corrosion. Alternating wetting and drying is particularly harmful because this leads to a concentration of atmospheric pollutants and contaminants [3.11.72].

As covered in Section 3.2.2.2.4, the IFSF first set of 1020 carbon steel corrosion coupons in 2013 had average crevice corrosion rates of 0.0475 ± 0.004 mpy. Two years later in 2015, the average ASTM A36 carbon steel crevice corrosion rates were 0.0364 ± 0.0172 mpy. Taking the higher of these two values, using the upper end tolerance, and multiplying by two (corrosion from both inner and outer DSC surfaces) provides a maximum total crevice corrosion rate of 0.107 mpy, which is lower than the 0.25 mpy uniform corrosion rate allowed on the DSC outer cover plates per the structural calculation [3.11.92]. Of course, this is a conservative value as it assumes equal amounts of maximum corrosion on identical locations on both sides of a DSC surface. However, the allowed corrosion rates in the UFSAR are an allowable uniform corrosion rate, not an allowable crevice corrosion rate.

Also, related to the crevice corrosion aging mechanism, decay heat will heat the air reducing the condensation of moisture for some DSCs. However, because the DSC decay heat will progressively decrease during the PEO, the presence of moist air cannot be ruled out. Air with enough moisture can facilitate the loss of material in steel caused by crevice corrosion. The zinc-based protective coating will help to mitigate the initiation of crevice corrosion during the PEO. However, after initiation of a coating defect, the coating could function as a crevice former and initiate crevice corrosion. Because steel DSC subcomponents exposed to the Sheltered Environment may be exposed to aqueous electrolytes, and the localized corrosion in this environment is possible, loss of material due to crevice corrosion is considered credible. Therefore, aging management of DSC surfaces in the Sheltered Environment for Crevice corrosion aging mechanisms is required during the PEO.

3.4.4.2.3 Pitting Corrosion

Pitting corrosion is an extremely localized corrosive attack in aqueous environments containing dissolved oxygen and chlorides. When passivity breaks down at a spot on a metal surface, an electrolytic cell is formed with the anode at the minute area of active metal and the cathode at the considerable area of passive metal. The large electric potential difference between the two areas accounts for considerable flow of current with rapid corrosion at the anode. The anode does not spread because it is surrounded by passive metal, and as the mechanism continues, it penetrates deeper into the metal, forming a pit. Pitting corrosion is less common with non-passive materials, such as carbon steels [3.11.72]. Pits can be either hemispherical or cup-shaped. Pitting corrosion can produce pits with their mouth open, uncovered, or covered with a semipermeable membrane of corrosion products.

Oxygen is required for pitting initiation. Areas in which aggressive species can concentrate, that is, locations of frequent or prolonged wetting or of alternate wetting and drying, are particularly susceptible to pitting. Pitting is predominantly the result of halide contamination, with chlorides, bromides, and hypochlorites being prevalent [3.11.72]. Pitting corrosion can be initiated by,

1. Localized chemical or mechanical damage to the protective oxide film. This is caused by moisture chemistry factors, which can cause breakdown of a passive film, such as acidity, low dissolved oxygen concentrations (which tend to render a protective oxide film less stable), and high concentrations of chloride.
2. Localized damage to, or poor application of, a protective coating.
3. The presence of non-uniformities in the metal structure of the component, e.g., nonmetallic inclusions.

Air with enough moisture can facilitate the loss of material in carbon steel caused by pitting corrosion. Decay heat will heat the air reducing the accumulation or condensation of moisture for some DSCs. However, because the DSC decay heat will progressively decrease during the PEO, the presence of moist air cannot be ruled out. The protective zinc coating will help to mitigate the initiation of pitting during the PEO. However, depending on the quality, chemical composition, and application of the coating, moisture could permeate coating defects, initiating pitting. Pitting action will be self-limiting as there will be limited mechanisms for removal of self-protective oxide films formed at potential corrosion sites within the DSC environments. The DSC HEPA filters will also minimize or eliminate contaminants from entering the Internal DSC Environment. As described in Section 3.8.3.3, atmospheric chlorides for the TMI-2 ISFSI site are categorized as very low. Any pitting corrosion on the exposed surfaces of the Sheltered Environment will be low and will be greater than or equal to that in the Internal DSC Environment. Therefore, aging management of DSC SSC surfaces in the Sheltered Environment for the mechanism of pitting corrosion is required during the PEO.

3.4.4.2.4 Galvanic Corrosion

Galvanic corrosion occurs when two or more metals of differing electrochemical potential are in electrical contact in a conductive fluid (the presence of an electrolyte). Under these conditions, an electrolytic cell is formed, transmitting an electrical current between an anode and a cathode. Loss of material occurs when ions of the metal with the lower potential, the anode, are being depleted and deposited onto the more noble metal, the cathode. Galvanic corrosion will not occur in a dry environment; an electrolyte must be present and remain liquid. The ratio between surface areas of the metals in contact is of key import. Corrosion rates increase when the more noble metal has a greater surface area than the more active metal in the presence of moisture [3.11.72].

The DSC is fabricated almost entirely of carbon steel. Potential sites of galvanic corrosion are:

1. Possible contact between the TMI-2 Canisters and either the inner bottom cover plate or the top shield plug
2. Interface between the HEPA filters and the DSC
3. Interface between the fasteners attaching the Purge and Vent Port Housings to the DSC
4. Graphite lubricant (Neolube 1) (Section 3.3.1 of [3.11.153]) used between the HSM hardened support rail faces with DSC Shell

Potential galvanic corrosion at site 1 above is limited for three reasons: the first reason is that the Anode-to-Cathode ratio for the TMI-2 Canister lower or upper heads with either the DSC inner bottom cover plate or the top shield plug is large. This corrosion site is hypothetical given the fact that the end of the TMI-2 Canister (either the top end or bottom end) may contact one end of the DSC but not both. Both DSC cover plate zinc-coated carbon steel surface areas are much greater than the potential contact area for 12 TMI-2 Canisters. This contact area on the upper head of the TMI-2 Canister consists of the skirt which is a 14-in. OD, ¼-in. wall pipe. The lower head contact area of the TMI-2 Canister is the reversed-dish radial contact circle. The second reason for limited galvanic potential is since the DSC and TMI-2 Canister are loaded horizontally, there is nothing maintaining contact force between the two bodies. As such, any initial corrosion potential between the two will end after the initial corrosion oxidation layer is formed. Finally, the fact that the DSC carbon steel surfaces are coated with the more noble zinc-based anodic coating will act to protect the carbon steel base material with any preferential corrosion occurring within the zinc coating instead.

Potential galvanic corrosion at sites 2 and 3 above is discounted based on the exclusive confinement function those SSCs perform and the maintenance of those SSCs. This is discussed in Section 3.4.4.4.

Therefore, galvanic corrosion will not be treated as an aging mechanism requiring management for the above affected areas of DSC SSCs for the PEO.

Potential galvanic corrosion of the DSC steel shell at site 4 above is limited for three reasons:

1. The purpose of the zinc-based primer coating on the DSC shell is to act as sacrificial protection for the iron in the steel. As such, any postulated galvanic corrosion occurs preferentially between the zinc coating and the out-of-scope graphite lubricant, prior to base metal corrosion.
2. Galvanic corrosion will be limited in the dry Sheltered Environment of the TMI-2 ISFSI due to the lack of moisture, although absence of moisture cannot be ruled out entirely.
3. The contact area between the lubricant and DSC shell outer surfaces is indeterminate but likely is sporadic and minimized due to the lubricant being liquid in nature and the DSC shell contacting the rail faces without lubricant in many areas. The black streaks in Figure 3-4 shows how the lubricant ran down the sides of the rails, post installation.

However, because the graphite lubricant is noble relative to the steel base metal and zinc-based coating of the DSC shell (See Figure 3-8), the possibility exists of inducing galvanic corrosion of the steel DSC shell or zinc coating. This could occur in the areas where the zinc coating was scuffed during loading. The zinc coating is also not credited in the UFSAR corrosion evaluation since there already is a corrosion allowance of 75 mils on the DSC shell. Therefore, loss of material due to galvanic corrosion of the DSC shell with the graphite lubricant is an aging effect requiring management for the DSC shell during the PEO.

3.4.4.2.5 Microbiologically Influenced Corrosion

Microbiologically influenced corrosion, also known as microbial corrosion or biological corrosion, is the deterioration of metals because of the metabolic activity of microorganisms. These microorganisms or bacteria can be broadly classified as aerobic (requires oxygen to become active) or anaerobic. Sulfate-reducing bacteria are anaerobic and are responsible for most instances of accelerated corrosion damage [3.11.73]. For instance, sulfate-reducing bacteria are of primary concern in wet, cool, and anoxic environments [3.11.76]. Active microbial metabolism requires water in the form of water vapor, condensation, or deliquescence, and available nutrients to support the microbial activity [3.11.76]. Microbiologically influenced corrosion has been found to be operable within a temperature range of 23 to 230°F (Section 3.2.1.4 of [3.11.76]). Microbiologically influenced corrosion acts as a precursor to localized corrosion effects, such as pitting [3.11.53].

Microbiologically induced corrosion is not expected to be an issue for carbon steel SSCs at the TMI-2 ISFSI because the requisite conditions for microbes to flourish do not exist. As indicated in Section 3.3.1.2, the humidity at the TMI-2 ISFSI is low during most of the year (< 70% on average), and condensation is only present for a few months in the winter when the mean air temperature approaches the mean dew point temperature (Figure 3-7). Microbiologically induced corrosion is limited where relative humidity is below 90% and negligible for relative humidity below 60% (pg. 239 of [3.11.75]). There is no OE of microbiologically induced corrosion degradation of carbon steel when continuously exposed to a relative humidity below 90% [3.11.76]. Since the TMI-2 ISFSI has an average relative humidity ranging from 30-70%, microbiologically induced corrosion is not a credible aging effect on the DSC SSCs for the PEO. Therefore, microbiologically influenced corrosion is not an aging mechanism requiring management during the PEO.

↑ LEAST NOBAL [SIC] (ANODIC)

MOST NOBAL [SIC] (CATHODIC) ↓

No.	MATERIAL	VOLTAGE RANGE
1	Magnesium	-1.60 to -1.67
2	Zinc	-1.00 to -1.07
3	Beryllium	-0.93 to -0.98
4	Aluminum Alloys	-0.76 to -0.99
5	Cadmium	-0.66 to -0.71
6	Mild Steel	-0.58 to -0.71
7	Cast Iron	-0.58 to -0.71
8	Low Alloy Steel	-0.56 to -0.64
9	Austenitic Cast Iron	-0.41 to -0.54
10	Aluminum Bronze	-0.31 to -0.42
11	Brass (Naval, Yellow, Red)	-0.31 to -0.40
12	Tin	-0.31 to -0.34
13	Copper	-0.31 to -0.40
14	50/50 Lead/Tin Solder	-0.29 to -0.37
15	Admiralty Brass	-0.24 to -0.37
16	Aluminum Brass	-0.24 to -0.37
17	Manganese Bronze	-0.24 to -0.34
18	Silicon Bronze	-0.24 to -0.30
19	Stainless Steel (410, 416)	-0.24 to -0.37 (-0.45 to -0.57)
20	Nickel Silver	-0.24 to -0.30
21	90/10 Copper/Nickel	-0.19 to -0.27
22	80/20 Copper/Nickel	-0.19 to -0.24
23	Stainless Steel (430)	-0.20 to -0.30 (-0.45 to -0.57)
24	Lead	-0.17 to -0.27
25	70/30 Copper Nickel	-0.14 to -0.25
26	Nickel Aluminum Bronze	-0.12 to -0.25
27	Nickel Chromium Alloy 600	-0.09 to -0.15 (-0.35 to -0.48)
28	Nickel 200	-0.09 to -0.20
29	Silver	-0.09 to -0.15
30	Stainless Steel (302, 304, 321, 347)	-0.05 to -0.13 (-0.45 to -0.57)
31	Nickel Copper Alloys (400, K500)	-0.02 to -0.13
32	Stainless Steel (316, 317)	0.00 to -0.10 (-0.35 to -0.45)
33	Alloy 20 Stainless Steel	0.04 to -0.12
34	Nickel Iron Chromium Alloy 825	0.02 to -0.10
35	Titanium	0.04 to -0.12
36	Gold	0.20 to 0.07
37	Platinum	0.20 to 0.07
38	Graphite	0.36 to 0.19

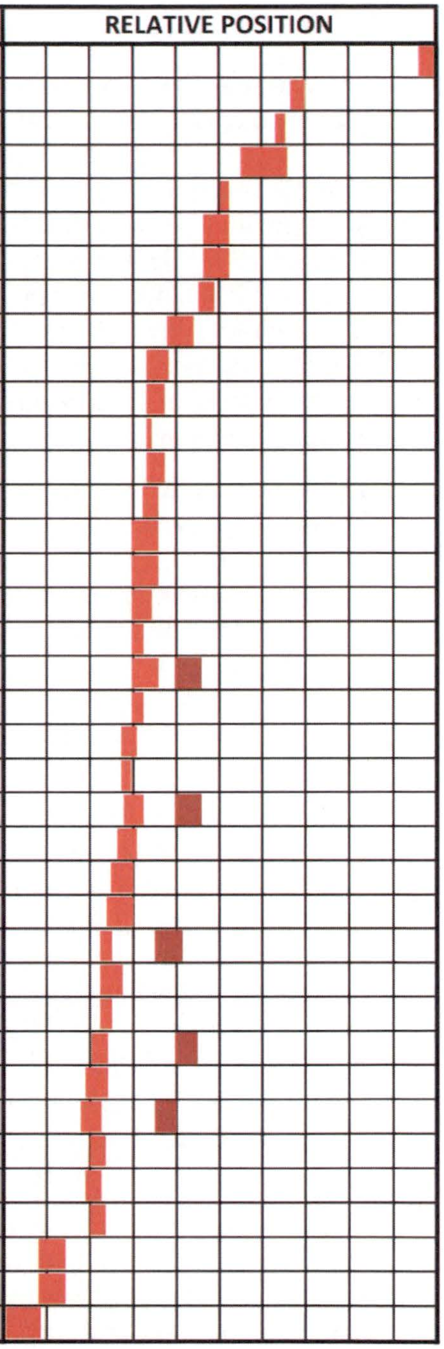

Figure 3-8: Listing of Galvanic Potentials for a Variety of Metals in Flowing Seawater [3.11.93]

Note: According to [3.11.93], stainless steels are generally in the more noble or cathodic region in the series. There have been studies showing that stainless steels exhibit a different voltage range in crevices or stagnant and poorly aerated water. These values are shown in brackets in the graphic.

3.4.4.2.6 Stress Corrosion Cracking

SCC is a localized non-ductile cracking failure resulting from an unfavorable combination of sustained tensile stresses either applied (external) or residual (internal), material condition, and the presence of a corrosive environment. SCC is a phenomenon that primarily can occur in carbon steels only if simultaneous tensile stress and a caustic environment exist. In terms of environment, caustic solutions such as: acidified hydrogen sulfide, calcium/ammonium/sodium nitrates, sodium hydroxide, hydrogen cyanide, anhydrous liquid ammonia, and carbonate/bicarbonate carbon monoxide/dioxides can provide the necessary environment for SCC to occur in carbon steel (Table 3.4 of [3.11.134]). None of these environments exist for the carbon steel DSC SSCs. However, in certain environmental conditions, some high-strength steel fasteners with yield strengths greater than or equal to 150,000 psi have been found to be susceptible to SCC under exposure to aqueous electrolytes [3.11.72] with specific contaminants.

In conclusion, SCC of the carbon steel DSCs is not considered a credible aging mechanism at the TMI-2 ISFSI because: 1) high strength steels are not used, 2) there are no caustic environments present, and 3) the DSCs are not subjected to high tensile stresses. As such, SCC is considered a non-credible aging mechanism on the carbon steel DSC SSCs and is not required to be managed for the PEO. In addition, SCC on the stainless-steel DSC SSCs is discounted as discussed in Section 3.4.4.4.

3.4.4.2.7 Intergranular Corrosion

The microstructure of metals and alloys is made up of grains; separated by grain boundaries. These grains are each composed of orderly arrays of atoms with the same spacing between the atoms in every grain. Grain boundaries are regions of high-energy concentration. Therefore, chemical or metallurgical reactions usually occur at grain boundaries before they occur within the grains. Intergranular corrosion takes place when the corrosion rate of the grain-boundary areas of an alloy exceeds that of the grain interiors. This is generally because of the differences in composition between the grain boundary and the interior. Intergranular corrosion is a localized attack along the grain boundaries, or immediately adjacent to grain boundaries, while the bulk of the grains remains largely unaffected. This form of corrosion is usually associated with chemical segregation effects (impurities have a tendency to be enriched at grain boundaries) or specific phases precipitated in the grain boundaries. Such precipitation can produce zones of reduced corrosion resistance in the immediate vicinity to the boundaries.

The attack is usually related to the segregation of specific elements or the formation of a compound in the boundary. Corrosion then occurs by preferential attack on the grain-boundary phase or in a zone adjacent to it that has lost an element necessary for adequate corrosion resistance, thus making the grain boundary zone anodic relative to the remainder of the surface. The attack usually progresses along a narrow path along the grain boundary, and with a severe case of grain-boundary corrosion - entire grains may be dislodged due to complete deterioration of their boundaries. As such, the mechanical properties of the structure may be adversely affected.

This form of corrosion can occur in many alloy systems; however, within plain carbon steel systems such as that of the DSC SSCs, the form would be considered atypical. The IFSF, as described in Section 3.2.2.2 is similar to the TMI-2 ISFSI in many respects including that the fuel storage canisters are fabricated from plain carbon steel. It is a dry storage facility that it is open to outside air and storage temperatures are close to average ambient temperatures. Intergranular corrosion has not been observed on the IFSF corrosion coupons ([3.11.90], [3.11.91]) or within the carbon steel in the IFSF dry storage facility over the 40+ years that the facility has been in service. As such, it is unlikely that the TMI-2 ISFSI, which has a similar environment, will have intergranular corrosion on carbon steel. Therefore, this form of corrosion will not be considered any further in the LRA as a credible aging mechanism for the carbon steel DSC SSCs during the PEO.

3.4.4.2.8 Creep

Creep is the time-dependent inelastic deformation that takes place at an elevated temperature and a constant stress. Creep requires a stress combined with high temperatures. Consistent with Section 3.2.16 of [3.11.76], creep activation temperatures above 829°F are required. The maximum normal DSC temperature for the 87°F ambient case at the top surface of the DSC shell at beginning of storage was 134.2°F per Table 8.1-9 of the UFSAR [3.11.2]. Given that this maximum DSC surface temperature is below the creep activation temperature, creep is not an aging mechanism requiring management during the PEO.

3.4.4.2.9 Thermal Fatigue

Thermal fatigue is the progressive and localized structural damage that occurs when a material is subjected to cyclic loading associated with thermal cycling. The only potential source of thermal fatigue of the DSC could be caused by ambient seasonal and daily temperature fluctuations. The average monthly temperature ranges from a low of 4°F in January to a high of 87°F in July (See Section 3.3.1.2). The largest mean daily temperature range for the TMI-2 ISFSI is 38°F during the months of July through August (Table 2.3.7 of the UFSAR [3.11.2]). These relatively low temperature changes combined with the vented design of the DSC provide for minimal stress inducing mechanisms that can cause any fatigue. Cyclic loading on the DSC confinement boundary is addressed in Section 8.3.2 of the UFSAR regarding all potential sources. An evaluation conducted in Appendix C.4.1 of the Standardized NUHOMS® FSAR [3.11.80] addressed these diurnal and seasonal temperature fluctuations on thermal fatigue, looking at the six criteria contained in NB-3222.4 of the ASME Code [3.11.81] for applicability. Since all of the six ASME Code criteria are complied with over a 50-year ISFSI operating period (See Section 1.3.1), then thermal fatigue mechanisms need not be specifically evaluated for the DSC SSCs and it follows that this aging mechanism need not be managed for the duration of the PEO.

3.4.4.2.10 Thermal Aging

The microstructures of most steels will change, given sufficient time at temperature, and this can affect mechanical properties. This process is commonly called thermal aging. The effect of thermal aging will depend on the time at temperature and the microstructure and carbon content of the steel subcomponents. Thermal aging is characterized by material embrittlement and loss of ductility (i.e., "temper embrittlement"). The maximum normal DSC temperature for the 87°F ambient case at the top surface of the DSC shell at beginning of storage was 134.2°F per Table 8.1-9 of the UFSAR [3.11.2]. Some hardened alloy steels can experience reductions in fracture toughness when tempered at temperatures greater than 390°F (pg. 703 of [3.11.82]). The degree of the reduction in toughness depends on the carbon content and the tempering conditions that were employed during processing. However, temper embrittlement does not occur in plain carbon steels (such as ASME SA-516 and ASTM A36 used in the DSC SSCs), only in alloy steels (pg. 699 of [3.11.82]). The steels used in the construction of the DSCs are not tempered and are not subjected to the elevated temperatures noted above for embrittlement. Therefore, thermal aging is not an aging mechanism requiring management on the DSC SSCs during the PEO.

3.4.4.2.11 Irradiation Embrittlement

High neutron radiation can cause loss of fracture toughness in steel (i.e., increases in the nil-ductility temperature) (pg. 653 of [3.11.82]). In general, the neutron fluence seen by the metal components of DSSs is generally orders of magnitude lower than that required to produce any adverse effect, so neutron radiation is unlikely to be an applicable aging mechanism for the steel SSCs. As indicated in Section 3.3.1.2.2, the maximum neutron fluence on the DSC shell assembly is calculated to be 1.98×10^{14} neutrons/cm^2 with the Am-Be-Cm startup source integrated over an assumed 60-year period (See Section 3.3.1.2.2). This is well below the level of concern for embrittlement of the carbon steel at 1×10^{18} neutrons/cm^2 [3.11.24]. Separately, gamma radiation effects on the properties of steel were reviewed. The evaluation (i.e., [3.11.24]) described in Section 3.3.1.2.2 includes energy deposition tallies for the steel with absorbed gamma energy on the DSC shell of 4.42×10^8 rad integrated over an assumed 60-year period (See Section 3.3.1.2.2). However, no limit on gamma radiation damage applicable to steel has been identified, which is consistent with the Standardized NUHOMS® System CoC LRA (Section 3.5.4.2 of [3.11.25]). Therefore, change in material properties due to irradiation embrittlement is not an aging mechanism requiring management for DSC SSCs.

3.4.4.2.12 Wear

Wear, in material science, simply means erosion or the displacement of a material from its original form. Wear is a mechanically assisted form of degradation that may involve both a wear mechanism and then subsequent corrosion mechanism. Wear is a phenomenon through which the deformation of surfaces of materials occurs due to interaction between surfaces, which causes the deformation and removal of material on the surfaces due to the effect of mechanical action between the sliding faces. Wear is the result of many things, such as corrosion, erosion, abrasion, chemical processes, or combinations of these factors. Potential types of wear on DSC SSCs include: (1) adhesive wear; (2) abrasive wear or loss of material resulting from sliding on hard surfaces, which can be seen as scratches, grooves, or corrugations; and (3) erosive wear, which is the result of impact of sharp particles on a surface. Each type of wear will be discussed in more detail below.

- Adhesive Wear

Adhesive wear is unwanted displacement and debris production resulting from frictional contact between surfaces. This phenomenon occurs when two metals rub together with sufficient force to cause the removal of material from the less wear-resistant surface. When two metal surfaces are exposed to each other, they initially touch only at a few rough points. Friction and wear originates at these points. When a compressive load is applied, these rough points are plastically deformed and finally welded together because of the high pressure that is created. As sliding continues, these bonds are broken, producing cavities/depressions on both surfaces. Abrasive particles detach and rub against the surface, contributing to wear. Adhesive wear is considered corrosion by means of mechanical action rather than chemical reaction and is visible by fretting, pits, holes, or scale transfer. There are several types of adhesive wear. These include (1) sliding wear when one solid slides over another solid; (2) galling wear, which is an intense form of adhesive wear; (3) scoring/scuffing wear or the formation of grooves and scratches in the sliding direction; and (4) oxidative wear, which is a wear in unlubricated ferrous systems.

Other than some initial scrapes/scoring/scuffing to: (1) the inside DSC surfaces due to the insertion of first the storage basket and then the TMI-2 Canisters into the DSC and (2) the DSC outer protective coating on the underside of the DSC shell, from when the DSCs were slid into HSMs (see Figure 3-4), no additional adhesive wear is expected since all SSCs of the ISFSI are static and do not move while in storage. However, corrosion may be more rapid in the area where coating was initially damaged on the DSC lower exterior surfaces during loading. Postulated adhesive wear to the basket or inner DSC shell surfaces when the basket was loaded into the DSC will be bounded by conditions of scuffing shown on the outer DSC shell. This is valid for three reasons: (1) the Internal DSC Environment is more benign than the Sheltered Environment (See Section 3.4.3.2) so subsequent corrosion will not occur at a greater rate; (2) the basket weighs less than the entire loaded DSC, and since adhesive wear is dependent on the frictional contact forces between the two surfaces, the effect of adhesive wear will be to a lesser degree; and (3) the basket was loaded vertically into the DSC and will likely have caused little wear to the DSC shell or itself.

On the DSC shell outer surface, although no corrosion is apparent in Figure 3-4, most likely due to sacrificial protection from the zinc in the coating, this may change once the zinc oxidizes in the process of protecting the carbon steel. After that, corrosion may increase in the bare areas where the primer has been scuffed. Adhesive wear itself, as an aging mechanism leading to loss of material, does not require management. Nonetheless, the mechanism of adhesive wear leading to possible loss of material from corrosion mechanisms will be managed on the DSC outer shell surfaces for the PEO.

- Abrasive Wear

Abrasive wear takes place when a rough, hard surface rubs against a surface that is relatively softer, such as when hard particles or a hard metal with rough surface rub against soft metal to promote wear.

Several factors influence the occurrence of abrasive wear and the way a material is removed. Three major abrasive wear mechanisms, defined by the way the material is eliminated, are (1) fragmentation, which takes place when a material is separated from the surface and results in indenting abrasion that can cause localized fracture where cracks spread freely leading to further material removal; (2) cutting, which occurs when a material separates from a surface in tiny chips or debris, with only minimal or no displacement to both of the groove sides (similar to conventional machining); and (3) plowing, where there is material displacement sideways, moving away from the particles of wear, resulting in groove formation that creates ridges along the grooves that may be eliminated by consequent abrasive material passage. No abrasive wear is expected while in storage since all DSC SSCs are static and do not move. Therefore, this aging mechanism will not be considered further.

- Erosive Wear

Erosive wear is caused by the impact of particles of solid or liquid against the surface of an object. The impacting particles gradually remove material from the surface through repeated deformations and cutting actions. A common example is erosive wear associated with the movement of slurries through piping and pumping equipment. Limited erosive wear is expected while in storage since the impact of particles of solid or liquid on the DSC SSC surfaces is limited to what is brought in through the vent holes in the back door of the HSM, and these particles have negligible velocity. In addition, any postulated erosive wear action would be constrained to SSCs in the Sheltered Environment only. In order to be a credible aging mechanism for the DSC Internal Environment, particles would have to make it through both the mesh wire cloth (0.12-in. opening size on mesh) on the back of the HSM rear access door, and then through the HEPA filter. There are no other possible flows of solids or liquids upon the DSC SSC surfaces. Therefore, erosive wear is not considered a credible mechanism for loss of material on the Sheltered Environment SSCs during the PEO. As such, this aging mechanism will not be managed for these DSC SSCs during the PEO.

3.4.4.2.13 Hydrogen Damage

Hydrogen damage is a form of environmentally assisted material degradation that results most often from the combined action of hydrogen and residual or applied tensile stress. Hydrogen damage to specific alloys manifest in many ways, such as cracking, blistering, hydride formation, and loss in tensile ductility. These failures have been collectively termed hydrogen embrittlement (pg. 162 of [3.11.88]).

One particular form of hydrogen embrittlement is through the mechanism termed HIC or Delayed Hydride Weld Cracking. The mechanism begins with atoms of hydrogen diffusing throughout the material. At elevated temperatures, hydrogen tends to have increased solubility, allowing it to disperse in the material. When these hydrogen atoms combine again within small metal voids to build molecules of hydrogen, they produce pressure within the cavity. The pressure created from continual buildup of hydrogen can reach high pressures within the voids, which makes the metal lose its tensile strength and ductility, reaching the point of cracking, or HIC [3.11.84]. The ductility of the metal typically decreases as the hydrogen content increases. HIC typically decreases when the metal is more ductile and increases with increase in alloy strength. Thus, very little plastic deformation occurs in high-strength alloys and a crack, rather than a blister, develops when the hydrogen gas precipitates at internal interfaces [3.11.85].

As described in the OE in Section 3.2.4.2 and CAL 97-7-001 [3.11.195], HIC on closure welds was observed on the carbon steel VSC-24 MSB at the shield lid-to-shell weld and was identified by the NRC as a possible failure mechanism for closure welds. This phenomenon on the VSC-24 applied when the weld was performed in a moist environment. The welds on the VSC-24 were performed immediately following the draining of water to a level 3 inches below the lid. In addition, the joint configuration for these weldments was recognized as being highly constrained so that residual stresses were expected to be at, or near, the yield level. Finally, the hydrogen content of the welding consumables was high enough to cause these welds to be susceptible to HIC. It was stated in an NRC technical evaluation regarding corrective actions of the VSC-24 weld conditions [3.11.196] that, “The water level inside the MSB should be drained to a level sufficiently below the shield lid to prevent water contamination of the weld.” Other root causes of the initiation of HIC in the VSC-24 welds are discussed in Section 3.2.4.2.2, and a description of an original RAI 4-1(a) [3.11.197] for the TMI-2 ISFSI is reviewed, addressing the conditions outlined in the CAL.

In summary, the TMI-2 DSC was loaded dry and the lid welds were performed in a dry environment. As such, HIC is not considered a credible aging mechanism on the closure welds. Furthermore, low hydrogen filler material was used to prevent hydrogen embrittlement and cracking. Equally important was consideration in the original design, accounting for proper joint design, which minimized residual stresses. As detailed in Section 3.2.4.2.2, substantial OE for the NUHOMS® design at both the TMI-2 ISFSI and other ISFSIs has proven the closure weld technique in practice. As such, hydrogen damage including HIC from original welding operations is not considered credible for DSC SSCs during the PEO since: (1) the generation rate of hydrogen is low (See Section 3.3.1.2.1); (2) the system operates at ambient temperatures and pressures (reduced driving forces for hydrogen migration into the metal); (3) generated hydrogen can easily diffuse out the HEPA filters with temperature and pressure variations imposed by the surrounding environment; and (4) there are no known high tensile stresses in the DSC SSCs. Therefore, Hydrogen Damage is not a credible degradation failure mechanism on the DSC SSCs and as such does not require management during the PEO.

3.4.4.3 Encased Environment DSC SSCs

The volume between the Top Cover Plate and Top Shield Plug and the volume between the Bottom Inner and Outer Plates (i.e., Bottom Shield Plug) are exposed to the Encased Environment. In addition, the Sample Port Bolt on the Vent and Purge Port Assemblies is also primarily within this environment. This bolt will be discussed separately in Section 3.4.4.4, but the premises discussed within this section apply. The Bottom Shield Plug and the Inner Bottom Cover Plate outside confinement weld are the SSCs on the bottom of the DSC within this environment. This confinement weld is a partial penetration weld and the weld on the opposite side is a partial penetration weld. These welds together provide a redundant confinement function with the Outer Cover Plate closure weld. The Bottom Shield Plug's sole function is to provide radiation shielding. The bottom of the Top Cover Plate and the top of the Top Shield Plug Plate are also within this environment. In addition, the top surface of the Top Shield Plug confinement weld and the bottom surface of the Top Cover Plate confinement weld are the SSCs at the top end of the DSC within this environment. Combined, these welds function as a dual, redundant confinement barrier. Finally, the internal support rods for the basket are encased within outer pipe sleeves, with only the threaded end surfaces exposed to the DSC Internal environment. The environment for all of these SSCs is described in Section 3.4.3.2 and is characterized as a dry, air-filled environment. The moisture in these volumes is limited to that present when the welds were applied at the fabricator or in the field in case of the top cover plate field welds. Therefore, corrosion processes that occur within these enclosed volumes will be entirely limited by the quantity of any retained atmospheric condensation and will cease upon exhausting this electrolyte. As a result, corrosion processes are limited within this environment and will not progress over the PEO. These limited aging effects on these SSCs within this environment will not adversely affect these SSCs to perform their intended functions. Other degradation mechanisms discussed in Section 3.4.4.2 are not reasonably expected to occur within this environment. Therefore, the limited degradation mechanisms and any postulated aging effects will not adversely affect the ability of the SSCs in performing their intended functions within the Encased Environment during the PEO and will not be managed.

3.4.4.4 Evaluation of DSC SSCs with an Exclusive Confinement Function

Several DSC SSCs perform exclusively a confinement function during the PEO. These include:

1. Vent and Purge Port HEPA Filter and Seal (Item 1 and 10 of Drawings 219-02-1010 [3.11.77] and 219-02-1011 [3.11.78]) on the Vent and Purge Port Assemblies
2. Sample Port Bolt and Seal (Item 14 and 20 of Drawings 219-02-1010 [3.11.77] and 219-02-1011 [3.11.78]) on the Vent and Purge Port Assemblies
3. Vent and Purge Port Filter Housing Attachment Bolt and Washer (Item 16 and 22 of Drawings 219-02-1010 [3.11.77] and 219-02-1011 [3.11.78])

As discussed in Section 1.3.3 regarding Amendment 4 and the vent/purge port sealing surfaces, "gaps between the vent and purge filter housings and the DSC lid are so small that it would be difficult for particulate radioactive material to pass through without significant motive force," as is stipulated in Section 8.1.4.2 on the UFSAR [3.11.2]. Therefore, any postulated aging effects will not credibly change any uncredited confinement function offered by the seals or sealing surfaces. A radiological evaluation of a complete radioactive particulate release was conducted as part of the amendment, with no confinement credit taken for the seals. The total dose at the INL Site boundary was calculated and was incorporated into UFSAR Section 8.1.4.3. The resulting accident dose at the INL Site boundary was less than the 10 CFR 72.106 [3.11.52] accident regulatory limit of 5 rem and found to be acceptable by the NRC.

A similar metallic seal ring (BOM item 20) on the Vent and Purge Filter assemblies (see Table 2-4) sits under the Sample Port Bolt (BOM item 14 on the Vent and Purge Port Assemblies). Other than the bottom shank surface, the Sample Port Bolt on the Vent and Purge Port Assemblies is completely encapsulated by the Filter Housing Body and the Sample Tube Plug (BOM item 7 on the Vent and Purge Port Assemblies). As identified in the introduction to TFR-219 [3.11.79] and as carried out in the DSC hydrogen sampling procedure TPR-7066 [3.11.48], this Sampling Port Fitting is unused. The Sample Port Bolt functions as a confinement barrier during normal passive operations by preventing radioactive particulate from migrating out of the internally machined ½-in. sampling duct and into the sampling port cavity. So long as the bolt exists and remains threaded into the sampling port cavity, it will continue to perform its intended function. There are no credible postulated aging effects that could adversely affect the Sample Port Bolts confinement function to change the continued storage analysis outlined in Section 8.1.4.3 of the UFSAR. As an uncredited defense-in-depth backup, the Item 7 sample port plug also acts in this capacity as a gross confinement barrier.

The sole function of the eight filter housing attachment bolts (BOM item 16) and washers (BOM item 22) on the vent and purge filter assemblies ([3.11.77], [3.11.78]) is to attach the filter housing to the top cover plate of the DSC. So long as the hardware maintains the clamp load, the vent/purge port seals will continue to perform their uncredited confinement function. As a result, any postulated aging effects (e.g., crevice or galvanic corrosion) on the filter housing attachment bolts and washers will not credibly change the above-described, sealing confinement function.

Separately, the periodic leak testing required by TS SRs 3.1.1.1 and 3.1.1.2 occurs on a 5-year basis for the dual metallic seals (BOM item 10 on the Vent and Purge Port Assemblies) and annually if the metallic seals are ever replaced with dual elastomeric seals. This aging monitoring activity already directly assures conformance with the intended function provided by the HEPA filters and helps ensure no unintended leakage through the seals. This is because that as part of Condition A of LCO 3.1.1 [3.11.113], if the Filter Housing seal leak rate is exceeded, these Filter Housing attachment bolts are reseated and the leak test repeated, showing a direct correlation as to the function provided by these bolts and washers. As a separate defense-in-depth reassurance, the exposed bolt head surfaces may be opportunistically inspected for any observed abnormal aging effects and corrective actions implemented, as outlined in Appendix A1.

As described in Section 4.3.1.1 of the UFSAR [3.11.2], the bank of Vent and Purge Port HEPA grade filters are "designed to be maintenance free." Annual sampling of the gas within the DSC is used for assuring that hydrogen gas concentration stays below the TS limit. The HEPA filters act to retain any radioactive particulate within the DSC confinement barrier. As discussed in Section 4.3.1.1 of the UFSAR, "accumulation of dust, although highly unlikely," "may restrict air flow," and "increased level of hydrogen within the DSC may be caused by clogged filters." If hydrogen levels exceed the TS limits, the filters are replaced. Therefore, so long as the HEPA filters exist and remain threaded into the filter housing, they will continue to perform their intended function. It follows that for the threaded surfaces and internal boundaries of the HEPA filters (including the elastomeric seal), any postulated aging effects, do not adversely affect the HEPA filter's confinement function, such that it changes the continued storage analysis outlined in Section 8.1.4.3 of the UFSAR. Nonetheless, as a separate defense-in-depth reassurance, the exposed outer HEPA filter surfaces may be opportunistically inspected for any abnormal aging conditions and corrective actions implemented (See Appendix A1).

Finally, LCO 3.2.2 [3.11.113] requires the surface dose rate of each HSM rear access door and the purge/vent filter housings be surveyed on an annual basis. This is confirmed by statements outlined in the TS bases, "If the radiation field at the vent approaches the limits specified, the cause will be evaluated and corrective action taken" [3.11.148]. Therefore, the associated SR 3.2.2.1 may also provide data representative of potential increased dose measurements attributable to hypothetical Filter Housing seal leaks, HEPA filter leaks or Sample Port Bolt leaks. Corrective actions would be taken should this occur. See Appendix A1 for details on using these measurements as part of annual trending analyses.

3.4.4.5 Coating Evaluation

In accordance with Section 4.6, "Cathodic Protection" of the UFSAR [3.11.2], the carbon steel DSC SSCs are coated with a zinc-rich inorganic coating with a high resistance to temperature and radiation (CARBOZINC® 11 or CARBOZINC® 11 HS). The extent of the limits to the coating coverage is discussed in Section 3.4.2.1. The main exception to the coverage on DSC SSCs is at the top end of the DSC shell (i.e., from the top shield plug plate 3 fillet weld location plus ½-in. to the end of the shell), which is not coated with the zinc-rich primer coating. The coating is the primary mitigating corrosion protection mechanism for the DSC carbon steel SSCs structural integrity. The minimum possible thickness, as identified in Section 3.4.2, is 2 mils.

The same coating is applied to both the interior and exterior of the DSC as well as the internal DSC SSCs (e.g., Vent Port Shield Block). The coating is subjected to the Sheltered Environment on the exterior of the DSC and to the Internal DSC Environment on the interior.

Numerous mechanisms for coating degradation including mechanical removal (scraping), corrosive oxidation, cracking, etc. have been identified as previously discussed. Failure of the coating does not prevent the DSC steel SSCs from satisfactorily accomplishing their intended functions. Yet, it may disguise indications of corrosion of the underlying steel. As described in Appendix A1, the coating system on the Sheltered Environment portions of the DSC will be monitored for adverse or abnormal aging effects during the PEO. This would include managing for loss of coating integrity due to blistering, cracking, flaking, peeling, or physical damage.

3.4.4.6 DSC Aging Effects Requiring Management

Aging mechanisms not applicable to any DSC SSCs are: microbiologically induced corrosion, SCC, creep, intergranular corrosion, thermal fatigue, thermal aging, irradiation embrittlement, and hydrogen damage.

There is one area described in Section 3.4.4.2.4 for a galvanic corrosive mechanism on the DSC shell. Section 3.4.4.4 provides an aging effects discussion regarding SSCs with an exclusive confinement function.

Other aging effects will be managed for those DSC SSCs in the Sheltered Environment. The applicable aging effect is Loss of Material with applicable mechanisms for DSC SSCs during the PEO established as:

- Loss of Material due to General Corrosion
- Loss of Material due to Crevice Corrosion
- Loss of Material due to Pitting Corrosion
- Loss of Material due to Galvanic Corrosion for the DSC shell contacting dry film lubricant at the sliding rail surfaces
- Loss of Material due to Adhesive Wear on DSC shell with potential for corrosion (of any type above)

In addition, as a defense-in-depth aging management function, the zinc-rich primer on the Sheltered Environment steel SSC subcomponents is included to assess loss of coating integrity due to blistering, cracking, flaking, peeling, or physical damage.

A summary of applicable aging effects/mechanisms on DSC SSCs is shown in Table 3-5. Management of these aging effects will be performed through the AMAs discussed further in Section 3.4.5.

3.4.5 Aging Management Activities for DSCs

(NUREG-1927, Section 3.2 and Section 3.4.1.3)

This section describes the AMAs resulting from the AMR. All ISFSI TLAAs are summarized in Appendix B, with those areas of the DSC AMR that can be addressed by TLAAs specifically addressed in Section 3.4.5.1. Appendix A1 describes the DSC AMP that is directed primarily as a visual examination (either direct visual or remote visual inspection) of the external surfaces of the DSC to manage the applicable aging effects described in Section 3.4.4.6. The AMP is the key operations and maintenance program for the DSC SSCs such that their intended functions are maintained during the PEO.

In addition, as described in the DSC AMP, both the radiation and hydrogen levels, monitored and tracked as part of the existing LCOs, are used to establish a trending analysis. Monitoring these levels is an indirect indicator of potential premature degradation occurring for the DSC SSCs. As part of the DSC AMP, these levels will be tracked and monitored to ensure trends remain within acceptable bounds for the duration of the PEO.

3.4.5.1 DSC Time-Limited Aging Analyses

The following are summary descriptions of the TLAAs and other supplemental evaluations that were identified and prepared based on the AMR of the DSC.

3.4.5.1.1 Thermal Fatigue Evaluation of the DSC

As incorporated in Section 8.3.2 of the UFSAR [3.11.2], a thermal fatigue TLAA documents the evaluation of the DSC for temperature fluctuations in accordance with the provisions of NB 3222.4(d) of the ASME Code [3.11.81]. As provided by NB 3222.4(d) of the ASME Code, fatigue effects need not be specifically evaluated provided the six criteria in NB 3222.4(d) are met. As demonstrated in Appendix C.4.1 of the NUHOMS® FSAR [3.11.80], an evaluation using these six criteria has been performed to show that the ASME Code fatigue requirements are satisfied for the DSC confinement boundary (See discussion in Section 3.4.4.2.9).

3.5 AMR RESULTS – HSM

This section summarizes the results of the AMR for the HSMs. The HSM and its SSCs along with the license renewal intended functions for these SSCs are described in the scoping evaluation summarized in Section 2.3.2.2.

3.5.1 Description of HSM

The HSM is a prefabricated, modular, reinforced concrete structure that is 10-ft 3-in. wide by 18-ft 2-in. long by 14-ft 6-in. high (nominal dimensions). The HSM consists of two separate reinforced concrete units (a base and roof). A typical reinforcing steel layout for the HSM floor, walls, and roof is shown in Figure 8.1-16 of the UFSAR [3.11.2]. The HSM primary functions are to provide decay heat removal of TMI-2 core debris, provide structural support and environmental protection to the loaded DSC, and to provide radiation shielding protection for both neutron and gamma radiation. The thick concrete roof slab and walls of the HSM provide this shielding. The nominal thickness of the HSM roof and exterior walls of an HSM array for biological shielding ranges from 2 to 3 feet. The thick concrete HSM sidewalls provide shielding between HSMs in the HSM array to prevent scatter in adjacent HSMs during loading and retrieval operations.

The HSM main module, comprised of the base unit and roof slab, is a low profile, reinforced concrete structure designed to withstand all normal and off-normal condition loads created by earthquakes, tornadoes, and other natural phenomena. The HSM is also designed to withstand postulated accident loadings.

At the ISFSI, the HSMs are installed in a dual row array of 15 side-by-side modules, providing 30 total HSMs. Adjacent HSMs have a 6-in. space between them to permit airflow and to allow for independent motion of each HSM during a seismic event. HSM-1 through HSM-14 are located on the south row with HSM-14 located on the west end. HSM-16 through HSM-30 constitutes the north row with HSM-16 on the east end and HSM-30 on the west end. Side-by-side end shield walls are located at both ends of each row, secured by tie plates to its end module, and grouted between each wall. The end shield walls provide additional shielding and environmental protection, completing the HSM installed configuration. The HSM arrangement is shown in Figure 1.3-2 of the UFSAR [3.11.2].

The DSC is slid into position in the HSM using a parallel structural steel beam structure supported by the front and back HSM concrete walls, also supporting the DSC during storage. The front and rear wall openings into the HSM are covered by thick steel doors, providing protection against tornado missiles. The front door assembly includes a solid concrete core, which acts as a combined gamma and neutron shield. The rear wall HEPA filter access opening is covered by a thick-hinged steel plate door. In addition, during DSC insertion/withdrawal operations, the TC is mechanically secured to TC restraint embedments provided in the front wall of the HSM. The DSC is prevented from sliding along the support rails during a postulated seismic event by rail stops attached to the HSM wall at the rear end (i.e., Rear DSC Support Structure Lug: Item 5107-148 from Table 2-3). After insertion of the DSC, a removable seismic retainer tube is placed into a sleeve embedded in the HSM front wall, behind the door between the DSC support beams.

Anchorages and embedments are the steel members, studs, etc., that are embedded in the HSM concrete, supporting the doors and DSC support structure. The TC restraint embedments, end shield wall attachment embedments (both in roof slab and outside wall of end modules), and front DSC support structure embedments all consist of a threaded stud, a coupling nut, and a standard hex nut. For the roof slab to base module attachment, the original roof attachment threaded rod configuration is shown in Detail 1 of HSM SAR drawing 219-02-6000 [3.11.10]. The cylindrical pocket below the washer plate in the roof slab was originally left unfilled during construction. In 2009, [3.11.119] polyurethane foam was filled into all roof bolt hole pockets with a polyurethane gasket and protective bolt covers added to all four roof bolts in 2011 [3.11.123], affording protection of the roof bolt hole pockets from moisture intrusion.

The HSM SSCs within scope of the AMP are summarized from Table 2-3 as follows:

- Reinforced Concrete Base Module, Roof Slab, and End Shield Wall
- Concrete Reinforcement Steel for Base Module, Roof Slab, and End Shield Wall
- Embedment Assemblies (i.e., Rail Extension, Seismic Retainer, HSM Roof Slab to Base Module, Front DSC Support Structure Attachment, TC Restraint, End Shield Wall, Shield Door Attachment)
- Nuts and Bolts for attachment of the End Shield Wall/Shield Door/HEPA Filter Door
- Shield Door Assembly
- HEPA Filter Door Assembly
- Washer Plates for End Shield Wall, Shield Door and Roof Protective Bolt Cover
- End Shield Wall Support Bolts/Nuts
- End Shield Wall Tie Plate and Embedded Attachment Bolt
- Nuts and bolts for attachment between Front DSC Support Structure Attachment Assembly and HSM
- DSC Support Structure Assemblies (i.e., Front and Rear Mounting Plates, Stiffener Plates, DSC Stop Plate, Support Rails, Beams)
- DSC Support Structure Attachment Assemblies
- Rear DSC Support Structure Lug Plate
- Seismic Retainer
- Roof Protective Bolt Cover and Roof Anchor Attachment Bolt & Nut
- Cementitious Grout for the End Shield Wall Panels, Roof Slab Lifting Strand Pockets and Mounting Holes & Embedment Voids in the Base Module
- Sealant used for End Shield Wall Panel Lifting Strand Pockets
- Roof Slab Bolt Hole Foam Filler and Gasket
- Protective Steel and Concrete Coatings

3.5.2 HSM Materials Evaluated

(NUREG-1927, Section 3.2 and Section 3.4.1.1)

Identification of the as-built materials is important in determining which aging effects may be monitored. The HSM materials within the scope of this AMR are identified based on fabrication drawings and specifications used during HSM fabrication and installation. The in-scope materials, referenced as-built drawings, and specifications are identified in Table 3-4 and are described in detail below.

3.5.2.1 Concrete

In accordance with the UFSAR [3.11.2], the HSMs were fabricated consistent with ACI 349-85 [3.11.9] using 5000 psi compression strength concrete with embedded steel reinforcement. At the time of fabrication and consistent with Note 1 on the SAR drawing for the HSMs [3.11.10], the concrete had a minimum density of 145 pounds per cubic foot (pcf) and a water-to-cement ratio of less than 0.45 [3.11.11]. The UFSAR in Section 4.2.5.1 states that the cement is Portland Type II meeting the requirements of ASTM C150 [3.11.8]. Consistent with ASTM C150 and Section 5.2.1 of [3.11.11], "the cement shall contain less than 0.60% by weight of alkalis calculated as sodium oxide equivalent ($Na_2O + 0.658\ K_2O$)." In addition, both the fine and course aggregates met the requirements of ASTM C33 [3.11.7]. According to [3.11.11], all reinforcement bar (rebar) was constructed to the requirements of ASTM A615 or A706, Grade 60 [3.11.13], [3.11.14].

Inspection and core sampling of three roof slabs and three HSM base units was performed in 2009 by an outside concrete consultant, WJE Associates, Inc., due to identification of spalling and cracking in the HSM concrete. Per the WJE investigative report [3.11.15] of the HSM concrete, the concrete was shown to be "generally hard, dense, and well-consolidated." The location of 12 cores were selected and marked out with the objective of obtaining samples of concrete representative of the observed deterioration. Evaluation of the core samples and a discussion in the report about the actual materials onsite at the ISFSI resulted in these findings:

> *"The bond between the aggregate and paste is judged to be weak, due to the round, hard, and smooth aggregate surfaces of the river gravel that was used and the observed high water-cement ratio paste at the interface, possibly due to casting concrete with very wet aggregates. The concrete contains widespread microcracking likely related to the high paste content, variable water-cement ratio and maybe other factors related to curing."*

As stated in the report, "these factors contribute to the sensitivity of the structures to shrinkage cracking," and are used as part of the determination that this is an aging effect requiring management during the PEO (See Section 3.5.4.2.6).

3.5.2.2 Steel

The HSM drawings indicate that bolt and stud type fastener SSCs are zinc-coated, consistent with the ASTM Standards identified in Table 3-4. The HSM documentation package [3.11.16] identifies the bolts as ASTM A325, Type 1 [3.11.60] and the studs as ASTM A193, Grade B7 [3.11.57]. ASTM A325 Type 1 structural bolt material is carbon, carbon/boron, or alloy steel. ASTM A193 Grade B7 fastener material is ferritic steel designed for use in high temperature service and could be used for both bolts and studs. Therefore, the bolts are carbon, carbon/boron, or alloy steel; and the studs are ferritic steel.

Nuts and coupling nuts are specified to meet ASTM A194 Grade 2H [3.11.59], or ASTM A563 Grade A [3.11.58] and are zinc-coated. The HSM documentation package [3.11.16] identifies the coupling nuts as ASTM A563, Grade A and the heavy hex nuts as ASTM A194, Grade 2H. ASTM A563, Grade A material is carbon steel. ASTM A194, Grade 2H material is a quenched and tempered carbon steel. Therefore, the nuts are carbon steel and the coupling nuts are quenched carbon steel.

Consistent with the HSM Documentation Package [3.11.63], structural SSCs, that include embedded plates and the DSC support structure, are fabricated from ASTM A36 [3.11.61] or ASTM A500, Grade B [3.11.62] carbon steel. Weld filler material for the DSC support structure is specified to have a minimum tensile strength of 70,000 psi. The protective roof bolt covers for the roof slab attaching hardware are fabricated from stainless steel.

3.5.2.3 Coatings

All exposed steel surfaces on in-scope HSM SSCs are either hot-dip galvanized or covered with a zinc-rich coating, with threaded fasteners electroplated consistent with the requirements of ASTM B633 [3.11.141] [3.11.17]. Hot-dip galvanizing is performed consistent with the requirements of ASTM A123 [3.11.140] with SSCs covered with a minimum thickness coating grade of 100 [3.11.17]. Consistent with Section 6.4 and Appendix A of the fabrication specification, the DSC support structure is coated with 2.0 to 6.0 mils DFT inorganic zinc-rich primer with a finish coat of high build epoxy enamel at 5.0 to 7.0 mils DFT [3.11.17]. A CARBOZINC® 11 primer coating and CARBOLINE® 890 top coats are the specified coating materials in the fabrication specification [3.11.17]. As-welded areas and areas needing touch-up (due to installation or shipment damage) are also specified to be coated with CARBOZINC® 11, along with a top coat of CARBOLINE® 890 (Section 5.5 of [3.11.18]).

As part of a work package in late 2011, CONSPEC® Silane 20 WB, a penetrating water-based silane water repellent coating, was applied to the exterior surfaces of the HSMs [3.11.19].

3.5.2.4 Other Materials

During construction of the HSMs, the roof slabs were lifted into place using embedded wire strand loops, which protruded from four recessed pockets in the top surface of the roof slab. After the roof slab was assembled to the base unit, the lifting strands were cut and the recessed pockets were filled with cementitious grout and finished to match [3.11.18]. The base unit drawings also called for grout to fill embedment voids in the floor that were used for formwork erection (note 8 of [3.11.22]). Mounting holes for alignment target assemblies and the rear-access angle assembly were also to be filled with grout after casting (diamond note 18 of [3.11.22]). Finally, gaps between adjacent panels in the end shield wall were filled with cementitious grout, per drawing requirements. Consistent with the documentation package [3.11.142], the grout was identified as SONOGROUT® [3.11.161]. The base unit drawings also called for grout to fill embedment voids in the floor, allowing for formwork erection. Cementitious grout was also used to pack the core sampling holes in 2009. WO 624131 [3.11.128] specified SikaGrout® 212 for this activity [3.11.162]. Cementitious grout was specified per ASTM C1107 requirements to have a 28-day minimum compressive strength of 5000 psi [3.11.143].

In addition, after the end shield wall panels were originally installed, plastic plugs were to be inserted into the coil inserts used for lifting (four per wall) and covered with a silicone sealant to prevent water collection and intrusion (Section A.3.4 of [3.11.18]). However, filling the coil insert holes was not completed. Nonetheless, in 2012, a chemical grout silicone sealant (Dow Corning® 890-SL Silicone Joint Sealant [3.11.164]) was used for filling the coil insert holes on the end shield walls (WO 642973) [3.11.27].

In 2009 [3.11.119], slow-rise polyurethane spray foam was injected as a chemical grout into the roof slab attachment bolt holes. The TIGER FOAM® product used is slow-rising, closed-cell urethane foam that contains a liquefied compressed gas-blowing agent [3.11.158]. In addition, a polyurethane gasket material was placed as a washer in the fastener joint for the roof slab attachment bolt holes, precluding water from both entering the bolt hole and solidifying during freezing weather conditions. In 2011, during installation of the protective roof bolt covers, these gaskets were replaced with new polyurethane gaskets (WO 635917) [3.11.123].

Various other chemical grout filler materials used in the HSM wall concrete matrix during repairs made from 2011-2015 include the epoxy injection (WO 636977) of cracks using MIRACLE BOND® 1350 epoxy as a cover paste and CRACKBOND® SLV-302 as the injected epoxy [3.11.26], and the MIRACLE BOND® 1450 epoxy [3.11.163] used for the shield wall spalling repairs (WO 656351) [3.11.28].

3.5.3 Environments for the HSM

(NUREG-1927, Section 3.2 and Section 3.4.1.1)

The environments that are experienced by HSM subcomponents, continuously or on a recurring basis, are summarized in Table 3-4 and Section 3.3.1.2, and described in detail below.

The HSMs are located outdoors; thus, the exterior surfaces of the HSM are exposed to all weather conditions, including insolation, wind, rain, snow, ambient temperature, and humidity. This is more broadly discussed in Section 3.3.1.2. The surface of SSCs exposed to this environment will immediately feel the effect of environmental temperature changes due to this direct contact.

The average monthly temperature ranges from a low of 4°F in January to a high of 87°F in July (Section 3.3.1.2). The temperature extremes at the Idaho facility range from -50°F to 103°F. Annual recorded precipitation ranges from a low of 4.50 inches to a high of 14.40 inches, with an average annual precipitation of 8.71 inches. The average yearly snowfall is 26 inches. The lowest absolute moisture content of the air occurs in the coldest part of the year with the average relative humidity ranging from 30-70% (Section 3.3.1.2). The monthly average wind speeds are 7.5 and 12.6 mph at 20 feet and 250 feet above ground level, respectively.

The site is not a flood-dry site, but the top of the ISFSI pad is designed to be at or above the PMF elevation to prevent flood loading into the HSM interior. Outdoor Environment SSCs are subject to solar insolation unless protected by shading. Other features of the Outdoor Environment are covered in detail in Section 3.3.1.2.

Within the concrete structure of each HSM is the Sheltered Environment, as described in Section 3.3.1.2. SSC subcomponents in this environment are protected from outdoor effects (e.g., precipitation), but experience higher temperatures and radiation levels, in an air environment. This environment is separated from the Outdoor Environment with 2 to 3 feet of concrete. There is no direct exposure to the sun, wind, or precipitation. The temperature in the Sheltered Environment is dependent on the ambient temperature as well as the decay heat of the TMI-2 core debris. Variations in temperature and humidity in the Sheltered Environment are damped by the large thermal mass of the concrete structure, resulting in slower thermal fluctuations than found in the Outdoor Environment. Observation of SSCs in this environment is not easily performed, but may be performed with borescopes or by removing or opening the door assemblies of the HSMs.

Contact between the Sheltered Environment and the Outdoor Environment is via two mechanisms:

1. Through a downward-sloped 3-ft long 2-in. diameter drain tube located at the bottom of the HSM interior floor leading outside to the rear of the HSM base module. The drain tube is shown on sheet 2 of the base unit fabrication drawing 219-02-5103 [3.11.22]. A threaded debris screen covers the end of the drain tube.
2. Around the perimeter of the rear vented access door and through two sets of 1-in. diameter vent hole arrays in the rear access door leading into the HSM interior. Behind the rear access door, the rear wall of the HSM has a 34-in. wide by 26-in. high by 12-in. deep square cutout. The back of the cutout has a small 14-in. cylindrical port pathway through the concrete for accessing the purge filter and a larger 18-in. cylindrical port pathway for the vent filters. Both ports are 15-in. deep. The access port details are shown on the base unit fabrication drawing 219-02-5103 [3.11.22].

The Embedded Environment is the third HSM service environment and is described in Section 3.3.1.2. This environment consists of the concrete matrix of the HSM and end shield walls. It typically consists of reinforcement steel and attachment point hardware embedded directly into the concrete matrix. Direct observation of these items cannot be performed without removal of the surrounding concrete. Generally, items within this environment are shielded from direct contact with both the Outdoor and Sheltered Environments. However, spalling and cracking of the concrete may expose embedded items to the Outdoor Environment.

The HSM concrete matrix and embedments are exposed to neutron and gamma radiation. Section 3.3.1.2.2 discusses the analyses performed to evaluate the effects of neutron fluence and gamma radiation on the mechanical properties of the HSM SSCs. Bounding sources and bounding MCNP models are used in order to envelop the HSM with or without the neutron startup sources inside the TMI-2 Canisters [3.11.24]. The total irradiation time (service life) of the HSM in-scope SSCs is assumed integrated over 60 years (See Section 3.3.1.2.2), with no credit taken for source strength decay over the period. The calculated maximum neutron fluence on the HSM concrete inner wall surface is 2.90×10^{13} neutrons/cm^2 with the Am-Be-Cm startup source. The maximum gamma radiation exposure in the concrete is 1.98×10^8 rad and occurs at the sidewalls of the HSM.

Table 8.1-8 in the UFSAR summarizes the maximum temperatures in the HSM concrete matrix and embedments for normal, off-normal, and accident conditions, with the maximum design basis heat load of 860 Watts per DSC (Section 8.1.3.1 of the FSAR) [3.11.2]. For normal operations, the bounding maximum predicted HSM concrete temperature at the beginning of storage in 1999 is 128.7°F (inner roof surface temperature).

3.5.4 HSM Aging Effects

(NUREG-1927, Section 3.2 and Section 3.4.1.2)

This section describes the aging effects that could, if left unmanaged, cause degradation of HSM SSCs, including concrete, reinforcing steel, and steel SSCs of the HSM (e.g., DSC Support Structure, Shielded Door Assembly). As such, applicable unmanaged aging effects could result in loss of the HSM SSC intended functions. Aging mechanisms that could lead to aging effects for HSM SSCs were determined using technical literature, related industry research, and existing OE. Aging mechanisms were evaluated to determine if the mechanisms could lead to an aging effect requiring management. Aging effects, mechanisms, and management activities for specific SSCs are identified in Table 3-5.

3.5.4.1 Identification of Aging Effects

Aging effects addressed herein are physical indications of the action of credible degradation mechanisms acting on the SSCs of the HSM. Aging effects are identified for three broad categories of HSM SSCs: concrete, exposed steel subcomponents, and embedded carbon steel subcomponents. In addition, coatings, chemical grout fillers, and sealants are separately addressed since they assist in preventing further degradation of the HSM SSCs. The aging effects and possible mechanisms are described below.

General concrete aging mechanisms and their effects found in nuclear safety-related structures are discussed in ACI 349.3R [3.11.70], "Evaluation of Existing Nuclear Safety-Related Concrete Structures." Specific aging mechanisms found in NUHOMS® concrete HSMs are identified and discussed in the draft MAPS Report [3.11.76]. The HSM SSC concrete matrix includes the cementitious grouting materials. In addition, in-scope embedded SSCs include the reinforcement bars of the HSM base module, end module shield wall and roof slab, and all in-scope attachment hardware embedded within concrete. Embedded subcomponents include those SSCs that are fully encased within the Embedded Environment as well as those that are partially encased.

Potential aging effects evaluated for the concrete and embedded SSCs, along with their postulated aging mechanisms, include the following:

- Loss of material through: spalling and scaling from freeze-thaw cycles, aggressive chemical attack, fatigue, irradiation, reaction with aggregates, and shrinkage
- Concrete cracking from: freeze-thaw cycles, aggressive chemical attack, fatigue, irradiation, reaction with aggregates, shrinkage, and elevated temperatures
- Reduction of concrete strength and modulus from: irradiation, aggressive chemical attack, reaction with aggregates, leaching of calcium hydroxide, elevated temperatures, and creep
- Loss of material of embedded SSCs from corrosion
- Increase in concrete porosity and permeability from leaching of calcium hydroxide
- Reduction of concrete pH from: aggressive chemical attack and leaching of calcium hydroxide

In addition, the HSM SSC concrete includes the cementitious grouting filler materials used during original fabrication and subsequent repairs. A discussion of the potential aging mechanisms related to the concrete HSM and these aging effects is presented in Section 3.5.4.2.

In-scope steel SSCs of the HSM are those found in contact with the Outdoor and Sheltered Environments. These SSCs include the DSC Support Structure, Shield Door Assembly, HEPA Filter Door Assembly, Seismic Retainer, and all in-scope attachment hardware. The weld filler material attaching these SSCs is also included. A discussion of the potential aging mechanisms related to the exposed steel SSCs of the HSM is presented in Section 3.5.4.3. Potential credible aging effects requiring management, with their postulated aging mechanisms, include the following:

- Loss of material due to corrosion (general, crevice, pitting)
- Loss of strength from irradiation and fatigue
- Cracking from irradiation, fatigue, and SCC

The concrete matrix is monitored such that the overall integrity of the continuous matrix is maintained. For the chemical grouting filler materials and sealants used during repairs, parameters monitored include the following aging effect identified in Section 3.5.4.5:

- Adhesive and cohesive failure of concrete repair chemical grout fillers and sealants from premature degradation, including UV exposure and irradiation

Finally, an aging review of the silane water repellent coating on the concrete is included to assess for its performance on preventing physical damage on the steel coatings and inhibition of moisture penetration on HSM concrete SSCs and rebar corrosion on HSM steel SSCs (See Section 3.5.4.4).

In addition, an aging review of the zinc-rich primer on the coated steel HSM SSCs is included to assess for its performance on preventing loss of coating integrity due to blistering, cracking, flaking, peeling or physical damage (See Section 3.5.4.4).

3.5.4.2 Concrete SSCs

3.5.4.2.1 Freeze-Thaw Cycles

Cyclic freezing-and-thawing of damp or wet concrete may result in reduction of strength properties and spalling, scaling, and cracking. Water pooling or collecting in recesses in the concrete allows for intrusion of moisture into the concrete. During freeze-thaw cycles, the water expands and contracts resulting in potential damage to the concrete and reinforcing steel.

This form of damage was observed in the TMI-2 HSM concrete when water collected in penetration holes for the roof slab bolt and made its way into the concrete. Issuance of a report in 2007, EDF-8465, [3.11.86] investigated the nature and significance of the observed condition found on several HSMs. The reported conditions consisted of white solid deposits, crazing, and cracks consistent with environmental causes. Recommendations were to continue to monitor conditions and to consider providing protection against water penetration to reduce the severity of freeze attack (JLS-04-12) [3.11.116]. A visual inspection of the HSMs was again performed in September 2008 to document efflorescence growth, cracking, and to evaluate general conditions. Recommendations were to hire a firm knowledgeable in concrete examination and testing to determine the cause of the cracking (EDF-8903) [3.11.117]. The extent of the damage was evaluated by a consultant, WJE Associates, Inc., in 2009 [3.11.15] and a series of repairs were recommended. Repair actions began in October 2009 by filling the HSM roof anchor bolt-through holes with polyurethane foam as recommended by WJE (FDC 6797 [3.11.118], WO 627046 [3.11.119], EDF-9565 [3.11.120]).

The HSMs were again inspected in September 2010 to assess their condition. Data providing crack location and severity was generated from the inspection (EDF-9897) [3.11.109]. Repair actions continued in June 2011 with installation of the HSM roof anchor bolt and through hole protective bolt covers (FDC 7682 [3.11.121], FDC 7715 [3.11.122], WO 635917 [3.11.123]). Cracks were repaired in September 2011 by capping and resin injection (FDC 7803 [3.11.124], WO 636977 [3.11.26]). HSM concrete surfaces were sealed against moisture intrusion in October 2011 (FDC 7901 [3.11.125], WO 637273 [3.11.19]). Due to the previous occurrences of loss of material and cracking from Freeze-Thaw cycles, aging management is required during the PEO.

3.5.4.2.2 Aggressive Chemical Attack

Exposure to aggressive groundwater, acid rain, seawater or salt spray, or exposure to acids and caustic materials may cause chemical attack leading to loss of material, cracking or change in material properties. Microbiological forms of chemical attack may also be induced from microbial growths on the concrete, but there has not been OE in DSS facilities and therefore would not be considered credible at the TMI-2 ISFSI. The characteristic effects of chemical attack include staining, erosion, degradation of the concrete, cracking, spalling, and corrosive attack on the rebar and embedments. Areas on the HSM susceptible to chemical attack include exterior surfaces exposed to the Outdoor Environment.

Continued or frequent cyclic exposure to the following aggressive chemical environments is necessary to cause adverse degradation of steel in concrete [3.11.126], [3.11.178]:

- Acidic solutions with pH < 5.5
- Chloride solutions > 500 ppm
- Sulfate solutions > 1500 ppm

None of these conditions exist in the environments of the HSM concrete SSCs. As discussed in Section 3.3.1.2, the TMI-2 ISFSI is located remotely and not in an area where it is subjected to aggressive chemicals from environmental or industrial sources, such as sulfur or nitric-based acid-rain. In addition, testing of chloride content in the concrete was assessed to be very low (pg. 12 of [3.11.15]), [3.11.116]. According to the WJE report [3.11.15], the chloride content ranged from 30 to 60 ppm. There are no acidic solutions permitted on the TMI-2 ISFSI, and typically concrete is highly alkaline (pH > 12.5) (Section A5.4.4.1 of [3.11.136]), therefore acid attack is not a credible aging mechanism. Sulfate solutions of potassium, sodium, and magnesium sometimes found in groundwater may attack concrete over time [3.11.136]. Because the HSMs are installed above-grade on the concrete basemat, the HSM concrete is not subjected to aggressive chemical attack due to prolonged wetting. The basemat elevation is designed to preclude flooding and is installed above the site's PMF elevation. Since all HSM SSCs are above ground, sulfate attack with solutions > 1500 ppm is not a credible aging mechanism. Therefore, aggressive chemical attack is not an applicable HSM SSC concrete aging mechanism and does not require management.

3.5.4.2.3 Fatigue

Fatigue loading is characterized by low-amplitude, high-cyclic loading due to mechanical, thermal, or combined effects. Fatigue loading can result in a loss of mechanical strength properties and manifests as cracking of the concrete. Since there are no mechanical cyclic loads applied to the HSM, cycling due to thermal exposure is the only credible form of fatigue loading.

The only source of thermal fatigue is daily and seasonal environmental temperature fluctuations. According to Table 2.3.7 of the UFSAR [3.11.2], the largest mean daily temperature range for the TMI-2 ISFSI is 38°F during the months of July through August, while Section 8.3.6 of the UFSAR states: "the largest mean daily change of temperature at the TMI-2 ISFSI site is 50°F." Average seasonal mean temperatures range from 4°F in January to 87°F in July (Section 3.5.3) for a seasonal (winter to summer) variation of 83°F. Using the TMI-2 ISFSI design life of 50 years (See Section 1.3.1), the daily seasonal variation will cycle approximately 18,250 times.

Assuming that all concrete subcomponents are constrained, the cyclic stress amplitude may be calculated using the following equation:

$$\sigma = \alpha \cdot E \cdot \Delta T$$

Where the coefficient of thermal expansion (α) for concrete may be taken as 5.5×10^{-6} in/in/°F and the modulus of elasticity (E) is 4.03×10^{3} ksi (Table 8.1-3 of the UFSAR) [3.11.2]. Using 50°F for the maximum daily temperature swing and 83°F for the maximum annual temperature swing, the stress induced from daily and annual seasonal temperature fluctuations are 1.10 ksi and 1.84 ksi, respectively.

These stresses are 22% and 37% of the minimum compressive strength of the concrete (5,000 psi per Section 3.5.2.1) for the daily and seasonal fluctuations, respectively. Assuming these loads are cycled daily, and referring to the S-N curve of concrete (Fig. 6-47 of [3.11.127]), the number of cycles before failure occurs is greater than 10,000,000. Since this value exceeds the postulated worst case 18,250 cycles, thermal cycling (fatigue) has a negligible effect on the HSM reinforced concrete. The high thermal mass of the HSM and low conductivity of the concrete material limit the magnitude of the thermal forces that could be developed due to temperature swings. Therefore, based on this information, concrete thermal fatigue due to the mechanism of daily and seasonal environmental temperature fluctuations is not an aging effect that requires management during the PEO.

3.5.4.2.4 Irradiation

The radiation effects on the HSM concrete are discussed in Section 8.1.1.5, HSM Loads Analysis, in the UFSAR (page 8.1-14 of [3.11.2]). This discussion is based on a design life of 50 years (See Section 1.3.1). The reasoning is as follows:

> *"As described in Reference 8.9, the accumulated neutron flux over the 50-year service life of the HSM for five year cooled intact fuel (which envelopes the TMI-2 fuel) is estimated to be 1.7E14 neutrons/cm^2. From the study by Hilsdorf, Kropp, and Koch [8.10], the compressive strength and modulus of elasticity of concrete is not affected by a neutron flux of this magnitude.*
>
> *"As described in Reference 8.9, the gamma energy flux deposited in the HSM concrete for five year cooled intact fuel (which envelopes the TMI-2 fuel) is 1.7 E9 MeV/cm^2-sec. or 3.0 E-4 Watt/cm^2. According to ANSI/ANS-6.4-1977 [8.11], the temperature rise in concrete due to this level of radiation is negligible. Thus, radiation effects on concrete strength are not evaluated further for the HSM design."*

Concrete structures have been regarded as being sound as long as the cumulative radiation does not exceed critical levels over the life of the structure. Additional detailed analysis reported in Section 3.5.3, shows that integrated over a service life assumed as a 60-year period (See Section 3.3.1.2.2), the maximum radiation exposure on the HSM concrete walls is 2.90×10^{13} neutrons/cm^2 neutron fluence and 1.98×10^{8} rad gamma. These calculated values are well below the level of concern for adverse neutron and gamma radiation effects on the concrete walls of 1×10^{19} neutrons/cm^2 and 1×10^{10} rad, respectively [3.11.24], (Section 3.5.1.9 of [3.11.76]).

The differences between the results above and those of the UFSAR are primarily the result of the conservative nature of the UFSAR evaluation. The total dry storage period for both the original license term and the PEO is 40 years, enveloping both evaluation results over the PEO. These evaluations demonstrate that the compressive strength and modulus of elasticity of reinforced concrete are not affected by this magnitude of neutron fluence or gamma exposure on these materials during the PEO. Therefore, irradiation is not an adverse aging effect on the HSM SSCs for the duration of the PEO and no aging management is required.

3.5.4.2.5 Reaction with Aggregates

Chemical reactions may develop between certain mineral constituents of aggregates and alkalis that compose the Portland cement paste. These alkalis are principally introduced in the concrete by cement, but may also be present from improper admixtures and salt-contaminated aggregates. Seawater and solutions of deicing salt can also inject alkalis into concrete by action of penetration. DOE-ID conducted core sampling in May 2009 on nine different HSMs, in areas including the roof, front wall, and rear wall [3.11.128]. A nominal 20-in. long by 4-in. diameter core sample was removed from 12 separate locations [3.11.129]. The WJE consultant contract in 2009 included laboratory testing on six of these core samples [3.11.15]. The testing included depth of carbonation, petrographic examinations, chloride content, and compressive strength. As indicated in Section 3.2.3.2.1, the initial WJE investigation on the core samples focused on deleterious reactions within the concrete, such as ASR and DEF, which can cause slow, but long-term and progressive failure of the concrete.

ASR results when reactive silica present in the aggregate comes in contact with the alkali salts in the concrete and moisture. Alkali salts are primarily found in the cement, but may be introduced through contamination in the aggregate as well as alkali salts found in some admixtures. With sufficient moisture available, ASR gel traps water and is highly expansive. In some cases, the amount of ASR gel produced can cause concrete to expand resulting in spalling, cracking and a loss of strength over time. Traditionally, testing of the aggregate for reactive silica, use of reduced alkali cement, and addition of admixtures are used to control for ASR.

DEF is a reaction that causes expansion of the concrete over time, occurring in concrete that has been heat-cured or which encountered a hot environment during curing. High temperatures break down ettringite, which normally forms immediately after water and cement first come into contact. The components that make up ettringite remain in the system and reform ettringite in the presence of moisture. Ettringite is expansive and produces internal pressures in the concrete leading to long-term damage. Additional symptoms of DEF include the presence of microcrystalline ettringite gel gaps around aggregate that develop as the cementitious matrix expands around the inert aggregate particles.

The findings for the 2009 core sample investigations indicated that ASR and DEF were not a factor in the premature aging evidenced by the cracking [3.11.15]. Rather, the premature aging (i.e., cracking) was due to the freeze-thaw cycles as discussed in Section 3.5.4.2.1. The concrete core samples examined were characterized as generally hard, dense, and well consolidated. No reportable differences were observed between four concrete samples that contained major cracks and two concrete samples that contained only minor cracks. No evidence of DEF was found in the core samples [3.11.15].

HSMs have about 20 years of OE without ASR-type cracking ever being observed [3.11.25]. This is primarily due to preventative measures in the concrete design and formulation. Three basic conditions must exist for ASR induced cracking to proceed in concrete (Section 3.1 of [3.11.209]). These three conditions are high alkalinity in the cement, moisture, and reactive silica in the concrete aggregate. During the design of the TMI-2 ISFSI, measures were taken to ensure the quality of the concrete used in the fabrication of the HSM ensuring both low pH cement and non-reactive silica aggregate [3.11.11]. In addition, moisture is limited due to the annually low average relative humidity for the INL site ranging from 30% to 70% and less than 10 inches per year of rainfall (See Section 3.3.1.2). Initiation and propagation of ASR requires a relative humidity greater than 80% (Section 3.5.1.3 of [3.11.76]). Therefore, all three conditions required are controlled or are limited in their existence.

As indicated in Section 3.5.2.1, the HSM fabrication specification [3.11.11] and ASTM C150 [3.11.8] required the cement to have low alkali content (less than 0.60% of Na_2O equivalent alkali by weight). Fabrication documents indicate the actual alkali content was lower, approximately 0.43-0.44% [3.11.142]. According to Section 3.1 of ACI 221.1R [3.11.209], during laboratory tests, when alkali contents were 0.40% or less "excessive expansion in the mortars did not occur." Maintaining an alkali content of less than 0.44% is not a guarantee against ASR expansion. On the other hand, excessive expansion is more unlikely for alkali contents between 0.40% and 0.44% due to the reduced ability to sustain the reaction, particularly when combined with negligible external sources of alkali. Considering the HSM concrete is above ground and not exposed to groundwater, and there are no other external sources of alkali present (See Section 3.3.1.2), therefore, the concentration of alkalizing salts is considered to be well controlled.

In addition, the concrete fabrication specification required ASTM testing for potential alkali reactivity of the aggregate [3.11.11]. Chemical testing was conducted in accordance with ASTM C289 [3.11.210] using the acceptance criteria of ASTM C289, Figure X1.1. Test results [3.11.211] show that both the fine and coarse aggregate were considered innocuous in terms of their potential reactivity with alkalis. The original ASTM C289 aggregate reactivity susceptibility test results have been confirmed by the 2009 petrographic study [3.11.15] and the greater than 15 years of field performance of the concrete at the TMI-2 ISFSI. The field performance basis comes from ASTM C1778 [3.11.212] "Standard Guide for Reducing the Risk of Deleterious Alkali-Aggregate Reaction in Concrete". ASTM C1778 provides guidance on how to address the potential for deleterious alkali aggregate reaction such as ASR in concrete construction. Section 7.1 of ASTM C1778 uses long-term field performance of the aggregate as a basis for adequacy. Figure 1 of ASTM C1778 provides a flowchart showing steps for evaluating the aggregate reactivity, with the first decision block being field history duration. Since damage from ASR can take more than ten years to develop, structures a minimum of 15 years showing non-reactive aggregates justifies their suitability in the field. The TMI-2 ISFSI has greater than 15 years of field historical performance without any deleterious expansion in concrete from the ASR aging effect.

Moreover, performance of the petrographic studies [3.11.15] meets the second decision block criteria in the Figure 1 flowchart of ASTM C1778, thus substantiating both the in-service exposure field history and the original ASTM C289 chemical reactivity conclusions. The petrographic study was conducted in accordance with the methods and procedures outlined in ASTM C856 [3.11.213] which follows the practice provided in Section 7.1.2 of ASTM C1778. General conclusions from the 2009 study regarding the concrete quality (including the aggregate) comprised the following statement:

> *"No serious deleterious internal reactions were found, and ASR, DEF and corrosion are not considered factors in the current distress..."*

As discussed in Section 3.5.4.2.1, the "current distress" described by the study was from freeze-thaw cycling and a design feature of the roof-bolt holes. As a result, water infiltration occurred over several years from the freeze-thaw cracking and damage. This damage was repaired and steps were taken to prevent the ingress of water into the HSM concrete. However, when the moisture conditions were sufficient to support ASR, the indications identified were insufficient to include it as either an initiator or contributor to the spalling or cracking of the concrete. In addition, future exposure to moisture is limited by the dry environment of the ISFSI and by the AMP annual water repellant testing of the HSM exterior concrete surfaces (See Section A2.4.1).

The age of the TMI-2 ISFSI concrete is greater than 15 years old with no signs of ASR or DEF induced expansive cracking. In addition, there is no source of external alkalis at the TMI-2 ISFSI and the concrete composition contains a low-alkali source of cement that cannot maintain aggregate reactions leading to deleterious aging effects. Additionally, the aggregate was considered non-reactive and the petrographic core studies in 2009 confirmed this. The 2009 study also did not show ASR or DEF indications and both the moisture sources are limited and the relative humidity is low onsite. Based on the above information, it is reasonable that the HSM concrete SSCs will continue to perform their intended functions during the PEO. However, even though HSM cement-aggregate reactions during the PEO are considered unlikely, one reaction type (ASR) will be added to the AMP corrective action program (Appendix A2.7), in order to ensure it is not the apparent or root cause of any premature degradation. Notwithstanding this AMP element inclusion, reasonable assurance exists that the HSM concrete SSCs are not subject to alkali-aggregate chemical reactions and will continue to perform their intended functions during the PEO.

3.5.4.2.6 Shrinkage

Volume changes manifest themselves as shrinkage of the concrete leading to possible loss of material and cracking. As indicated in Section 3.5.2.1, a review of the core samples in 2009 [3.11.15] judged the bond between the aggregate and paste to be weak. The finding from the report was that, "the concrete contains widespread microcracking likely related to the high paste content, variable water-cement ratio and maybe other factors related to curing. These factors contribute to the sensitivity of the structures to shrinkage cracking."

As part of the design basis, this aging mechanism was addressed in Section 8.1.1.5.B of the UFSAR [3.11.2]:

> *"Shortening due to creep and shrinkage occurs gradually over a period of time, and the effects are lessened by plastic creep flow and micro cracking of the members. Ambient humidity also acts to reduce the effects of creep and shrinkage. The PCI Design Handbook [8.8] suggests that the calculated creep and shrinkage shortening values be reduced by a factor of three to five for design. Also, creep and shrinkage forces act opposite to those of thermal expansion forces for the HSM. Hence, it is conservative to neglect creep and shrinkage effects. Therefore, creep and shrinkage are not considered further for the HSM design."*

Consistent with Table 2.4.1 of ACI 209R-92 [3.11.130], concrete shrinkage of moist cured concrete occurs according to the following schedule: 91% in first year, 98% in 5 years, and 100% in 20 years. Twenty years will have occurred by the initiation of the PEO. The shrinkage aging mechanism will have ceased by the initiation of the PEO. However, since onsite OE showed that microcracking in the base module HSM SSCs was observed in 2009 [3.11.15] and was "primarily caused by shrinkage of the concrete that is internally restrained by the structure," the resultant cracking aging effect requires management during the PEO.

3.5.4.2.7 Leaching

Leaching of calcium hydroxide [$Ca(OH)_2$] due to water penetration can result in loss of concrete material, converting the cement into gels that have no strength. Leaching of $Ca\text{-}OH_2$ (i.e., lime) over long periods can increase the porosity and permeability of concrete, making it more susceptible to other forms of aggressive attack and reducing strength. Leaching can also lower the pH of the concrete and affect the integrity of the protective oxide film of reinforcement steel. The significance of the effect is governed by water temperature and salt content (Section 4.1.2.1 of [3.11.131]). This leaching action of the water can only occur if the water passes through the concrete (i.e., penetration). Water that merely passes over the surface will not cause leaching leading to a loss of HSM SSCs intended functions.

During the 2009 WJE inspections, efflorescence and water staining was common around cracks near the top corners of the HSMs [3.11.15]. Efflorescence typically is calcium carbonate formed when lime in the concrete is dissolved by moisture and carried to the surface of the concrete where it reacts with carbon dioxide. It was a strong indicator of persistent moisture moving through the concrete at the time. As empirical evidence of the aging mechanism, the WJE report described the paste content of the HSM-29 concrete core sample (rear-base portion) as follows:

> *"The paste contains moderate amounts of partially hydrated portland cement and unhydrated cement particles, estimated at 5 to 7 percent by volume of paste. Cement hydration characteristics appear normal. Extent of cement hydration is advanced. Calcium hydroxide is mostly uniformly distributed throughout the paste (frequent thin rims of calcium hydroxide around fine aggregate particles), and occurs as tabular and irregularly shaped crystals 5 to 30 μm in diameter. Estimated calcium hydroxide content is 7 to 10 percent by volume of paste. Calcium hydroxide was not observed in the vicinity of the crack; the paste is nearly isotropic (leaching has removed calcium hydroxide). No supplementary cementitious materials were detected."*

In summary, the 2009 inspections revealed efflorescence on the exterior surface of the concrete consisting of scaly deposits of calcium carbonate; calcium leached from the cement paste and deposited on the outer surface. Efflorescence and secondary ettringite was evidence of water infiltration and long-term exposure to moist conditions. Overall, however, secondary deposits were not abundant in the body of the concrete, suggesting that water migration occurred predominantly along the freeze-thaw cracks. Thus, the leaching was also amplified by the increased presence of water from the freeze-thaw cracking causing additional filling of water within cracks. As evidenced by subsequent inspections, this effect was reduced substantially after the concrete cracks were repaired and the surfaces of the concrete protected from water intrusion. Nonetheless, given the history of this aging mechanism, leaching of calcium hydroxide is an applicable TMI-2 ISFSI concrete aging mechanism. Therefore, the resultant aging effects, including loss of material/strength and increase in permeability requires management during the PEO.

3.5.4.2.8 Elevated Temperature

Elevated temperature could result in a reduction in concrete strength and concrete cracking. According to Appendix E, "Thermal Considerations" of the ACI 349 code for concrete SSCs [3.11.9], the surface temperature limitations under long-term normal operations shall not exceed 150°F, except for localized areas. Local areas are allowed to have increased temperatures not to exceed 200°F. As stated in Section 3.5.3 and in accordance with Table 8.1-8 of the UFSAR [3.11.2], the maximum HSM concrete temperature for normal operating condition is 128.7°F (inner roof surface temperature) at the beginning of the initial license period. This bounding temperature will have decreased at the initiation of the PEO. Maximum long-term concrete temperatures are below the long-term ACI 349 code limits of 150°F over the PEO. Therefore, elevated temperature is not an applicable concrete aging mechanism on the concrete HSM SSCs.

3.5.4.2.9 Creep

Creep is the time-dependent increase of strain in hardened concrete that has been subjected to sustained stress, primarily compressive. The sustained stress results from dead load, live load, pre-stress on the structure, and from temperature effects. Creep deformation is a function of loading history, environment, and material properties of the concrete. The time-dependent creep deformation of concrete under compressive load consists of cumulative strain resulting from progressive cracking at the aggregate-cement paste interface, from moisture exchange with the atmosphere, and from moisture movement within the concrete.

Creep-induced concrete cracks are typically not large enough to result in concrete deterioration or in exposure of the reinforcing steel to environmental stressors. Cracks of this magnitude do not reduce the concrete's compressive strength [3.11.25] [3.11.76]. Creep is more prevalent when new concrete is subjected to load and decreases exponentially with time, with any degradation noticeable within the first few years of operations. According to Table 2.4.1 of ACI 209R-92 [3.11.130], 78% of creep occurs within the first year, 93% within 10 years, 95% within 20 years, and 96% within 30 years. As identified in Section 3.5.4.2.6, creep was addressed in Section 8.1.1.5.B of the UFSAR [3.11.2] stating it was "conservative to neglect creep effects." Creep was not a degradation mechanism identified during the 2009 WJE inspections [3.11.15], nor was it identified by related OE with the Standardized NUHOMS® HSMs [3.11.25]. Therefore, creep is not an applicable concrete aging mechanism for the HSM concrete SSCs during the PEO.

3.5.4.3 Steel SSCs

3.5.4.3.1 Corrosion of Embedded Steel

Loss of material (evidenced by concrete cracking or spalling) may result from corrosion of embedded steel within the concrete matrix. Corrosion is an electrochemical process involving metal, oxygen, and an electrolyte that results in the formation of ferric oxide, that is, rust. The oxide product, which has a considerably greater volume than the original metal can result in tensile stresses and eventually cause hairline cracking, followed by rust staining, spalling, and more severe cracking in the concrete surrounding the embedded steel. Typically, the high alkalinity ($pH > 12.5$) nature of concrete provides an environment around embedded steel and steel reinforcement that protects them from corrosion. If the pH is lowered (for example, $pH < 10$) due to leaching of alkaline products through cracks, intrusion of acidic materials, or carbonation, corrosion may occur [3.11.136]. Carbonation results from the chemical reaction between the hydrated cement components (mainly calcium hydroxide and calcium-silicate hydrate) and atmospheric carbon dioxide. The reaction lowers the pH of the concrete pore water to a level where passivity of the embedded steel surface is no longer supported, leading to initiation of rebar corrosion and subsequent concrete degradation [3.11.137]. Chlorides could also be present in constituent materials of the concrete mix (that is, cement, aggregates, admixtures, and water), or they may be introduced environmentally [3.11.136]. Chloride contents above 0.020 to 0.030 % by mass of concrete, depending on cement content, can promote corrosion of embedded steel in non-carbonated concrete.

As indicated in Sections 3.5.4.2.2 and 3.5.4.2.5, the chloride content in the concrete, and that measured in two core samples in 2009 was low. Using methodology from ASTM C 1152, acid-soluble chloride analysis was performed at two depths in core samples from HSM-7 and HSM-27 [3.11.15]. Very low chloride contents, near the minimum sensitivity of the test (ranging from .003-.006% of sample mass), were measured at depths averaging 3/8-in. and 1-½-in. in both cores. Per the analysis in Section 3.5.1.6 of [3.11.76], this level of chloride content would be considered insufficient to promote corrosion of embedded metals.

Furthermore, the HSM concrete mix design was fabricated consistent with ACI 318-95 [3.11.139]. Per the concrete construction specification [3.11.11], controls were placed on: the chloride content as shown above, water-cement ratio (less than 0.45), air content (between 3.5% and 5.75%), cement types (less than 0.60% by weight of alkalis), aggregates, and admixtures. These stringent controls ensured good quality concrete resistant to chemical attack and, together with adequate concrete cover, make the reinforcing steel less susceptible to corrosion.

However, findings from visual inspections of the HSM end shield walls in 2009-2015 showed spalling progression along the base of the walls. A picture (Figure 3-9) shown in Appendix FF of RPT-1443 [3.11.138] from a September 2015 inspection of the southwest shield wall showed exposed rebar with rust staining. The condition exceeded the ACI 349.3R second-tier criteria for spalling (less than ¾-in. depth and 8 inches in any direction). After this inspection was completed, the active spalls were repaired in October 2015 (WO 656351) [3.11.28], with the repair shown in Figure 3-10. According to the 2009 WJE inspection, "This damage was apparently caused by point loading, likely due to irregularities on the slab or shield wall surface, when the shield wall was installed. This does not appear indicative of on-going deterioration; however, additional investigation would be required to determine its cause." This is confirmed in an October 2000 inspection conducted by Transnuclear West, Inc. [3.11.191]. However, corrosion of embedded steel cannot be ruled out as a mechanism for such concrete spalling. Of note, this condition of spalling was limited to bases of the end shield walls only and did not affect the HSMs themselves. Although all observed cases of spalling were repaired, environmental degradation of the HSM concrete due to rebar corrosion may still be considered applicable. Finally, if the concrete is degraded by other aging mechanisms causing a reduction in the protective cover of the steel, corrosion may occur at a higher rate. As previous TMI-2 ISFSI OE has shown, the exposed surfaces of HSM structures can be subjected to freeze-thaw cracking and leaching of calcium through cracks. As is documented in the 2016 HSM concrete inspection report [3.11.214], spalling along the base of the end shield walls has been repaired. Nonetheless, there is still active spalling occurring as shown in Appendix FF (Figure 5) of the 2016 inspection report with signs of freeze thaw degradation. Due to the history of spalling and freeze-thaw cracking at the TMI-2 ISFSI and other instances of spalling OE described in [3.11.25], loss of material due to steel embedment corrosion is considered an aging effect requiring management for the HSM SSCs. Therefore, corrosion of embedded steel including reinforcing steel is an applicable concrete aging mechanism and will be managed during the PEO.

3.5.4.3.2 Corrosion

Metal surfaces in contact with moist air or water are subject to corrosion (i.e., uniform, pitting, and crevice). The rate of corrosion is governed by several factors, such as the moisture of the air, the salinity level of the air, the temperature of the metal surface, and the specific type of metal involved. For HSM carbon and low alloy steel SSCs, loss of material due to corrosion is a credible aging effect for the Outdoor and Sheltered Environments. A more detailed discussion of each corrosion type on plain carbon steel SSCs is provided in Sections 3.4.4.2.1 through 3.4.4.2.3. As indicated in Section 3.5.2.3, all of the structural steel SSCs and fasteners are zinc-coated with the only exception being the NITS protective roof bolt covers, which are stainless steel. Therefore, general loss of material of steel from corrosion will not occur until the sacrificial zinc coating has oxidized. As discussed in Section 3.2.3, the Pre/Application inspections of the interiors of HSMs 15 and 16 [3.11.133] [3.11.83] showed that only minor corrosion has occurred. The minor corrosion appeared only in areas where the zinc coatings have been damaged from abrasion, most likely due to handing during loading operations. However, because of the potential for corrosion effects, especially in the areas with damaged coatings, this aging effect requires management. As discussed in Section 3.8.4.2.1, corrosion of stainless steel at the TMI-2 ISFSI is limited due to the dry conditions. However, management for the loss of material on the coated steel SSCs and the stainless steel protective roof bolt covers ensures their continued performance of their intended functions during the PEO.

3.5.4.3.3 Stress Corrosion Cracking

SCC is a localized non-ductile cracking failure resulting from an unfavorable combination of sustained tensile stresses either applied (external) or residual (internal), material condition, and the presence of a corrosive environment. As discussed in Section 3.4.4.2.6, SCC as a phenomenon would not be characteristically associated with carbon steel and low-alloy materials in the environments that the HSM carbon steel SSCs are exposed.

High-strength steel fasteners with yield strengths greater than or equal to 150,000 psi have been found to be susceptible to SCC under exposure to aqueous electrolytes [3.11.72]. Failures have been observed in bolting materials subjected to water or steam environments containing various contaminants, particularly when containing hydrogen sulfide. Laboratory tests indicate that hydrogen sulfide may be released from molybdenum disulfide decomposition in aqueous environments with high temperatures [3.11.135]. Specifically, SCC failures of bolting materials within the energy industry have been reported for two classes of bolting materials: high-nickel maraging steels and low-alloy quenched and tempered steels. In most cases, SCC involves crack initiation, subcritical crack growth, and failure when the crack reaches a critical size and the tensile strength of the remaining material is exceeded. This phenomenon can produce cracking at stress levels below a material's yield strength. The crack or fracture will appear brittle, with no localized yielding, plastic deformation, or elongation. The only TMI-2 HSM steel SSCs applicable for the aging effect are the quenched and tempered ASTM A194, Grade 2H nuts/coupling nuts [3.11.59] which are specified to have a minimum proof stress matching the 150,000 psi strength value.

SCC also requires the presence of a sufficient tensile stress. According to Section 3.2.1.5 of [3.11.76], "Calculations using the approach proposed by Baggerly (1999) show that the stress threshold to initiate SCC of steel bolts is usually larger than 70 percent of the bolting material's minimum yield strength." As stated in [3.11.76], the Standardized NUHOMS® system high-strength structural bolts in the HSM are installed "snug tight" and are not loaded close to critical stresses. "Snug tight" torqueing of all the TMI-2 HSM fasteners is also specified on the design/fabrication drawings and Section 5.3 of the installation specification [3.11.18].

SCC of the carbon steel in the HSM is not considered a credible aging mechanism at the TMI-2 ISFSI because 1) high-strength steels are limited to the ASTM A194, Grade 2H nuts [3.11.59] and these SSCs are not subjected to high tensile stresses; 2) there are no caustic environments present; and 3) high temperatures are not present as was shown to be necessary per the OE.

As discussed in Section 3.8.4.2.5, SCC of stainless steel at the TMI-2 ISFSI is limited due to the dry conditions. Therefore, management of SCC on the stainless steel protective roof bolt covers is not required. Furthermore, the fact that these covers are not subjected to high stresses supports the assessment that SCC on these SSCs does not require management for the PEO. As such, SCC is considered a non-credible aging mechanism on the steel HSM SSCs and does not require management during the PEO.

Figure 3-9: Southwest Shield Wall – Left Panel (September, 2015)

Figure 3-10: Southwest Shield Wall – Left Panel (March, 2016)

3.5.4.3.4 Irradiation Embrittlement

High neutron radiation can cause loss of fracture toughness in steel (i.e., increases in the nil-ductility temperature) (pg. 653 of [3.11.82]). In general, the neutron fluence seen by the steel SSCs of the HSMs is generally orders of magnitude lower than that required to produce any adverse effect, so neutron radiation is unlikely to be an applicable aging mechanism.

The location of the HSM steel SSCs ranges from near contact with the DSC shell to the exterior of the concrete structure. As indicated in Section 3.3.1.2.2, the maximum neutron fluence on the DSC shell assembly is calculated to be 1.98 x 10^{14} neutrons/cm^2 with the Am-Be-Cm startup source, integrated over an assumed 60-year period. The neutron fluence in the concrete for the localized source is 2.90 x 10^{13} neutrons/cm^2, integrated over this 60-year period. Both of these values are well below the level of concern for embrittlement of the carbon steel at 1 x 10^{18} neutrons/cm^2 [3.11.24].

Separately, gamma radiation effects on the properties of steel were reviewed. The evaluation [3.11.24] described in Section 3.3.1.2.2 includes energy deposition tallies for the steel. Absorbed gamma energy integrated over the assumed 60-year period in the DSC shell and HSM concrete were 4.42 x 10^8 rad and 1.98 x 10^8 rad, respectively. However, no limit on gamma radiation damage applicable to steel has been identified, which is consistent with the Standardized NUHOMS® LRA (Section 3.5.4.2 of [3.11.25]). Therefore, change in material properties due to irradiation embrittlement is not an aging mechanism requiring management for the HSM steel SSCs during the PEO.

3.5.4.3.5 Fatigue

As discussed in Section 3.5.4.2.3 for concrete fatigue, the only source of thermal fatigue is due to environmental temperature fluctuations. Thermal fatigue is the progressive and localized structural damage that occurs when a material is subjected to cyclic loading associated with thermal cycling. Excessive fatigue effects could lead to either cracking or loss of strength. The DSC steel support structure is located inside the HSM in the Sheltered Environment where the thermal fluctuations due to external ambient temperature fluctuations are substantially reduced due to the large thermal mass provided by the HSM enclosure walls and roof, and the low DSC decay heat. As was discussed in Section 3.4.4.2.9 regarding thermal fatigue effects on the DSC, this was evaluated as part of the UFSAR, and found to be of no consequence. Therefore, thermal cycling fatigue due to fluctuations in the more benign conditions outside of the DSC is not considered a credible aging mechanism for the DSC steel support structure. Therefore, loss of strength and cracking due to the mechanism of fatigue are not aging effects requiring management for the HSM steel SSCs during the PEO.

3.5.4.4 Coatings Evaluation

Listed in Table 3-6 are the coated HSM SSCs. For the HSM SSCs, no credit is taken for coating for the prevention of aging effects. However, the inorganic zinc-rich primer and high-build epoxy enamel finish coatings, both NITS SSCs, are an integral part of the in-scope carbon steel SSCs, providing them a defense-in-depth protection from corrosion, whether credited for that protection or not. Similarly, a silane water-based water repellent coating protects the concrete HSM SSCs from water intrusion, but no credit is taken for its prevention of aging effects.

Metallic subcomponents within the HSM are carbon steel. Consistent with [3.11.17], all carbon steel surfaces are either painted or hot-dip galvanized, except that threaded fasteners are electroplated, consistent with the requirements of ASTM B633 [3.11.141]. Painted surfaces are coated consistent with Appendix A of the fabrication specification [3.11.17]. Hence, all steel materials described in Section 3.5.4.3 are protected against corrosion, as a defense-in-depth function. As described in Section 3.5.2.3, a prime coat of inorganic zinc-rich primer is first applied on the surface of the steel. A high-build epoxy enamel finish coating provides additional protection. Alternatively, hot-dip galvanization (with a minimum thickness coating grade of 100) of carbon steel HSM SSCs is performed per ASTM A123 [3.11.140]. These coating systems have excellent adhesion to steel and resistance to alkalis, and are intended to provide protection for the steel against corrosion in the TMI-2 ISFSI environment. Numerous mechanisms for coating degradation including mechanical removal (scraping), corrosive oxidation, and cracking have been identified as previously discussed in Section 3.4.4. Failure of the coating does not prevent the HSM steel SSCs from satisfactorily accomplishing their intended functions. Yet, it may disguise indications of corrosion of the underlying material. Therefore, aging management of the coating is considered preventive maintenance during the PEO. This would include managing for loss of coating integrity due to blistering, cracking, flaking, peeling, or physical damage.

For the concrete SSCs of the HSM, in 2011, all exterior surfaces were coated with a penetrating water-based silane water repellent coating [3.11.19]. Like the steel protective coatings, the silane concrete coating does not provide a credited function in the design safety bases. However, it was identified by WJE inspections in 2009 [3.11.15], as a recommended course of action to limit further concrete degradation. During the 2009 inspections, water intrusion was identified as a probable cause of scaling and cracking of the TMI-2 HSM concrete and end shield wall SSCs. As such, the silane coating affords a defense-in-depth function, providing long-term water repellent protection, inhibiting both moisture penetration and rebar corrosion [3.11.15]. Therefore, aging management of the silane water-based coating integrity and functionality during the PEO allows continued protection of the underlying HSM concrete SSCs.

Table 3-6: Coated HSM SSCs

SSC	Material	Coating
DSC Support Structure	Coated Carbon Steel	Zinc-rich primer with epoxy topcoat
HSM Wall Connections	Coated Carbon Steel	Zinc-rich primer with epoxy topcoat
Door Plates	Coated Carbon Steel	Zinc-rich primer with epoxy topcoat
DSC Seismic Restraints	Galvanized Steel	Galvanized Steel
Threaded fasteners	Zinc Electroplate	Zinc Electroplate
Embedments	Coated Carbon Steel	Zinc-rich primer with epoxy topcoat
HSM Base Unit and Roof Slab	Reinforced Concrete	Silane water-based water repellent coating

3.5.4.5 Other Fillers (Chemical Grouts) and Repair Sealant Materials

As indicated in Section 3.5.2.4, polyurethane spray foam was injected into the voids between the roof slab bolt and bolt holes. In addition, a gasket made from polyurethane foam material was placed over the sprayed foam and under the plate steel washer/protective bolt cover, halting the intrusion and collection of water. These remediation actions provide weatherability and limit water intrusion from initiating freeze-thaw cracking of the concrete HSM roof slab and base unit top corners. The polyurethane foam and gasket are NITS SSCs, as they do not provide a credited function in the design safety bases. However, WJE inspections in 2009 [3.11.15] identified installation of these items as a recommended course of action to limit further concrete degradation from freeze-thaw cracking. According to the Statement of Work (SOW-7948) included with [3.11.119], that with the inclusion of these polyurethane materials, "It is expected that the HSMs will be able to meet their designed service life of fifty (50) years with installed polyurethane fill and water-resistant gaskets." According to the manufacturer [3.11.158], "Cured foam is resistant to heat and cold -200° F to +200° F. It is also resistant to negative effects of aging. It is not resistant to UV light and must be painted, coated, or covered if exposed to direct sunlight after application." Thus, inclusion of the protective roof bolt covers was added to limit both direct sunlight and direct exposure to rain and snow. As discussed in Section 3.5.4.2.1, the protective bolt covers were placed over the repaired roof slab bolt holes (WO 627046) [3.11.119]. As such, the initial polyurethane gaskets were exposed to UV light for a period from October 2009 to June 2011. However, during the installation of the bolt covers, the original polyurethane gaskets were replaced with new polyurethane gaskets as part of WO 635917 [3.11.123].

The gasket edges may be exposed to moisture if it is allowed to collect on the roof slabs. In terms of water exposure, when polyurethane foam at constant temperature is exposed to water, in either liquid or vapor form, little moisture will accumulate in the foam, since 90% of the cells are closed and hence bound by continuous membranes that the water cannot penetrate. The presence of air and blowing agents inside the cells also protects the foam from damage due to freeze-thaw cycling [3.11.159].

However, the polyurethane foam may be susceptible to aging having been exposed to radiation from the TMI-2 core debris. In addition, the ACI 546.3R guide [3.11.166] recommends routine inspection and maintenance and indicates that, "Polyurethane sealants can provide a service life from 3 to 10 years, at which time they need to be removed and replaced." It follows that aging management of these polyurethane filler materials (i.e., the TIGER FOAM® and gasket) is required. This is necessary in order to limit water intrusion into the roof bolt holes, and checking for premature aging effects, including bonding or adherence fractures and any signs of water infiltration into the bolt holes. This is to ensure continued performance of the HSM SSCs intended structural integrity function during the PEO.

Also covered in Section 3.5.2.4 are other repair materials that were added to the HSM concrete from 2011-2015. Although NITS items, premature degradation of these materials potentially could adversely affect the protected concrete and steel HSM SSCs structural integrity intended functions. The materials include the epoxy resins CRACKBOND® SLV-302 used in the injection repair of cracks and MIRACLE BOND® 1350 used to cover the crack surfaces [3.11.26]. In addition, Dow Corning® 890-SL silicone sealant was used for filling the coil insert holes on end shield walls [3.11.27], and the MIRACLE BOND® 1450 epoxy [3.11.163] was used for the shield wall spalling repairs [3.11.28], previously discussed in Section 3.5.4.3.

The epoxy resin CRACKBOND® SLV-302 was injected into cracks in the HSM concrete matrix under a cover paste of MIRACLE BOND® 1350 epoxy resin, preventing water intrusion and further damage to the HSMs. These epoxy resins are not a structural component in themselves and their failure will not directly affect the structural integrity of the HSM. However, if the resin degrades prematurely or fails, a path for water intrusion into the concrete could be reopened. This could allow for renewed freeze/thaw aging and other aging conditions with the potential to affect adversely the concrete and steel HSM SSCs structural integrity. Similarly, the silicone sealant used in the coil insert holes in the end shield walls prevent water intrusion and pooling within the holes and premature aging of the concrete in those areas. Finally, the MIRACLE BOND® 1450 repair epoxy is also used to protect areas impacted by spalling, thus providing a protectant for further degradation in those distressed sections of HSM SSCs.

ASTM C717 [3.11.160] provides a definition for aging effects requiring management on sealants: 1) 'adhesive failure' between the sealant and concrete substrate, and 2) other 'cohesive failure' characterized as rupture within the sealant or filler. Therefore, aging management of these aging effects on chemical grout and other repair sealant materials is required to ensure the intended functions of the protected HSM SSCs are maintained during the PEO.

3.5.4.6 HSM Aging Effects Requiring Management

Discussion of postulated aging mechanisms with resulting effects on HSM SSCs is provided in Sections 3.5.4.2 through 3.5.4.5. Based on these evaluations, several pertinent aging mechanisms and effects were identified for management during the PEO.

Potential aging effects evaluated for the concrete and embedded SSCs along with their postulated aging mechanisms, include the following:

- Loss of concrete through spalling and scaling from freeze-thaw cycles and shrinkage
- Concrete cracking from freeze-thaw cycles and shrinkage
- Reduction of concrete strength, modulus, and pH from leaching of calcium hydroxide
- Increase in concrete porosity and permeability from leaching of calcium hydroxide
- Loss of material of embedded SSCs from corrosion

The HSM SSC concrete includes the cementitious grouting filler materials used during original fabrication and subsequent repairs. The concrete matrix is monitored such that the overall integrity of the continuous matrix is maintained. For the chemical grouting filler materials and sealants used during repairs, parameters monitored include the following aging effect identified in Section 3.5.4.5:

- Adhesive and cohesive failure of concrete repair chemical grout fillers and sealants from premature degradation, including UV exposure and irradiation

In addition, as a defense-in-depth aging management function, the silane water repellent coating on the concrete is included to assess for physical damage on the steel coatings and inhibition of moisture penetration on HSM concrete SSCs and rebar corrosion on HSM steel SSCs.

In addition, the following aging effect on in-scope steel SSCs of the HSM includes:

- Loss of material due to corrosion (general, crevice, pitting)

In addition, as a defense-in-depth aging management function, the zinc-rich primer on the coated steel HSM SSCs is included to assess loss of coating integrity due to blistering, cracking, flaking, peeling, or physical damage.

A summary of applicable aging effects/mechanisms on HSM SSCs is shown in Table 3-5. Management of these aging effects will be performed through the AMAs discussed further in Section 3.5.5.

3.5.5 Aging Management Activities for the HSMs

(NUREG-1927, Section 3.2 and Section 3.4.1.3)

This section describes the AMAs resulting from the AMR. All ISFSI TLAAs are summarized in Appendix B, with those areas of the HSM AMR that can be addressed by TLAAs specifically addressed in Section 3.5.5.1. Appendix A2 describes the HSM AMP that is directed primarily as a visual examination (either direct visual or remote visual inspection) of the surfaces of the HSM to manage the applicable aging effects described in Section 3.5.4.6. The AMP is the key operations and maintenance program for the HSM SSCs such that their intended functions are maintained during the PEO.

In addition, the TMI-2 ISFSI radiation levels are currently monitored and tracked as part of the existing TMI-2 ISFSI LCO 3.2.1. Monitoring radiation levels is an indirect indicator of potential premature degradation occurring for the HSM SSCs. The DSC AMP, as described in Appendix A1 provides a data trending analysis of these ISFSI radiation-monitoring measurements, providing assurance that trends remain within acceptable bounds for the ISFSI and by extension for the HSM SSCs for the duration of the PEO.

3.5.5.1 HSM Time-Limited Aging Analyses

The following are summary descriptions of the TLAAs and other supplemental evaluations that were identified and prepared based on the AMR of the HSM.

3.5.5.1.1 Irradiation Effects Evaluation of the HSM

As incorporated in Section 8.1.1.5.D of the UFSAR [3.11.2], a TLAA documents the effects of cumulative neutron and gamma irradiation on the HSM concrete showing no deleterious aging effects. As discussed in more detail in Section 3.5.4.2.4, concrete structures are considered sound as long as the cumulative radiation levels do not exceed critical levels over the life of the structure. A TLAA evaluation in the UFSAR over a 50-year period of the ISFSI demonstrates the cumulative radiation exposure to the HSM SSCs is below the maximum radiation exposure limits. Therefore, there is no credible degradation of the mechanical properties of HSM concrete due to effects of irradiation.

3.6 AMR RESULTS – TC

This section summarizes the results of the AMR for the TC. As discussed in Section 2.3.2.4 for the scoping evaluation, an OS197 TC aged greater than 20 years is allowed for use at the TMI-2 ISFSI, whereas an MP187 TC aged greater than 20 years is not allowed. AMR evaluations for the OS197 TC have been performed by the CoC holder in the Standardized NUHOMS® CoC renewal application [3.11.25]. As identified and IBR herein, Sections 1.2.2.3, 3.3.3, 3.4, 3.4.1, 3.4.2, 3.4.3, and 3.7 of [3.11.25] pertaining to the OS197 TC provides the AMR results, including:

- Description of the OS 197 TC and its associated SSCs determined to be within renewal scope
- Identification of OS197 TC design, fabrication and maintenance considerations
- Identification of materials and environments for the OS197 TC and associated subcomponents
- Identification of OS197 TC aging mechanisms and effects requiring management
- Identification of any OS197 TC TLAAs and OS197 TC AMPs for managing aging effects

Specifically, Section 3.7 of [3.11.25] regarding the OS197 TC has been reviewed and bounds its use at the TMI-2 ISFSI. One TLAA has been identified for the OS197 TC. This TLAA evaluates the effects of fatigue on the mechanical properties of the OS197 materials. The TLAA is identified in Appendix 3B of [3.11.25] and is IBR herein (See Appendix B). Due to the higher OS197 TC maximum temperatures and longer PEO identified in the TLAA than is needed at the TMI-2 ISFSI, the TLAA's applicability at the TMI-2 ISFSI is bounded. In general, IBR an OS197 aged greater than 20 years is considered appropriate because any safety-significant variations on applicability at the TMI-2 ISFSI will be bounded by conditions already contained within [3.11.25] (i.e., stronger source terms, higher decay heat loads, ability to add contents to the ISFSI, high burn-up fuel, longer PEO, etc.).

One point of clarification is that the use of both a carbon steel DSC and TC spacers inside the OS197 TC is considered suitable, because there would be no new aging effects due to both lack of moisture and the temporary nature of the particular configuration. The difference being that the DSC evaluated in [3.11.25] is fabricated from stainless steel with the TC spacers being fabricated from either stainless steel or aluminum. In contrast, the TMI-2 ISFSI DSC and TC spacers are coated carbon steel. Therefore, as discussed below, an aging assessment of this distinction in adjoining materials with respect to the stainless steel OS197 TC is verified. In terms of environment, the lack of moisture within the TC interior recognizes the fact that both the TC spacers and DSC are in an environment similar to the Internal DSC Environment, so the conditions necessary for corrosive aging mechanisms do not exist (e.g., general corrosion, galvanic corrosion, crevice corrosion, pitting corrosion). Another enveloping parameter in this environment is that the design basis heat load for the OS197 TC is 24 kW [3.11.25]. Therefore, allowable interior TC temperatures are significantly greater in [3.11.25], bounding the original TMI-2 DSC design basis heat load of 0.86 kW. The other significant factor considered is that the configuration with the DSC or TC spacers loaded into a TC is an intermittent state, which occurs only during the short DSC loading and retrieval period. Hence, long-term, progressive deleterious aging mechanisms are not germane. In summary, aging considerations due to the material variances between the TMI-2 ISFSI's DSC and TC spacers and the DSC and TC spacers in [3.11.25] and any interactions with the stainless steel OS197 TC are not necessary and no further AMR assessment is provided. See Appendix A3 for additional aging discussions regarding the TCs, including the associated AMPs for managing any applicable aging effects determined from [3.11.25].

3.7 AMR RESULTS – BASEMAT AND APPROACH SLAB

This section summarizes the results of the AMR for the concrete basemat and asphalt approach slab. The basemat is a reinforced concrete structure designed to support the HSMs. The approach slab is an asphalt apron providing access and support for the Transfer Trailer while it transitions onto the basemat. The soil supporting the slab is excavated and backfilled to provide adequate bearing pressure for all postulated loads and to ensure adequate drainage.

As described in Section 3.7.3, the Basemat and Approach Slab exposed surfaces are located outdoors and are exposed to all weather conditions, including insolation, wind, rain, snow, ambient temperatures, humidity, and airborne particulate.

3.7.1 Description of Basemat and Approach Slab

The basemat is designed for dead load, live load, tornado-generated wind load, and seismic loads consistent with the ACI 318-95 ([3.11.139] code and Section 5.5.4.2 of [3.11.4]). These include design-loading combinations for the basemat. Load values are based on the TMI-2 ISFSI site design parameters listed in Chapter 3 of the UFSAR [3.11.2]. Special heavy loading conditions resulting from transport of SNF storage casks on the Basemat and Approach Slab were considered. These include the Transfer Trailer/tractor on its tires and jacks, as well as large-capacity cranes.

3.7.2 Basemat and Approach Slab Materials Evaluated

(NUREG-1927, Section 3.2 and Section 3.4.1.1)

According to general note 3.2 of the basemat fabrication drawing 219-02-5200 [3.11.20], the material of construction for the basemat is reinforced concrete, Portland cement (ASTM C150, Type II) [3.11.8]. Maximum coarse aggregate size is limited to 1–½-in., ASTM C33, Class 4S [3.11.7] with a minimum 28-day compressive strength not less than 4,500 psi. The maximum water-to-cement ratio is 0.45. The 18-in. thick basemat is strengthened via reinforcement bar embedded within the concrete matrix as shown on [3.11.20] with #8 rebar located approximately 5 inches from the bottom of the slab and #7 rebar located approximately 5 inches from the top of the slab.

The subgrade below the basemat consists of the 12-in. thick excavated and re-compacted alluvium described in diamond note 2.1 of [3.11.20]. Diamond note 2.2 of [3.11.20] indicated additional backfill was optional; however, backfill gravel was not used [3.11.151]. For the materials of the approach slab, sheet 2 of [3.11.20] identifies the approach slab subgrade as having an 8-in. dense graded aggregate base course with two, 2-in. layers of bituminous concrete (prime coat and tack coat) and one 1–½-in. top layer of bituminous concrete.

3.7.2.1 Other Materials

A water-repellent sealant was originally specified in flag note 3.7 of the basemat drawing 219-02-5200 [3.11.20]. By WO 636531 performed in late 2011 into early 2012 [3.11.21], CONSPEC® Silane 20 WB, a penetrating water-based silane water repellent coating, was reapplied to the exterior surface of the basemat, excluding inaccessible surfaces underneath the HSMs. Other maintenance activities at this time included as-needed repairs of minor cracking along with installation of a closed cell backer-rod to reduce joint and gap depth. DEGADECK® crack sealer, an unprocessed Acrylic reactive resin on Methacrylate base, was applied to the cracks with a light broadcast of clean, dry quartz sand applied prior to sealer hardening. The maintenance activities included filling control and expansion joints with SONOLASTIC® SL 2 elastomer-type sealant and filling the gap between the asphalt apron and concrete base mat with SOF-SEAL®, a low modulus crack and joint sealer.

3.7.3 Environments for the Basemat and Approach Slab

(NUREG-1927, Section 3.2 and Section 3.4.1.1)

The basemat and approach slab are located in the TMI-2 ISFSI Outdoor Environment. The exposed exterior surfaces of the basemat and approach slab are exposed to all weather conditions, including insolation, wind, rain, snow, and humidity. The TMI-2 ISFSI is located in a non-corrosive environment, away from saltwater and industrial facilities. The Outdoor Environment where the basemat and approach slab reside is described in detail in Section 3.3.1.2.

The areas of the basemat within the footprint of the installed HSM array are in the "Sheltered Environment". These areas are protected from outdoor effects (e.g., direct sunlight, precipitation, etc.) and experience temperatures and radiation exposure levels that are bounded by those of the HSM concrete SSCs. The Sheltered Environment is described in detail in Sections 3.3.1.2 and 3.5.3.

The below-grade portion of the basemat is in an underground environment exposed to the 12-in. thick excavated and re-compacted alluvium described in diamond note 2.1 of [3.11.20], while the approach slab is exposed to the 8-in. dense graded aggregate base course indicated in Section 3.7.2.

3.7.4 Basemat and Approach Slab Aging Effects

(NUREG-1927, Section 3.2 and Section 3.4.1.2)

This section describes the aging effects that could, if left unmanaged, cause degradation of the Basemat and Approach Slab. As such, applicable unmanaged aging effects could result in loss of the intended functions for these SSCs. Aging mechanisms that could lead to aging effects were determined using technical literature, related industry research, and existing OE. Differential settlement was the only aging mechanism considered applicable and is evaluated in Section 3.7.4.1 whether it requires management, or not.

3.7.4.1 Differential Settlement

Differential settlement is a time-dependent mechanism that, according to the UFSAR [3.11.2], could affect retrievability of the DSC, lower the elevation of the basemat below the PMF, or in the unlikely event that large settlements of the ISFSI foundation occur, the resultant shifting of adjacent HSMs may cause the HSMs to separate reducing HSM self-shielding. Differential settlement was also a NUHOMS® system OE consideration (Section 3.6.4.2 of [3.11.25]). According to ACI 349.3R [3.11.70]:

> *"Settlement of a structure occurs as a result of subgrade consolidation or movement of soils upon which the structure is founded or, in the case of a dynamic event such as an earthquake, the liquefaction of the soils. Provisions for a limited amount of settlement are generally taken into account at the design phase based on predicted soil behavior; such settlements typically manifest themselves within the first three years of the service life."*

Furthermore, settlement of a structure may be due to changes in the site conditions (e.g., water table, soil). When concrete is older than 20 years with negligible settlement or settlement is within predicted values, settlement is not an aging mechanism (Section 5.3.2.4 of [3.11.150]). Settlement was considered in Chapter 2 of the UFSAR and was considered of relatively low potential given the site location and geological characteristics [3.11.2].

In Section 2.6.4 of the UFSAR, the statement is made that during earthquakes:

> *"Saturation of interbeds is not considered to be a problem for settling of structures or liquefaction during earthquakes because the shallowest interbed is at a depth of 100 ft., and is overlain by 55-60 ft of basalt bedrock. The surficial sediments are not considered to be a problem for settling or liquefaction because they are not saturated."*

Appropriate excavation, backfill, levelling, and compaction of the subbase and base limited the possibility of differential settlement. Visual inspections of accessible concrete surfaces of the TMI-2 basemat have verified this, with inspections being conducted in August 2010 [3.11.109], November 2012, and November 2014 [3.11.110] with no identified differential settlement or unanticipated basemat cracking being observed. Based on these inspections, no age-related differential settlement of the basemat and approach slab has occurred since original construction.

The resultant shifting of adjacent HSMs due to differential settlement, which could cause the HSMs to separate reducing HSM self-shielding, has already been evaluated in Section 8.2.1 of the UFSAR [3.11.2] and will not be considered further.

In terms of PMF, the maximum floodwater elevation is well below the bottom of the DSC, which is approximately 5-ft 9-in. above the slab surface [3.11.2]. Therefore, even with gross settlements of the basemat (i.e., event-driven conditions, not age-related), it is not a credible aging effect that would affect flood loads acting on the TMI-2 ISFSI SSCs. If gross settlement did occur, recovery according to Section 8.2.1.4 of the UFSAR includes unloading and removing from service any affected HSMs until foundation repairs are made [3.11.2].

In terms of retrievability, the basemat provides a firm and level surface for alignment of the TC with the HSM to allow loading and unloading. During loading operations at the HSM, four hydraulic jacks on the Transfer Trailer may account for variability in basemat levelness. The jacks have adequate vertical stroke, allowing for vertical adjustment in either unison or individually [3.11.108]. In addition, for accessing the basemat with the Transfer Trailer, the Transfer Trailer is equipped with a vertically articulated hydraulic suspension system, which allows for an adjustable deck height, compensating for: road surface irregularities, uneven terrain, railroad tracks, and road crowns [3.11.108]. In any event, no age-related differential settlement of the basemat and approach slab has occurred since original construction, which for the initial TMI-2 ISFSI licensing period is the equivalent length of time (20 years) identified in the EPRI report [3.11.150]. As a result, any age-related differential settlement should have occurred prior to the PEO, and therefore differential settlement is not a credible aging effect and does not require management during the PEO.

3.7.4.2 Basemat and Approach Slab Aging Effects Requiring Management

The following aging effects and mechanisms are applicable for Basemat and Approach Slab SSCs. As discussed in Section 3.7.4.1, differential settlement is not considered a credible aging effect that would prevent fulfillment of the intended functions for the basemat and approach slab. There are no other credible aging effects requiring management for the duration of the PEO on the Basemat and Approach Slab SSCs.

3.7.5 Aging Management Activities for Basemat and Approach Slab

(NUREG-1927, Section 3.2 and Section 3.4.1.3)

Based on this evaluation, no further action is required for monitoring or other aging management activities of any aging effects on the Basemat and Approach Slab SSCs during the PEO.

3.8 AMR RESULTS – TMI-2 CANISTER

This section summarizes the results of the AMR for the TMI-2 Canisters. The TMI-2 Canisters and its SSCs along with the license renewal intended functions for these SSCs are described in the scoping evaluation summarized in Section 2.3.2.3. The TMI-2 Canisters' primary function is to maintain the geometric position of the TMI-2 core debris and prevent gross dispersion of the TMI-2 core debris into the DSC interior. Other intended functions of the TMI-2 Canisters include criticality control, radiation shielding, structural integrity for the geometric confinement and criticality control functions, and heat transfer to the DSC shell. Once inside the DSC, the TMI-2 Canisters are confined by the DSC shell and by multiple barriers at each end of the DSC.

3.8.1 Description of TMI-2 Canister

The material stored inside the DSC consists of canisterized core debris removed from the damaged TMI Unit 2 reactor core during defueling operations. TMI-2 was a Babcock & Wilcox (B&W) PWR. The material contained in the TMI-2 Canisters is primarily the remains of the TMI-2 core [3.11.2], with some exceptions for non-core material as described in Section 1.3.

There are three types of TMI-2 Canisters stored inside the DSC:

- TMI-2 Fuel Canisters -large pieces of TMI-2 core debris (See Figure 3-11)
- TMI-2 Knockout Canisters - TMI-2 core debris from the use of the debris vacuum system ranging in size from 140 microns up to the size of whole fuel pellets (0.375-in. diameter by 0.6 in. long) and larger pieces of re-solidified, once-molten fuel (See Figure 3-13)
- TMI-2 Filter Canisters - fines generated from the use of the debris vacuum system and defueling water cleanup system (See Figure 3-12)

Table 3.1-1 from the UFSAR lists the principal design parameters determined for the TMI-2 Canisters used as the design basis for the NUHOMS®-12T system. Additional details of the design and original function of the three types of TMI-2 Canisters are provided in B&W Final Design Report 77-1153937 [3.11.34]. The key physical parameters of interest are the TMI-2 Canister weight, length, cross-sectional dimensions, contents, and internal poisons. The values of these parameters form the basis for the radiological, criticality, thermal, and structural design of the TMI-2 Canister and its internals. In addition to the intended functions of the TMI-2 Canisters outlined in Chapter 2, more details regarding the various subcomponents are described below.

Common to all three TMI-2 Canister designs, the outer shell originally served as a pressure vessel protecting against leakage of the TMI-2 Canister's contents as well as providing structural support for the neutron absorbing materials. The TMI-2 Canisters are designed to withstand the pressures associated with normal operating conditions occurring within the pools at TMI-2 and TAN. The shell is fabricated from a section of welded 14-in. OD, ¼-in. thick pipe. All weld joints in the outer shell are full penetration welds, joints that had full radiographic or UT inspections. Therefore, the shell response to structural loads is considered the same for all types of TMI-2 Canisters. In addition, the shell serves as the primary SSC for providing criticality control (geometric spacing) between the 12 TMI-2 Canisters contained in a single DSC.

Although identical in diameter, length, and lower head design, each TMI-2 Canister design has a different upper head design and contains different internal SSCs in order to be compatible with the various defueling techniques previously used at TMI-2. The upper head is a flat plate machining that is welded to the shell on the TMI-2 Filter and Knockout Canisters and is bolted to the shell via a welded bulkhead on the TMI-2 Fuel Canister. The closure bolts on the TMI-2 Fuel Canister are eight ¾-in. bolts. The upper head contains penetrations previously used for dewatering and defueling and a recess for interfacing with a handling grapple. Including a protective skirt at the top, all of the TMI-2 Canisters have an overall length of 149.75 ± ¼-in. All three TMI-2 Canister designs use the same reversed dish lower head.

In addition, all three TMI-2 Canister designs use a similar inner bottom support plate welded to the inside of the shell just above the lower head, supporting their internal structure and their payload. This bottom support plate ranges from ½-in. thick on the TMI-2 Fuel Canister, to 1-in. thick on the TMI-2 Filter Canister, and 1–¼-in. thick on the TMI-2 Knockout Canister. As shown in Figure 3-11, for the TMI-2 Fuel Canister, the BORAL® shroud and TMI-2 core debris (by means of the bottom impact plates) rest on this bottom support plate. The bottom support plate is welded to the shell via an all-around, ¼-in. fillet weld. The TMI-2 Fuel Canister poison shroud, discussed in Section 3.8.2.1, is welded to the upper side of the bottom support plate.

The criticality control mechanism used in the TMI-2 Filter and Knockout Canisters consists of poison rods containing sintered B_4C pellets, as discussed in Section 3.8.2.1. For the TMI-2 Knockout Canister, there is one central 2–1/8-in. OD tube and four 1–5/16-in. OD periphery tubes, with the pellets encased within each tube. The poison rods are constructed from either pipe or tube stock, with welded end caps for constraining the pellets. As shown in Figure 3-12, for the TMI-2 Filter Canister, there is one central 2–1/8-in. OD tube with welded end caps, having the pellets encased within. The bottom support plate also provides structural rigidity for the bottom of the TMI-2 Canisters, retaining the poison rods in their positions in the internals assembly.

As shown in Figure 3-13, the TMI-2 Knockout Canister has seven intermediate support plates (i.e., support spiders) that are spaced equally along the length of the internals weldment. In addition to an upper support ring spider plate, the intermediate support plates provide lateral structural rigidity for the center strongback tube and outer poison tubes. The plates retain the center strongback tube via ¼-in. all-around fillet welds located on both sides of the plates. For the outer poison tubes in the upper support ring and intermediate support plates, 1.44-in. holes with a nominal 0.061-in. radial clearance in the plates capture the tube shell. The reason for the tube-within-tube design was that the annulus between the 2–1/8-in. OD of the poison tubing sheath and this 2–¼-in. ID center strongback tube served as the drain for TMI-2 Canister dewatering. The center strongback tube is welded to the bottom support plate, at each of the intermediate support plates, and at the top support plate ring. The strongback tube protects the poison rod tubing, and helps distribute normal and accident loads to the support plates.

For the TMI-2 Fuel Canister, the upper head dual impact plates, and shock absorber could absorb energy during end-drop accident conditions, affording protection to the upper head assembly and payload, cushioning from secondary impacts of the loose TMI-2 core debris within the TMI-2 Fuel Canister. According to Section 8.2.5.2.A of the UFSAR [3.11.2] for the accident drop analyses, "the TMI-2 canisters could bear on the DSC shell" in a lateral side drop and oblique end drop case. Therefore, structural integrity of the TMI-2 Canister includes load transfer through the shock absorber and impact plates, into the upper head and closure bolts.

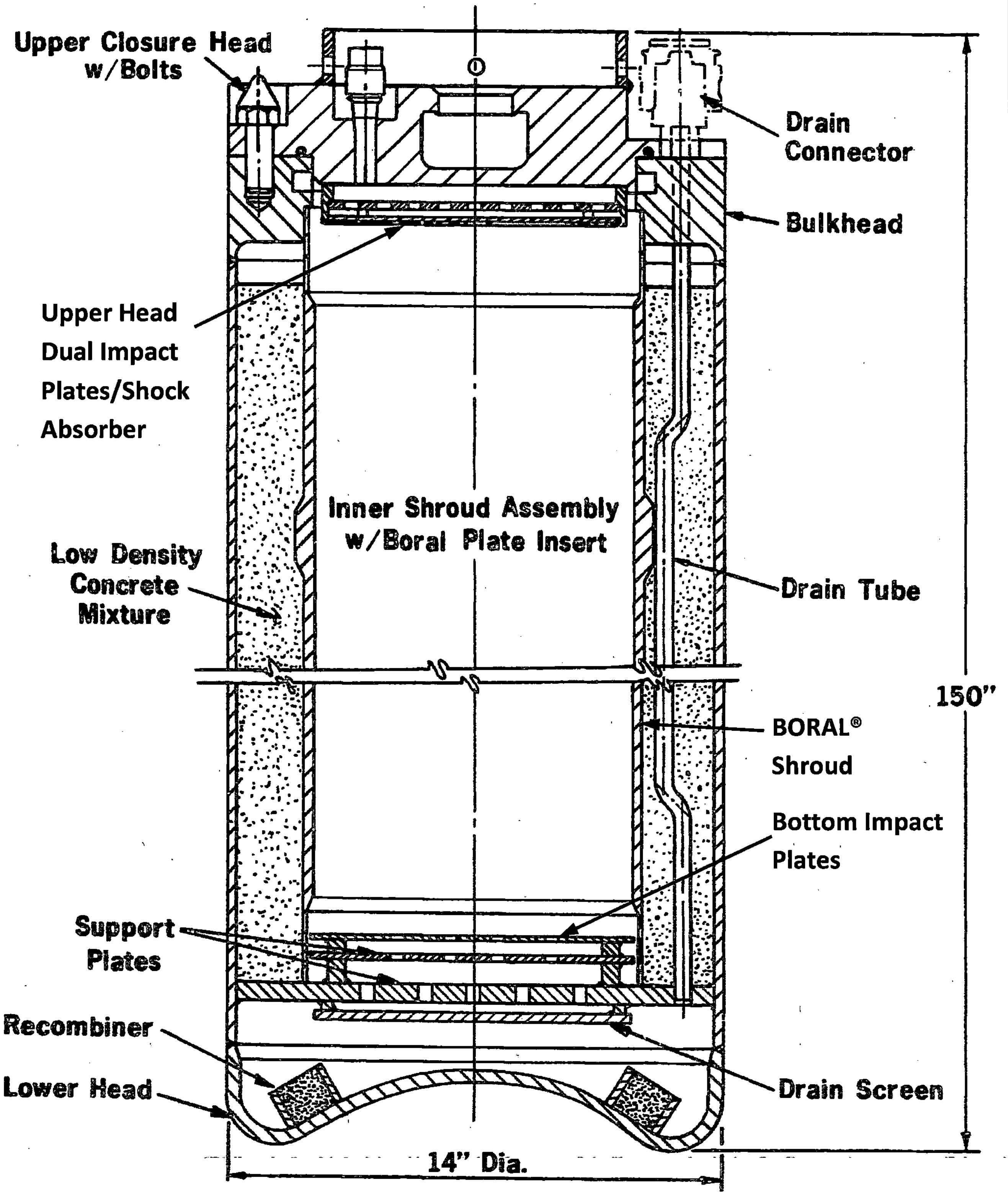

Figure 3-11: Overall Cross-sectional Profile View of TMI-2 Fuel Canister

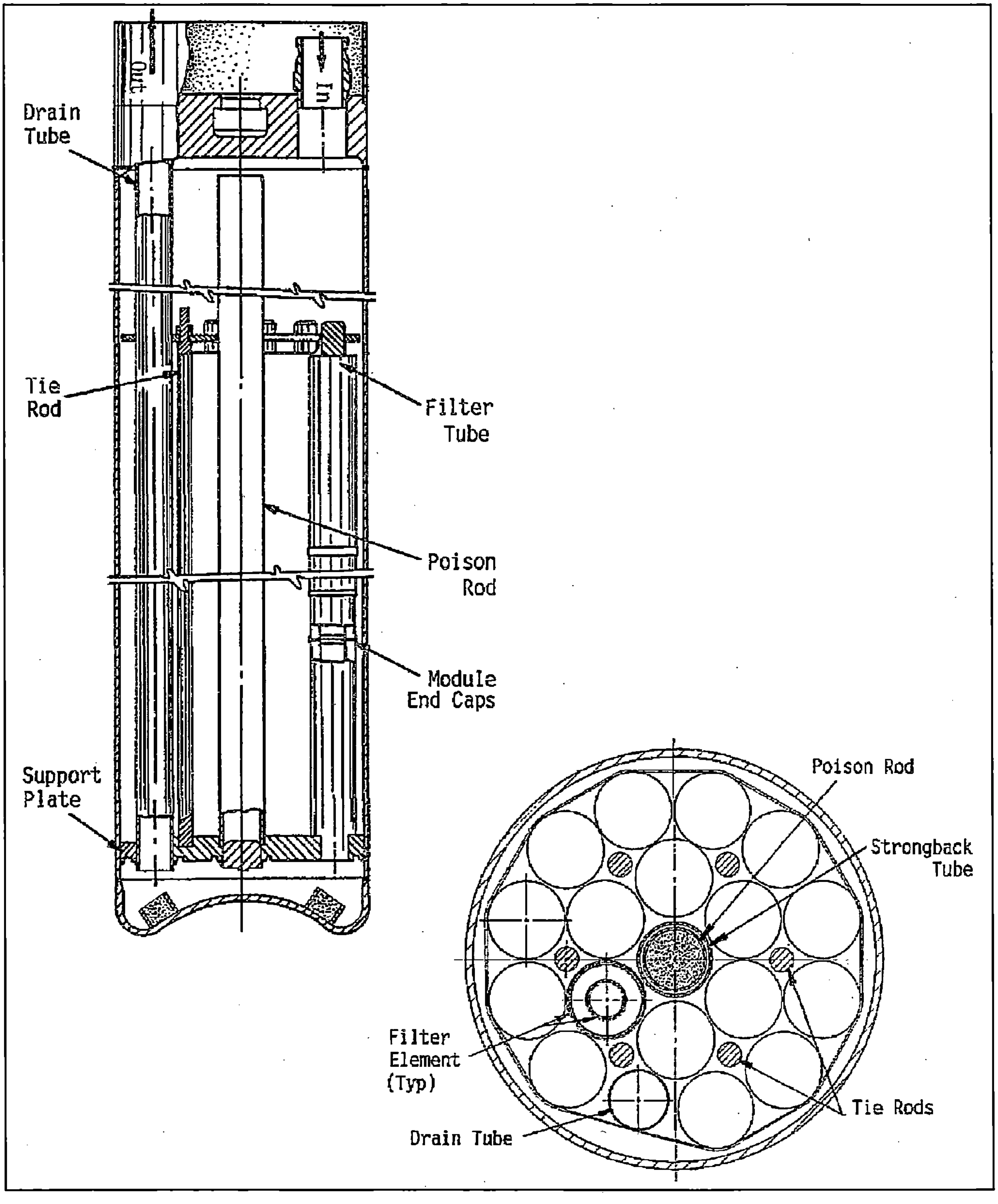

Figure 3-12: Overall Cross-sectional Profile and Plan View of TMI-2 Filter Canister

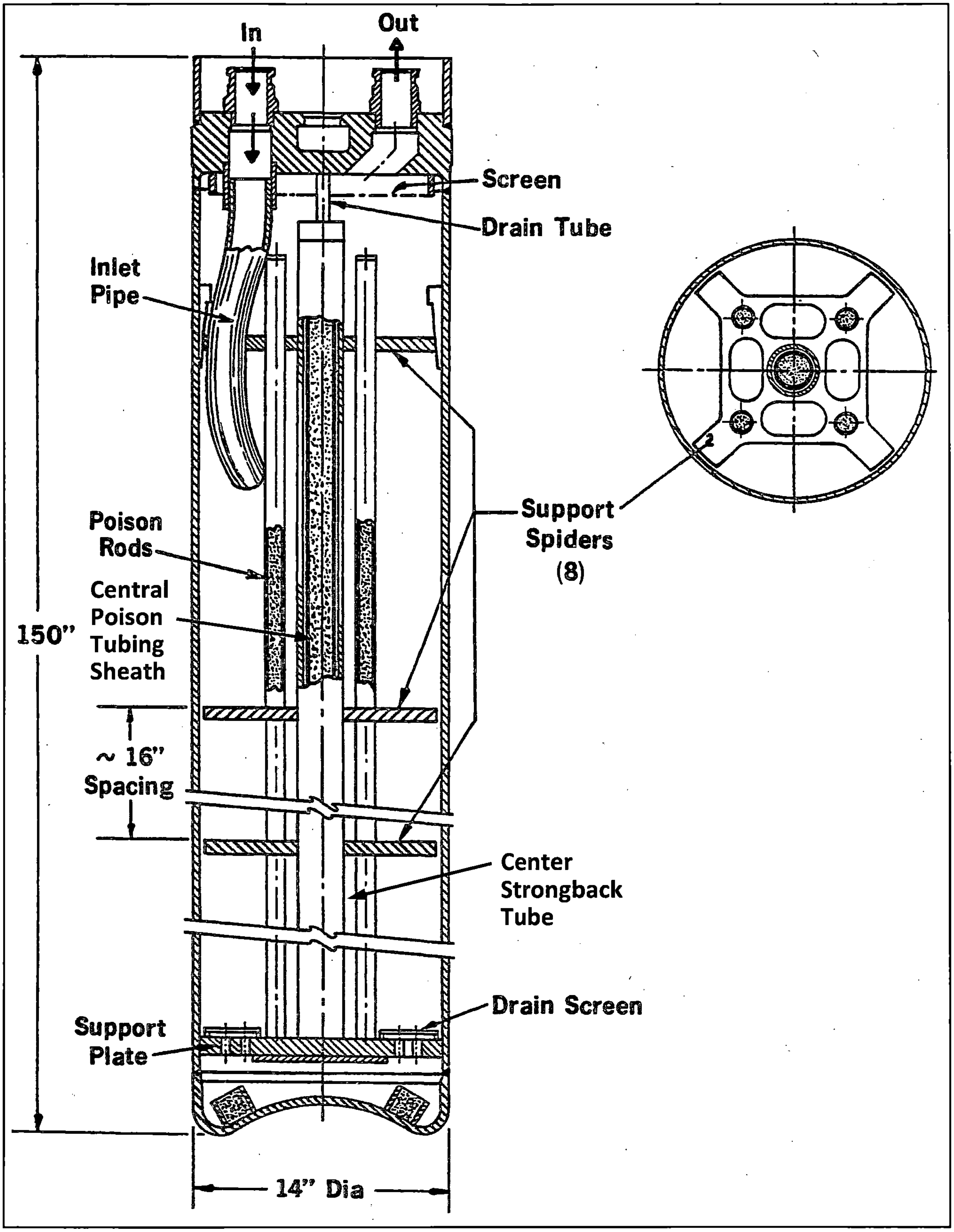

Figure 3-13: Overall Cross-sectional Profile View of TMI-2 Knockout Canister with Intermediate Support Plate Plan View Inset

3.8.2 TMI-2 Canister Materials Evaluated

(NUREG-1927, Section 3.2 and Section 3.4.1.1)

All structural SSCs except the TMI-2 Fuel Canister bolts are fabricated from 300 series low-carbon stainless steel. As described in the Certified Material Test Report (CMTR) [3.11.100], the bolts are made from nickel-based Inconel 625. Characteristically, stainless steel and Inconel materials provide both excellent corrosion resistance and tough, resilient structural properties. The materials of construction for the TMI-2 Canisters are outlined in Table 3-4. Table 3-7 shows the chemical constituents of the in-scope SSCs for the TMI-2 Canister structural stainless steel SSCs along with the TMI-2 Fuel Canister bolts. As shown in Figure 3-14, the TMI-2 Canister stainless steel is generally austenitic in structural form, with up to 20% ferrite structure based on the Nickel and Chromium percent equivalent alloying elements, as shown in Table 3-7.

3.8.2.1 Neutron Absorber Materials

Boron carbide is used as the neutron-absorbing material in a pellet form as poisons in both the TMI-2 Knockout Canister and TMI-2 Filter Canister. The pellets are formed from ASTM C750-1980, Type 2 boron carbide powder [3.11.65]. For the periphery tubes in the TMI-2 Knockout Canister, the pellets are stacked to produce a minimum linear density of 1.66 grams of B^{10} per inch, with a minimum stack loading weight of 1,500 grams B_4C. For the central tube, in the TMI-2 Knockout Canister, the pellets are stacked to produce a minimum linear density of 10.0 grams of B^{10} per inch, with a minimum stack loading weight of 9,115 grams B_4C. For the TMI-2 Filter Canister, there is one central poison tube with the pellets stacked to produce a minimum linear density of 10.0 grams of B^{10} per inch, with a minimum stack loading weight of 9,465 grams B_4C.

Within the shell of the TMI-2 Fuel Canister, a full-length square shroud forms the internal cavity used to place the partial fuel assembly debris and other TMI-2 core debris. The shroud assembly consists of a pair of concentric square stainless steel tubes seal-welded to encapsulate completely four sheets of BORAL® neutron-absorbing material. Consistent with the documentation package [3.11.64], the BORAL® material consists of ASTM C750-1980, Type 3 [3.11.65] boron carbide particles ($B \geq 76\%$) in an aluminum matrix with a B^{10} loading ≥ 0.040 grams/cm^2. Of note, the BORAL® sheets were fabricated by mixing the Boron carbide powder with the atomized aluminum powder within extruded aluminum channels, heating in an induction oven, and then rolling the BORAL® ingots to the desired thickness.

3.8.2.2 TMI-2 Fuel Canister Licon Material

The space between the shroud and the shell is filled with "Licon", a low-density concrete mixture of cement, glass bubbles, and demineralized water. "Licon" is a trade name for a lightweight concrete made of calcium aluminate cement (Alcoa product type CA-25C) and air-filled glass spheres as aggregate.

The Licon consists of the following weight percent constituents [3.11.66]:

Ingredient	Vendor	Weight Percent
CA-25C Refractory Cement	Alcoa	60
Glass Bubbles, B28/750	3M Company	11
Deionized Water	--	29

The Alcoa CA-25C is a high-purity, high-alumina cement composed of 80% Al_2O_3, 18% CaO, minor impurities and 1.5% volatile material [3.11.66]. Composition conforms to the empirical molar formula $CaO \cdot 2.5Al_2O_3$. Typical chemical analysis is as follows:

Typical chemical analysis, %	
Al_2O_3	79.7
CaO	18.4
MgO	0.4
SiO_2	0.2
Fe_2O_3	0.3
Na_2O	0.5

The glass bubbles, B28/750, are a product of the 3M Company. The glass bubbles are hollow, unicellular glass microspheres composed of a water-resistant and chemically stable soda-lime-borosilicate glass. The glass microspheres provide a low-density aggregate that can effectively lower the density of the concrete [3.11.66]. As supplied, the volatile content of the glass bubbles will be a maximum of 0.5% by weight.

Regarding the Licon water content, after vacuum drying at TAN, Section 6.0 of EDF-1466 estimated that nearly all of the unbound water and much of the bound water in the Licon vaporized out of the TMI-2 Fuel Canister [3.11.5]. "Bound" water is that which is chemically adsorbed and "binds" to the solid surface during the cementation process. EDF-1466 predicted that at the time the ISFSI was loaded in 1999, the bulk of any remaining bound water less than the 2.3-liter limit that [3.11.5] imposed would be within the core debris itself, not the Licon. This is because the TMI-2 Fuel Canister core debris cannot be dried much until the Licon is dried, and the water within the Licon will receive most of the heat first during the drying process. Nevertheless, Section 6.4 of [3.11.5] states "It is doubtful that a very large Licon slab can ever dry," indicating complete removal of the water of hydration is unlikely. This is because the water is dispersed throughout a porous matrix. The matrix both impedes heat transfer required to vaporize the water and the migration of the vapor out [3.11.111].

Table 3-7: Composition of Stainless Steel and Nickel Alloys Used to Fabricate TMI-2 Canister Structural Components

CONSENSUS CODE NO.		C	Mn	P	S	Si	Ni	Cr	Mo	N	Cb+Ta	Co	Fe	Al	Ti	Cu
ASME SA-240 GRADE 304L [3.11.41]		0.030	2.00	0.045	0.030	0.75	8.0-12.0	18.0-20.0	--	0.10	--	--	BAL.	--	--	--
ASME SA-240 GRADE 316L [3.11.41]		0.030	2.00	0.045	0.030	0.75	10.0-14.0	16.0-18.0	2.00-3.00	0.10	--	--	BAL.	--	--	--
ASTM A-269 GRADE 304L [3.11.45]		0.035	2.00	0.045	0.030	1.00	8.0-12.0	18.0-20.0	--	--	--	--	BAL.	--	--	--
ASTM A-269 GRADE 316L [3.11.45]		0.035	2.00	0.045	0.030	1.00	10.0-15.0	16.0-18.0	2.0-3.0	--	--	--	BAL.	--	--	--
ASTM A-276 GRADE 316L [3.11.46]		0.030	2.00	0.045	0.030	1.00	10.0-14.0	16.0-18.0	2.0-3.0	0.10	--	--	BAL.	--	--	--
ASME SA-312 GRADE 304L [3.11.42]		0.035	2.00	0.040	0.030	0.75	8.00-13.00	18.0-20.0	--	--	--	--	BAL.	--	--	--
ASME SA-312 GRADE 316L [3.11.42]		0.035	2.00	0.040	0.030	0.75	10.0-15.0	16.0-18.0	2.00-3.00	--	--	--	BAL.	--	--	--
ASME SA-479 TYPE 304L [3.11.43]		0.030	2.00	0.045	0.030	1.00	8.0-12.0	18.0-20.0	--	0.10	--	--	BAL.	--	--	--
ASME SA-479 GRADE 316L [3.11.43]		0.030	2.00	0.045	0.030	1.00	10.0-14.0	16.0-18.0	2.00-3.00	0.10	--	--	BAL.	--	--	--
WELD WIRE PER AWS A5.4 GRADE 316L [3.11.40]		0.04	0.5-2.5	0.04	0.03	0.90	11.0-14.0	17.0-20.0	2.0-3.0	--	--	--	BAL.	--	--	0.75
WELD WIRE PER AWS A5.4 GRADE 308L [3.11.40]		0.04	0.5-2.5	0.04	0.03	0.90	9.0-11.0	18.0-21.0	0.75	--	--	--	BAL.	--	--	0.75
WELD WIRE PER AWS A5.9 GRADE 316L [3.11.39]		0.03	1.0-2.5	0.03	0.03	0.30-0.65	11.0-14.0	18.0-20.0	2.0-3.0	--	--	--	BAL.	--	--	0.75
WELD WIRE PER AWS A5.9 GRADE 308L [3.11.39]		0.03	1.0-2.5	0.03	0.03	0.30-0.65	9.0-11.0	19.5-22.0	0.75	--	--	--	BAL.	--	--	0.75
ASME SB 446, GRADE 1 NICKEL ALLOY [3.11.44]	**MIN**	--	--	--	--	--	58.0	20.0	8.0	--	3.15	--	--	--	--	--
	MAX	0.10	0.50	0.015	0.015	0.50	--	23.0	10.0	--	4.15	1.0	5.0	0.40	0.40	--

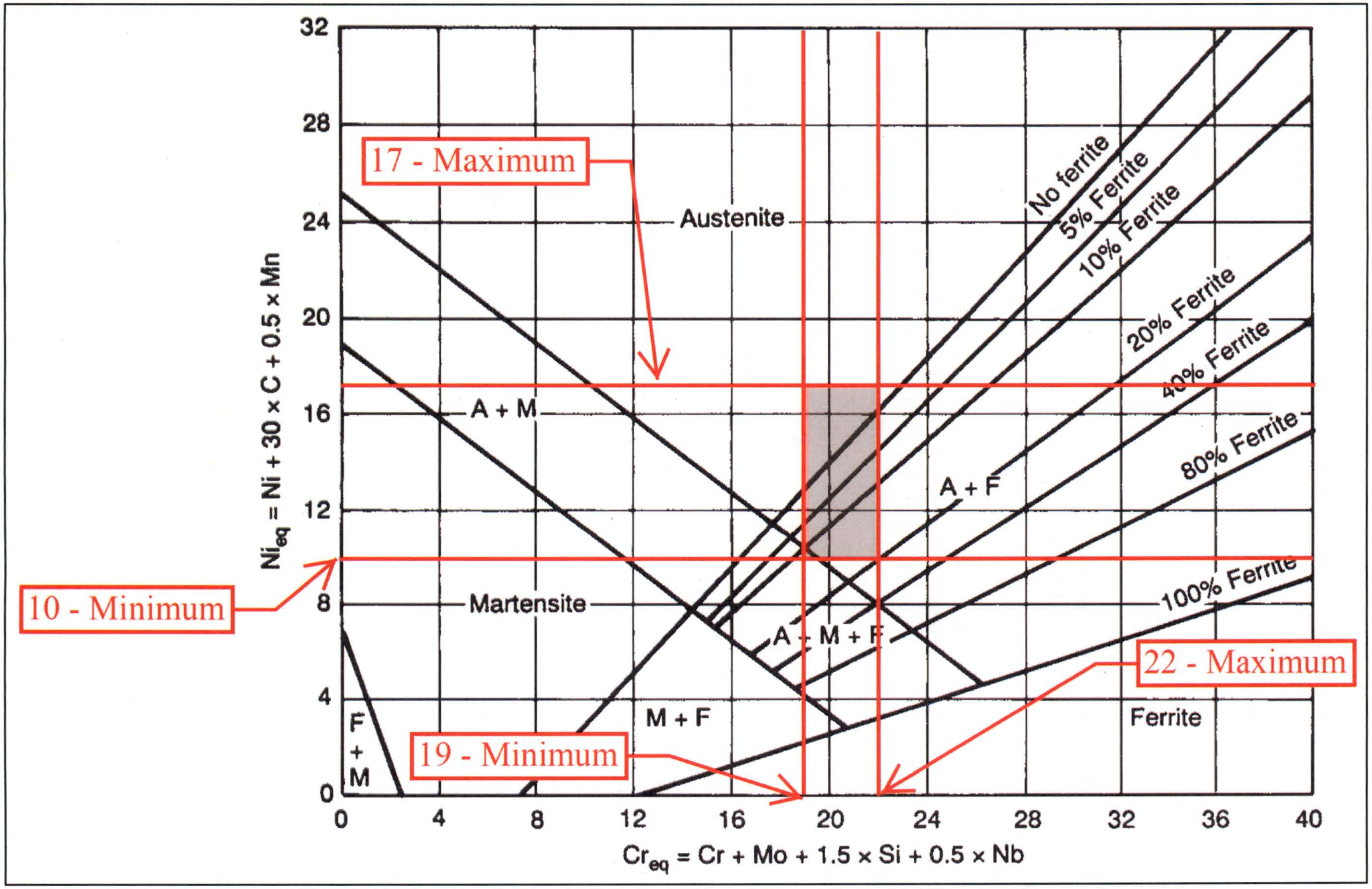

Figure 3-14: Schaeffler-Delong Stainless Steels Constitution Diagram with Annotations for TMI-2 Canister Grades (From Chapter 6/Figure 1 of [3.11.99])

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3.8.3 Environments for TMI-2 Canisters

(NUREG-1927, Section 3.2 and Section 3.4.1.1)

The environments that affect the subcomponents of each TMI-2 Canister, both externally and internally, are those that are normally (continuously) experienced, and are as described below. Outlined in Table 3-4 are the environments that each of the in-scope TMI-2 Canister SSC subcomponents is exposed.

3.8.3.1 External

For the TMI-2 Canisters, the external environment refers to the Internal DSC Environment discussed in Sections 3.3.1.2 and 3.4.3.2. In dry storage, the exterior surfaces (TMI-2 Canister shell, upper and lower heads) are subject to an AMR when stored in the ambient environment of the Internal DSC Environment.

The TMI-2 Canister exterior surfaces are exposed to neutron and gamma radiation. Section 3.3.1.2.2 discusses the analyses performed to evaluate the distribution of neutron fluence and gamma radiation at the TMI-2 Canister's exterior. Bounding sources and bounding MCNP models are used in order to envelop the TMI-2 Canisters with or without the neutron startup sources inside [3.11.24]. The total irradiation time (service life) of the TMI-2 Canister in-scope SSCs is assumed to be 60 years (See Section 3.3.1.2.2), with no credit taken for source strength decay over the period. Integrated over the period, the calculated bounding maximum neutron fluence on the TMI-2 Canister assembly is 5.06×10^{14} neutrons/cm^2. This value includes the Am-Be-Cm startup source and internal hardware in the MCNP model, as described in [3.11.24]. Likewise, the bounding computed gamma energy deposition is 2.00×10^9 rad, with the distributed gamma radiation source, excluding the internal hardware in the MCNP model.

The UFSAR thermal analysis of the DSC and HSM is conservatively based on a total decay heat of 860 Watts /DSC and 80 Watts /TMI-2 Canister. However, as detailed in Section 3.3.1.2.3, the thermal analysis described in Chapter 8 of the UFSAR is intended to estimate maximum temperatures for conservatively evaluating structural conditions during accidents. As a reference, the 80-Watt value was estimated based on the maximum heat load for any TMI-2 Canister of 60 Watts (UFSAR Section 3.1.1.2 [3.11.2]) in 1999. 60 Watts was the bounding thermal heat load value for TMI-2 Knockout Canister K506, which had a 31.57-Watt decay heat load, with 1,857-pound core payload [3.11.30]. Multiplying by a 1.9 hot channel peaking factor yielded the 60-watt maximum. Based on the Table 3-1 data and including the hot channel peaking factor, it is estimated that the maximum decay energy for K506 is 35.3 watts in 2019 at the beginning of the PEO (based on decay from 60 Watts).

As stated in Section 3.3.1.2.3, an average heat load for all of the TMI-2 Canisters is 11.47 Watts at the beginning of the PEO. As shown in Table 3-3 and discussed in Section 3.3.1.2.3 (at initiation of PEO in 2019), using 12 average decay heat load TMI-2 Fuel Canisters with convective effects included in the HSM interior, maximum surface temperatures on the TMI-2 Canister shell exterior in July are just over 77°F, with average TMI-2 Canister shell temperatures ranging from 24.1°F in January, to 73.6°F in July. Some of the TMI-2 Canisters (such as the TMI-2 Filter Canisters) have no heat load (zero Watts) due to the very low activity of those TMI-2 Canisters (Table 1 of [3.11.30]). Therefore, the minimum average temperature of the TMI-2 Canister exterior with negligible decay heat (i.e., TMI-2 Filter Canister F-434 with zero pounds of core debris) is considered identical to the minimum average monthly temperature of the ambient air, indicated as 4°F in January (listed in Section 3.3.1.2). All of these reported surface temperatures continuously decrease from the beginning of the PEO through the end of the PEO.

3.8.3.2 Internal

The Internal TMI-2 Canister Environment is that located within the TMI-2 Canister annular cavity. This environment is even more protected from outdoor ambient conditions than either the Sheltered or Internal DSC Environments. The TMI-2 Canister interior elements (i.e., the inside surfaces of the TMI-2 Canister shell and interior TMI-2 Canister SSCs) are exposed to the Internal TMI-2 Canister Environment. It is a very similar environment to the Internal DSC Environment. Exceptions with the Internal DSC Environment are minor, but include exposure to slightly higher decay thermal heat load and higher neutron and gamma fluence. This is described in Sections 3.3.1.2.3 and 3.3.1.2.2, respectively. In addition, per Section 3.3.1.2.2 for the gamma source in the TMI-2 Fuel Canister MCNP model, the maximum absorbed energy in the stainless-steel BORAL® shroud is 1.96 x 10^9 rad and 1.61 x 10^9 rad in the Licon with the half-nominal water content. Also, at the beginning of the PEO, the maximum individual TMI-2 Canister dose rate on the TMI-2 Canister internal components is 1745 rad/hr (See Section 3.3.1.2.2). In addition, as indicated in Section 3.3.1.2.2, the total neutron fluence ($E > 0$ MeV) with the localized Am-Be-Cm design basis source in the stainless-steel BORAL® shroud is 1.77 x 10^{15} neutrons/cm^2, while the total neutron fluence in the Licon is 9.83 x 10^{14} neutrons/cm^2.

Regarding temperatures in the Internal TMI-2 Canister Environment, as shown in Table 3-3 and discussed in Section 3.3.1.2.3 (at initiation of PEO in 2019), using 12 average decay heat load TMI-2 Fuel Canisters with convective effects included in the HSM interior, maximum surface temperatures on the TMI-2 core debris fuel (i.e., Internal TMI-2 Canister Environment) in July are 78°F, with average TMI-2 core debris fuel temperatures ranging from 24.6°F in January to 74.1°F in July. Some of the TMI-2 Canisters (such as the TMI-2 Filter Canisters) have no heat load (zero Watts) due to the very low activity of those TMI-2 Canisters (Table 1 of [3.11.30]). Therefore, the minimum average temperature of a TMI-2 Canister interior with negligible decay heat (i.e., TMI-2 Filter Canister F-434 with zero pounds of core debris) is considered identical to the minimum average monthly temperature of the ambient air, indicated as 4°F in January (listed in Section 3.3.1.2). All of these reported surface temperatures continuously decrease from the beginning of the PEO through the end of the PEO.

According to Appendix C of the UFSAR, the Internal TMI-2 Canister Environment is calculated to have a higher hydrogen concentration than the Internal DSC Environment due to anticipated radiolysis from the interaction of absorbed radiation with any remaining water (See figure on p. C.18 of UFSAR [3.11.2]). Of note however, is that each TMI-2 Canister was heated and vacuum-dried after being in the pool at the TAN facility (See Section 3.3.1.2.1). According to EDF-1466 [3.11.5], the source of the radiolysis comes from the fact that the TMI-2 Canister may have some bound water in the TMI-2 core debris, and it is possible that a small amount of moisture is reabsorbed while being in storage. EDF-1466 estimated a maximum of 2.3 liters of water remaining in the TMI-2 core debris after the heated vacuum drying process. The Internal TMI-2 Canister Environment is vented to the Internal DSC Environment providing a mode of gas transport by diffusion between the two environments. There are two possible vent paths from the TMI-2 Canisters, one vent penetration and one dewatering penetration, both located on the TMI-2 Canister upper head. These two quick-disconnect fittings (one 3/8-in. drain port dewatering fitting and one ¼-in. vent port dewatering fitting) provide a diffusion pathway for possible hydrogen and other gases produced from mechanisms such as radiolysis or corrosion. The amount of production from each process (radiolysis or corrosion), however, is indistinguishable from the other. A more thorough discussion regarding the hydrogen and oxygen concentrations is included in Section 3.3.1.2.1.

3.8.3.2.1 TMI-2 Canister Encased Environment

The second interior environment in the TMI-2 Canister is defined as "Encased". This environment is limited to three specific locations within the TMI-2 Canister interior:

1. The volume within the poison tubes is bounded by the poison tube endcap and pipe inner wall surfaces. This environment is applicable for both the TMI-2 Filter and Knockout Canister poison tubes. In addition, the inner wall surfaces of the Center Tube (and top surface of the bottom seal plate) which enclose the entirety of the TMI-2 Knockout Canister central poison tube are bounded by this environment (See Figure 3-13). The Boron carbide pellets are entirely contained within this environment.

2. The poison shroud of the TMI-2 Fuel Canister containing the BORAL® poison is also within the Encased Environment. The boundary of this volume is the inner walls of the inner and outer skin of the shroud and the all-around fillet welds sealing the joints between these two SSCs.

3. The Licon of the TMI-2 Fuel Canister is almost entirely within the Encased Environment, with the exception being the top surface of the poured Licon, which instead is exposed to the Internal TMI-2 Canister Environment. The other bounds of the Licon Encased Environment are the outer skin of the poison shroud, the inner surfaces of the TMI-2 Canister shell, and the top surface of the bottom support plate.

This environment is characterized as a dry, air-filled environment. The moisture in these volumes is limited to that present when the welds were applied at the fabricator, except as that described in Section 3.8.2.2 for the Licon. As such, the moisture content consists of that volume retained in the zones when they were welded in place. Other similarities of this environment are bounded by those conditions representative of the Internal TMI-2 Canister Environment.

3.8.3.3 Chloride Environment

The likelihood of CISCC initiation and growth for the welded 300-series stainless steel TMI-2 Canisters relies primarily on the quantity of chlorides within the proximity of the TMI-2 ISFSI environment. ISFSI susceptibility assessment criteria are developed in this section to provide a relative ranking of the TMI-2 ISFSI in terms of chlorides. This review follows the assessment criteria in EPRI Report 3002005371 [3.11.37], which assesses such conditions for stainless steel DSCs. The criterion in [3.11.37] uses a combination of environmental factors to develop a numeric relative ranking of a given ISFSI location. This ranking is intended to identify if the ISFSI environmental conditions result in a relatively higher likelihood of CISCC due to the presence of chlorides compared to other ISFSI sites.

As a summary, the TMI-2 ISFSI site ranks the lowest (1) on a 1 to 10 scale, indicating a quantifiable lack of chlorides at the TMI-2 ISFSI.

The two environmental parameters used to assess the susceptibility ranking of a given ISFSI are atmospheric chlorides and mean Absolute Humidity (AH). The likelihood of CISCC causing the initiation of an engineering-sized flaw (typically on the order of 0.04 in. deep) within a given storage time is dependent on the surface chloride loading, which is in turn dependent on the concentration and size of aerosol particles with chlorides. The ranking for atmospheric chlorides is based on distance from the source of chloride aerosols and the type of source. When the absolute humidity is high, salts will be deliquescent at higher surface temperatures for more of the year. A factor based on the yearly mean AH is used to modify the primary ISFSI ranking.

The ISFSI ranking factor (Z_{ISFSI}) reflects the relative susceptibility of an ISFSI location and ranges from 1 to 10. Z_{ISFSI} is calculated as follows:

$$Z_{ISFSI} = Cl_{starting} + Cl_{adj} + AH_{adj}$$

Z_{ISFSI} = relative CISCC susceptibility ranking, related to the aggressiveness of the environment with higher values indicating elevated susceptibility (range of 1 to 10, inclusive)

$Cl_{starting}$ = initial ranking based on marine aerosol

Cl_{adj} = adjustment factor for local sources of chloride

AH_{adj} = adjustment factor to account for differences in susceptibility due to climate

The dependence on chloride is determined by the chloride starting value and chloride adjustment factor to account for local chloride sources. Similarly, AH is incorporated using an adjustment factor. If adjustment factors result in a Z_{ISFSI} value outside the 1 to 10 range, Z_{ISFSI} should be truncated at the range limit.

3.8.3.3.1 Chloride Starting Value (Proximity to Marine Shore)

The level of chlorides at the TMI-2 ISFSI is first assessed by the distance from the ISFSI pad to a seawater marine shore ($Cl_{starting}$). The concentration of atmospheric chlorides is strongly correlated to distance from an ocean shoreline. Since the aerosol atmospheric concentration is the prominent factor in deposition, distance to a marine shore sets the initial value from which the ISFSI ranking is adjusted. The atmospheric chloride ranking value is defined based on the distance from the ISFSI pad to the nearest marine shore and is shown in Table 3-8. Since the TMI-2 ISFSI is more than 20 kilometers from a marine shore, the $Cl_{starting}$ value is one.

Table 3-8: Chloride Starting Value Criterion

Distance from ISFSI to Marine Shore	Starting Value ($Cl_{starting}$)
Less than 90 meters	9
90 meters to 1 kilometers	8
1 to 5 kilometers	5
5 to 20 kilometers	2
More than 20 kilometers	1

3.8.3.3.2 Chloride Adjustment Factor (Other Sources)

In addition to the ocean, there are anthropogenic sources of chloride aerosols that may result in elevated chloride aerosol concentrations within a local area surrounding that source. Additionally, when ISFSIs are located very close to seawater sources, they tend to have higher aerosol concentrations. Therefore, an adjustment factor is applied. The distance from key sources of local elevated chloride aerosol concentrations is used as an adjustment factor to the Z_{ISFSI} value. The three primary adjustment factors are additive (e.g., an ISFSI can be near a salted road and have a saline cooling tower, but a saline tower is not the sum of the saline and non-saline cooling tower values) and are shown in Table 3-9.

The adjustment for elevation adjusts for the more rapid removal of large marine aerosols from the atmosphere, as an air mass is forced to rise over geography. Because the TMI-2 ISFSI is not located next to a marine shore, this adjustment value does not apply. The draft from cooling towers that use saline water sources contains a large number of droplets that can contain an appreciable mass of chloride. There are no cooling towers at the TMI-2 ISFSI; thus, this adjustment value does not apply.

Road salt can be aerosolized by fast-moving traffic and with high traffic can result in a substantial chloride source term. This was discussed in detail in Appendix 5A of the Standardized NUHOMS® LRA [3.11.25]. According to Section 3.1 of [3.11.37], a salted road is one where chloride salts are applied routinely (i.e., salted five or more weather events per year) during the winter for ice/snow removal with daily average traffic greater than 1,000 cars, and with a speed limit greater than 40 mph. The thresholds of 1,000 cars per day and a speed limit of 40 mph are used to include major roadways, while excluding low traffic, limited speed plant access roads. As stated in Section 3.3.1.2, no deicing compounds, such as road salt, are brought within the ISFSI boundary. The nearby graveled areas at the INTEC facility are also not salted. The nearest paved area is approximately 50 yards west of the ISFSI pad and may be graveled and salted after being plowed. Also, as stated in Section 3.3.1.2, the whole of the INTEC facility does not adjoin any roadways and only gas- and diesel-powered vehicles occasionally pass nearby at speeds well under 40 mph. Because the low traffic (< 1,000 cars/day) and speed-limited site at INTEC does not meet the conditions required for the Salted Road adjustment factor (See Table 3-9), no increase to the Z_{ISFSI} value is needed. In summary, the adjustment factor for local sources of chloride at the TMI-2 ISFSI does not apply (i.e., $Cl_{adj} = 0$).

No later than the start of the PEO at the TMI-2 ISFSI, the use of road salt and deicing compounds in and near the TMI-2 ISFSI will be administratively controlled using the DOE-ID commitment management program.

Table 3-9: Chloride Adjustment Factor Criterion

Source of Change in Local Chloride Levels	Distance to Source	Adjustment Value (Cl_{adj})
Elevation	Maximum elevation between the ISFSI and marine shore of > 90 meters, **AND** < 5 kilometers to marine shore	-1
Cooling Tower	≤ 1,000 meters	Non-Saline (If Average Feedwater Salinity < 0.5 Weight %), +1
		Low-Saline (If Average Feedwater Salinity ≥ 0.5 wt% and < 1.5 Weight %), +2
		Saline (If Average Feedwater Salinity ≥ 1.5 Weight %), +3
Salted Road	≤ 200 meters	+2

3.8.3.3.3 Absolute Humidity

Deliquescence of deposited salt particles at elevated humidity is the predominant source for a sustained aqueous environment on exterior surfaces of stainless steel SSCs. Adjustment factors listed in Table 3-10 are therefore based on annual average AH at the TMI-2 ISFSI. Evaluations performed as part of an EPRI flaw growth modeling effort calculated the effect of different climates on the crack growth rate on stainless steel storage casks, using ambient temperature and ambient AH data [3.11.38]. An ISFSI climate is considered more aggressive if it is warmer and if it supports relative humidity on stainless steel SSC surfaces, which are above the deliquescence relative humidity for more of the time during a typical year. The narrow range of the humidity adjustment factor reflects the expectation that variation in chloride areal densities at different ISFSI locations will have a greater impact on the likelihood of CISCC initiation than the climate. At the TMI-2 ISFSI site, the annual average humidity is low. Shown in Figure 3-15 is the AH data from August 1, 2013 through August 1, 2016 at the Idaho Falls Regional Airport NOAA monitoring station. The location is approximately 50 miles due east of the TMI-2 ISFSI and is representative of the ISFSI site conditions for the AH. The AH data was calculated from the atmospheric monitoring data (Temperature and Dew Point) for the Idaho Falls NOAA monitoring station and Equation C-1 in Appendix C of [3.11.37]. The chart shows hourly AH data points for a 3-year period and is representative of the annual AH at the TMI-2 ISFSI. In addition, a rolling, accumulative average is applied from the initiation of the chart, continuing through the end, providing an annual average over the 3-year period. The annual average is just under 5 grams/m^3 (4.94 grams/m^3) at the end of the three-year period. Therefore, based on Table 3-10, an adjustment value of -1 for the AH_{adj} factor may be applied to the Z_{ISFSI} value.

Table 3-10: Absolute Humidity Factor Criterion

Annual Average Absolute Humidity	Adjustment Value (AH_{adj})
< 8 gram/m^3	-1
8 – 12 gram/m^3	0
12 – 15 gram/m^3	+1
>15 gram/m^3	+2

Based on all the adjustment factors, the final Z_{ISFSI} ranking value for the TMI-2 ISFSI is as follows:

$$Z_{ISFSI} = Cl_{starting} + Cl_{adj} + AH_{adj} = 1+0-1 = 0 \rightarrow 1$$

Since the overall Z_{ISFSI} ranking of 0 is below the threshold of the allowed bounds between 1 and 10, the Z_{ISFSI} used for the TMI-2 ISFSI is truncated at 1 per the guidance of [3.11.37]. Therefore, the TMI-2 ISFSI has the lowest possible ISFSI ranking criteria of one. This ranking indicates a quantifiable lack of chlorides at the TMI-2 ISFSI, and shows the extent to which the environment could influence aging effects related to the extremely low presence of chlorides. Amongst other references, this information will be discussed in the context of the TMI-2 Canister materials and temperatures, and used to confirm if CISCC is an applicable aging effect in Section 3.8.4.2.5.

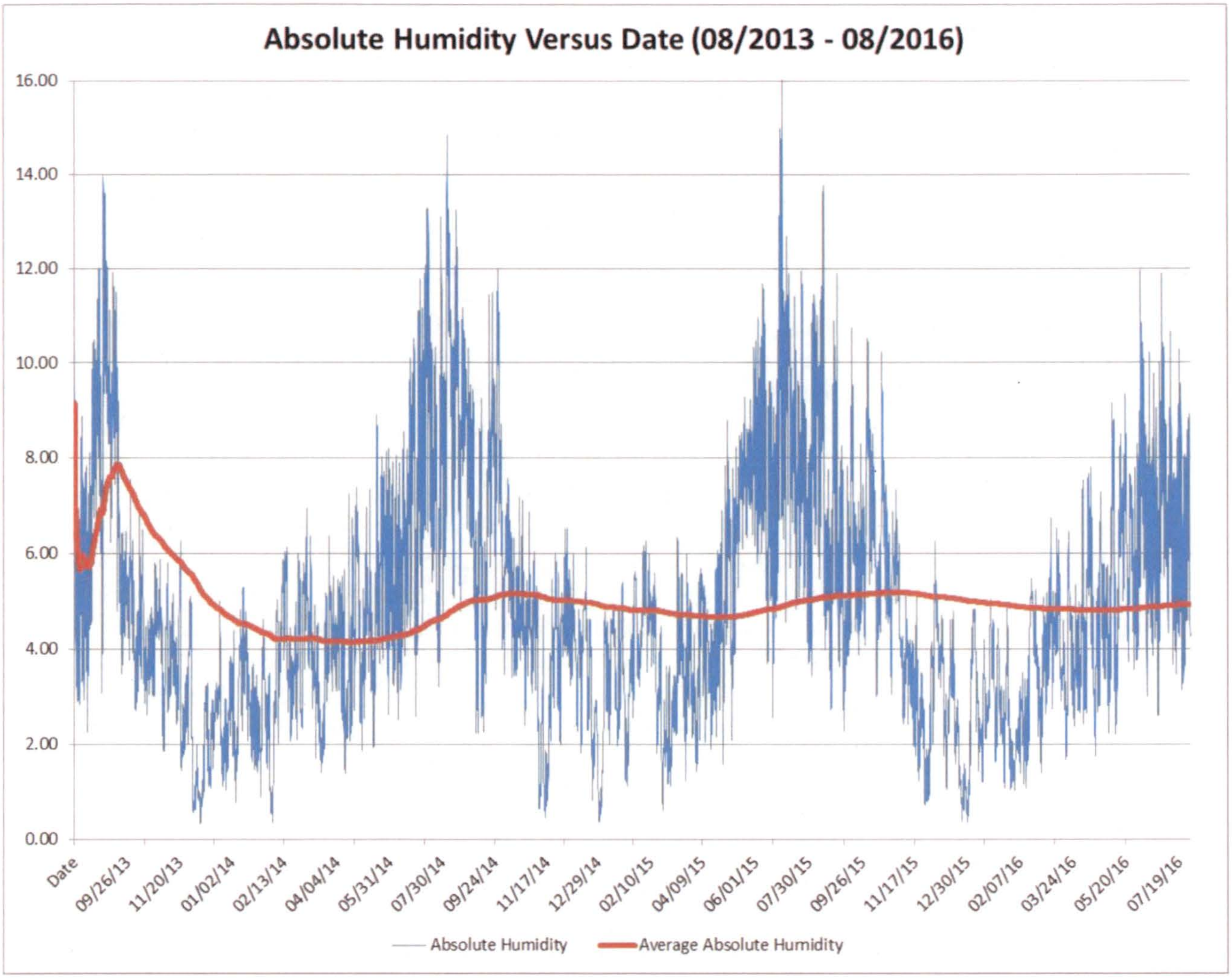

Figure 3-15: Absolute Humidity Data (08/2013 – 08/2016) at the Idaho Falls Regional Airport

3.8.4 TMI-2 Canister Aging Effects

(NUREG-1927, Section 3.2 and Section 3.4.1.2)

This section identifies the possible effects of storage on the TMI-2 Canister in-scope SSCs. As such, applicable unmanaged aging effects could result in loss of intended functions for the TMI-2 Canister SSCs. Aging mechanisms that could lead to aging effects for TMI-2 Canister SSCs were determined using technical literature, related industry research, and existing OE. Aging mechanisms were evaluated to determine if the mechanisms could lead to an aging effect requiring management. Applicable aging effects, mechanisms, and management activities for TMI-2 Canister SSCs are summarized in Section 3.8.4.7 and listed in Table 3-5.

Stainless steels and other metals are discussed in Section 3.8.4.1 with aging mechanism discussions covered in Section 3.8.4.2. Exceptions to aging effects on particular SSC surfaces bounded by the Encased Environment are, as described in Section 3.8.4.3. Additional exceptions to stainless steel are the ceramic boron carbide pellets used in the TMI-2 Knockout and Filter Canisters, as addressed in Section 3.8.4.4. Furthermore, as is described in Section 3.8.2.1, the TMI-2 Fuel Canister internal cavity is surrounded with a stainless-steel shroud, which encases the neutron absorber material (boron carbide infused within an aluminum matrix, a material known as BORAL®). Exceptions to aging effects on the BORAL® are also addressed in Section 3.8.4.4. Finally, aging effects and relevant aging mechanisms with respect to the lightweight concrete (i.e., Licon) intended functions are covered in Section 3.8.4.5.

3.8.4.1 Stainless Steel and Other Metals

As discussed in Section 3.8.3, the TMI-2 Canisters are constructed almost entirely of stainless steel. As shown in Table 3-7, the structural SSCs are primarily constructed of Grade 304L or 316L stainless steel. The main exception being that the TMI-2 Fuel Canister upper head attachment bolts are fabricated from the nickel-based alloy Inconel 625, as discussed in detail in Section 3.8.4.6.

The environments of the TMI-2 Canister SSCs are described in Section 3.8.3. The exterior surfaces of the TMI-2 Canister shell and head SSCs and associated welds are exposed to the Internal DSC Environment of the DSC. In addition, the exterior surfaces of the TMI-2 Fuel Canister upper head attachment bolts are exposed to the Internal DSC Environment. The remaining in-scope TMI-2 Canister SSCs are either within the Internal TMI-2 Canister Environment or the Encased Environment.

The majority of the applicable aging mechanisms discussed in Section 3.8.4.2 will affect all of these TMI-2 Canister SSCs to some extent. Therefore, the applicable aging mechanisms discussed below are operative on the internal and external surfaces of the TMI-2 Canister albeit to an equivalent or lesser degree on the former. Unless otherwise indicated, discussions in Section 3.8.4.2 regarding stainless steel are applicable to the Inconel TMI-2 Fuel Canister bolts, since the bolts are similar if not more corrosion resistant, due to both the high chromium and nickel content. In addition, as stated above, the TMI-2 Fuel Canister bolts are also addressed specifically in Section 3.8.4.6. Finally, since the weld filler materials listed in Table 3-7 are as close in electrochemical properties as the base metal as possible, the aging mechanisms discussed in Section 3.8.4.2 will be applicable unless specifically noted.

The aging effects that could cause loss of intended functions are:

- Loss of Material
- Cracking
- Change in Material Properties

These aging effects and causative mechanisms are summarized in the following subsections: 3.8.4.1.1, 3.8.4.1.2, and 3.8.4.1.3, for each aging effect type. Each aging mechanism is evaluated in Section 3.8.4.2 to determine if the mechanisms could lead to an aging effect requiring management.

3.8.4.1.1 Loss of Material Aging Effects Assessment

- Loss of Material due to General Corrosion
- Loss of Material due to Localized Corrosion (Crevice and Pitting)
- Loss of Material due to Galvanic Corrosion
- Loss of Material due to Microbiologically Induced Corrosion
- Loss of Material due to Wear

3.8.4.1.2 Cracking Aging Effects Assessment

- Cracking due to SCC
- Cracking due to Thermal Fatigue

3.8.4.1.3 Change in Material Properties Aging Effects Assessment

- Change in material properties due to Intergranular Corrosion
- Change in material properties due to Creep
- Change in material properties due to Thermal Embrittlement (Thermal Aging)
- Change in material properties due to Irradiation Embrittlement

3.8.4.2 Discussion of Aging Mechanisms

3.8.4.2.1 General Corrosion

The most obvious property of stainless steels is their ability to resist corrosion and retain a substantially unchanged appearance after long exposure to an aqueous atmosphere. As a result, the TMI-2 Canister stainless steel surfaces in contact with moist air or condensed water vapor are not subject to uniform corrosion under the enclosed ambient environmental conditions experienced within the DSC. This fact is supported by the assessment in Section 3.2.2.1 of [3.11.76] and the following review of the aging mechanism.

The corrosion resistance of chromium-iron alloys under oxidizing conditions tends to increase as the chromium content is raised. There are improvements at about 12% chromium and again around 20% chromium. The typical chromium content of 316L and 304L stainless steel ranges from 16 to 20% chromium (See Table 3-7). The advantages associated with the higher chromium contents are used when a high degree of corrosion oxidation resistance is required. Therefore, the general corrosion rate for the 300 series stainless steels used in a dry storage environment like the TMI-2 ISFSI is not an issue. As an example, the IFSF dry storage facility, discussed in Section 3.2.2.2, has a similar environment to the TMI-2 ISFSI. Both facilities waste canisters are shielded from the elements (e.g., rain, snow, etc.) and both are exposed to outside air, which is normally at temperatures near ambient. Therefore, SNF canisters from both facilities are expected to have similar corrosion rates from any moisture in the air. As indicated in Section 3.2.2.2.4, two 304L stainless steel general corrosion coupons were evaluated over a 2-year period from 2011-2013 at the IFSF [3.11.90]. The actual 304L stainless steel general corrosion rate of these coupons was less than the measurement error, with a reported corrosion rate of <0.0006 mpy (See Table 2 of [3.11.90]). Such low corrosion rates will not have a deleterious impact on the performance of the TMI-2 Canister SSCs' intended functions over the PEO. As a reference point, the original design specifications for the TMI-2 Canister, as a code-compliant ASME pressure vessel, provided a corrosion allowance of 20 mils or approximately 10% of the TMI-2 Canister wall (pg. 26 of [3.11.34] and pg. 13 of [3.11.114]). In summary, loss of material due to general corrosion of the TMI-2 Canister SSCs is not an aging mechanism requiring management during the PEO.

3.8.4.2.2 Localized Corrosion (Pitting and Crevice)

Localized corrosion, pitting, and crevice corrosion of stainless steels are highly influenced by the presence of halogen (i.e., chloride) ions. Halogen ions penetrate passive films and induce localized corrosion. Localized corrosion is most likely with acidic chlorides. Stagnant conditions also promote localized corrosion, since it is more likely to allow deposits to become lodged on the metal surface, and they are more likely to permit concentration of damaging species, such as chlorides, in the localized areas. Similarly, crevice corrosion can occur inside crevices and under shielded areas on the metal surface where a stagnant solution exists. This is due to the limitation of oxygen diffusion to the area in order to heal or reform the oxide layer when there is damage to the oxide coating. Therefore, crevice corrosion is strongly dependent on the presence of dissolved oxygen. As such, moisture is required for the mechanism to operate. Typically, atmospheric pollutants and contaminants, both indoors and outdoors, are insufficient to concentrate and thereby promote localized corrosion. Locations of frequent or prolonged wetting or of alternate wetting and drying are particularly susceptible to localized corrosion, but which are not a factor at the TMI-2 ISFSI.

Molybdenum-bearing grades of stainless steel are used for their improved localized corrosion resistance and stabilization of the passive film. Increasing the molybdenum content in the alloy, as is the case for 316L stainless steel, produces greater resistance to the corrosion mechanism. Therefore, high molybdenum – high chromium alloys generally provide a highly effective, localized corrosion resistance (pg. 550 of [3.11.88]).

Overall, three factors influence localized corrosion: chloride content, pH, and temperature. Figure 3-16 shows the pitting corrosion relationship as a function of chloride content, pH, and molybdenum content of austenitic chromium alloys [3.11.165]. The temperature range for the data plotted in Figure 3-16 was 149–176°F. For each stainless-steel type, pitting is not problematic below its respective line on the chart. For a given chloride content, a higher temperature and lower pH encourage pitting. Conversely, a lower temperature and a higher pH reduce pitting. The condensate films within the TMI-2 ISFSI are anticipated to be near neutral (pH 6.5-7), similar to measurements made in similar environments (Table 2 of [3.11.146]), (Table 4 of [3.11.147]). This is because acidity from dissolved CO_2 will be mostly neutralized by cations in the environment such as Ca^{2+}, thus giving an alkaline character to condensed dew. Plotting this pH on Figure 3-16 shows a minimum chloride level of 175 ppm needed to facilitate the localized corrosion mechanisms on the Grade 304L stainless steel and 1,220 ppm on the Grade 316L stainless steel with the minimum 2% Molybdenum content.

Since the Chloride assessment for the TMI-2 ISFSI provided by the evaluation in Section 3.8.3.3 is ranked the lowest on the EPRI scale, the conditions do not exist to promote localized corrosion on the TMI-2 Canister stainless steel SSCs. In fact, these SSCs are in the even more isolated Internal DSC and TMI-2 Canister Environments than that of either the Outdoor or Sheltered Environments. As such, the DSC HEPA filters and TMI-2 Canister internal filter screens will tend to reduce any postulated halide concentration further.

In summary, the TMI-2 Canister SSCs do not favor localized corrosion for the following six reasons:

1. The TMI-2 Canisters are stored in a dry environment. Average ISFSI site Absolute Humidity is ~5 grams/m^3, per Section 3.8.3.3.3.
2. A wet anaerobic environment is unlikely to develop due to diffusion and the natural respiration of the DSCs as the ambient temperature fluctuates.
3. Radiation, which favors passivation because of the production of more effective oxidants in water/electrolyte solutions, should inhibit crevice corrosion (Section 5.2.2 of [3.11.98]).
4. Low temperatures (TMI-2 core debris internal temperature is under 80°F per Section 3.8.3.2) and nearly neutral pH do not favor localized corrosion aging mechanisms.
5. There is not a credibly sufficient corrosive electrolyte within the TMI-2 Canister environment conducive to promoting localized corrosion.
6. As described in Section 3.2.2.2.4, the crevice corrosion rate measured in the IFSF (with similar environment to TMI-2 ISFSI) was below the level of measurement error for two corrosion coupon samples with the reported rate on the lower molybdenum content stainless steel (Grade 304L) of < 0.0007 mpy (Table 2 of [3.11.90]).

As a result, loss of material due to localized corrosion aging mechanisms of the TMI-2 Canister SSCs is not an aging mechanism requiring management during the PEO.

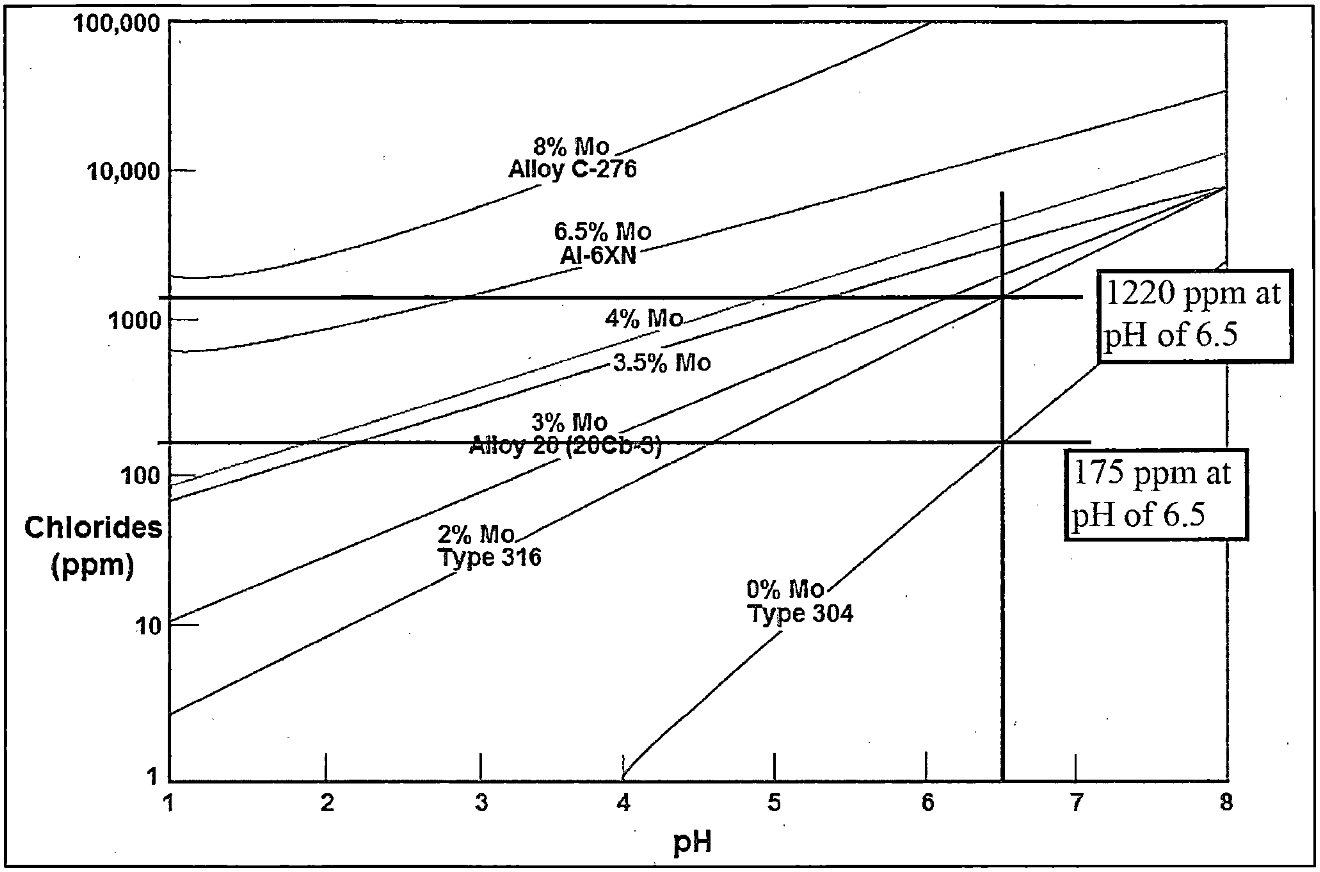

Figure 3-16: Pitting Corrosion Relationship as a Function of Chloride Content, pH, and Molybdenum Content of Austenitic Chromium Alloys [3.11.165]

3.8.4.2.3 Galvanic Corrosion

Galvanic corrosion behavior of stainless steels is difficult to predict because of the influence of passivity. In the common galvanic series, a more noble position is assumed by stainless steels in the passive state, while a less noble position is assumed in the active state (see Figure 3-8). For galvanic corrosion, the critical point is the difference in potential of the two materials being considered as a joined pair. A difference of hundreds of millivolts could result in galvanic corrosion, but only a few tens of millivolts are unlikely to be a problem. As indicated, stainless steels have two ranges listed in Figure 3-8. The first range is for the potential of stainless steel with its protective oxide coating intact. The range in parentheses is for activated stainless steel or stainless steel where the oxide coating has been compromised. Iron and steel tend to protect stainless steel in aqueous environments when galvanically coupled. The passive behavior of stainless steels makes them easy to polarize; thus, galvanic effects on carbon steel or other alloys tend to be minimized. However, galvanic corrosion of steel can be induced by stainless steels, particularly in aqueous environments and with adverse area ratios. As described in Section 3.4.4.2.4, carbon steel to stainless steel surface ratios in the DSC are not adverse, and therefore do not favor galvanic corrosion of the carbon steel.

The best indication as to what to expect for the TMI-2 Canister galvanic corrosion rate would be when compared with that of the IFSF site galvanic corrosion coupon rates described in Section 3.2.2.2.4. Four sets of 304L stainless steel to plain carbon steel galvanic corrosion coupons were evaluated. Two of the sets were evaluated over a 2-year period from 2011-2013, while the second set was evaluated over a 4-year period (2011-2015) [3.11.90], [3.11.91]. In 2013, the galvanic corrosion rate was less than the measurement error of the equipment used at the time to weigh the samples, having a reported galvanic corrosion rate of < 0.0006 mpy. In 2015, at the end of the 4-year period, more precise equipment was used and the reported average galvanic corrosion rate was 0.0002 ± 0.0006 mpy [3.11.91].

In the passivated state, 304L/316L stainless steel would be cathodic to the carbon steel DSC. Hence, the carbon steel DSC would corrode preferentially to the stainless steel TMI-2 Canisters in the TMI-2 ISFSI, as long as an oxidizing environment remained. An oxidizing environment is expected due to diffusion and the natural respiration of the DSC as the temperature fluctuates within the ISFSI. Thus, the corrosion rates would be expected to be lower than the corrosion rates given above.

The TMI-2 Canister is fabricated almost entirely of stainless steel. Potential sites of galvanic corrosion are:

1. Possible contact between the TMI-2 Canisters and either the DSC inner bottom cover plate or the DSC top shield plug
2. At the interface between the TMI-2 Canisters and the DSC basket
3. For the TMI-2 Fuel Canister, in the Encased Environment between the BORAL® sheets and the stainless-steel BORAL® shroud
4. For the TMI-2 Fuel Canister, any galvanic potential difference between the upper head and the TMI-2 Fuel Canister attachment bolts
5. Possible galvanic couple between the TMI-2 Canister stainless steel and the zirconium in the stored TMI-2 core debris

Galvanic site 1 above is addressed in Section 3.4.4.2.4, with no deleterious consequence to the in-scope TMI-2 Canister heads.

For galvanic site 2 above, the effect of galvanic corrosion would be upon the DSC basket, increasing the maximum hole diameter of the TMI-2 Canister openings in the basket spacer disks. However, no marginal change to the spacer disk hole size prevents the baskets locational support for the TMI-2 Canisters. In addition, the TMI-2 Canister shell itself is unaffected, therefore galvanic corrosion on this contact area is of no consequence.

For galvanic site 3 above, the BORAL® poison sheets in the TMI-2 Fuel Canister may contact the surrounding stainless steel shroud. The atmospheric moisture in this environment would be limited to that present when the shroud was welded shut, unless it was damaged sufficiently during TMI-2 core debris loading to cause a breach of the shroud. There is no evidence that this occurred however. Even with a breach, as discussed previously in Section 3.8.3.2, the Internal TMI-2 Canister Environment is not conducive to providing adequate free moisture, as the TMI-2 Canisters were vacuum-dried and heated prior to loading into the DSC. Therefore, even with a breach of the BORAL® shroud, the necessary free electrolyte available to promote galvanic corrosion is not credible.

For galvanic site 4 above, the TMI-2 Fuel Canister attachment bolts are the nickel-based Inconel 625, whereas the TMI-2 Fuel Canister bulkhead is either ASME SA-240 Grade 316L or 304L stainless steel plate. Figure 3-8 indicates that the galvanic potential for a nickel chromium alloy 600 such as Inconel 625 ranges from –150 to –90 millivolts, whereas the Grade 316 stainless steel ranges from -100 to 0 millivolts. Therefore, along with the nature of the environment being unlikely to drive this corrosion mechanism, this galvanic potential difference between the materials is inadequate to cause an electron flow between the surfaces. In any case, missing or loose TMI-2 Fuel Canister bolts have previously been evaluated and shown to be adequate for their intended function (See Section 3.8.4.6).

For galvanic site 5 above, there is also the possibility of a galvanic couple between the TMI-2 Canister 304L/316L stainless steel and the zirconium in the stored TMI-2 core debris fuel. The TMI-2 core debris SNF materials include the zirconium cladding, uranium dioxide fuel, and associated stainless steel and zirconium hardware from the reactor core. Much of the zirconium was oxidized during the reactor accident, so that the stored fuel material consists of zirconium, zirconium dioxide, uranium dioxide, and some steel. The material potential of zirconium in flowing seawater is –40 millivolts (pg. 675 of [3.11.88]), which places it within the stainless-steel range on the galvanic series chart of Figure 3-8. Therefore, zirconium is of equivalent nobility with 304L and 316L stainless steel (which can range from -130 to 0 millivolts in Figure 3-8 depending on grade) and, in contact with stainless steel while immersed in an electrolyte, may be cathodic to the stainless steel. However, zirconium is a reactive metal and the ease at which it picks up hydrogen may cause it to become embrittled in a galvanic couple.

In terms of contact area ratios between the TMI-2 core debris and the TMI-2 Canister, most of the TMI-2 Canisters are TMI-2 Fuel Canisters that have an inner storage shroud preventing the TMI-2 core debris from contacting the TMI-2 Canister shell, limiting the contact points. Some of the TMI-2 Canisters are TMI-2 Filter Canisters that contain fuel fines embedded on stainless steel filters that do not contact the stainless-steel shell. The remaining TMI-2 Canisters are TMI-2 Knockout Canisters that contain small TMI-2 core debris SNF pieces that may contact the TMI-2 Canister shell. Therefore, only a limited number of TMI-2 Canister shells are susceptible to galvanic corrosion with zirconium.

Galvanic corrosion of the stainless-steel contacting zirconium will not adversely affect the TMI-2 Canister SSCs for three primary reasons:

1. The TMI-2 Canister, including core debris was dried, therefore, does not contain aqueous water that the coupled metals must be immersed in for corrosion to occur. Condensation is seasonal, with spring through fall drying conditions removing any condensate that may have collected during the winter. Even condensate films are unlikely to cause galvanic corrosion because they are not electrically conductive.
2. The zirconium in the fuel is mixed with oxides that inhibit the metal contact needed for galvanic corrosion.
3. The galvanic potential difference between the materials is inadequate to cause an electron flow between the surfaces.

In summary, galvanic corrosion is an aging mechanism shown not to require management on the affected areas of TMI-2 Canister SSCs for the PEO.

3.8.4.2.4 Microbiologically Influenced Corrosion

The discussion in Section 3.4.4.2.5 regarding microbiologically influenced corrosion on plain carbon steel is also applicable to stainless steel. Therefore, deterioration of the stainless steel TMI-2 Canister SSCs under atmospheric conditions, due to microbiologically influenced corrosion is not considered credible, and it follows that aging management is not required during the PEO.

3.8.4.2.5 Stress Corrosion Cracking

SCC is a localized non-ductile cracking failure resulting from an unfavorable combination of sustained tensile stresses, either applied (external) or residual (internal), material condition, and the presence of a corrosive environment. SCC is a phenomenon that occurs in austenitic stainless steels, but becomes significant only if tensile stress and a corrosive environment exist. In most cases, SCC involves crack initiation, subcritical crack growth, and failure when the crack reaches a critical size and the tensile strength of the remaining material is exceeded. In terms of corrosive environment, dissolved oxygen, sulfates, fluorides, and chlorides can provide the necessary environment for SCC to occur [3.11.72], and is termed CISCC while exposed to a chloride environment. OE documented in IN 2012-20 [3.11.193] has shown that austenitic stainless steels under tensile stresses are known to be susceptible to SCC when exposed to chlorides in the environment.

In austenitic stainless steels in aqueous chloride environments, CISCC is influenced by a number of interrelated variables such as alloy composition, temperature, stress level, chloride concentration, corrosion potential, surface conditions, pH, and oxygen content of the electrolyte. If a given stainless steel is stressed to a low level, it may still fail by SCC if the other variables are unfavorable, but the same alloy stressed to its yield strength may not fail if one or more of the variables increase resistance. The SCC coupons in the IFSF with the similar environment to the TMI-2 ISFSI have shown no evidence of corrosion or SCC [3.11.90], [3.11.91]. As described in Section 3.2.2.2, both facilities are normally dry, contain no chloride sources, and operate at nearly ambient temperatures.

In 1987, the Materials Technology Institute of the Chemical Process Industries published results [3.11.94] from an experience survey on SCC of austenitic stainless steels in water (see Figure 3-17). The curve in the chart represents the boundary where industry OE has experienced SCC in actual practice. There were multiple austenitic stainless steel SCC failures reported when operating to the right of the curve, but no occurrences arose when operating to the left of the curve. Figure 3-17 shows that for grades 304 and 316 stainless steel, the threshold temperature for initiation of SCC is approximately 60°C (140°F) at nearly any chloride concentration. Of note, Figure 3-17 correlates well with Chapter7/Figure 28 of [3.11.99], which shows a cut-off temperature of 50°C (122°F) for SCC initiation for both 304L and 316L when tested in a neutral aerated salt solution for 1,000 hours.

Despite the high susceptibility, SCC and CISCC are not expected to be a problem for the 304L/316L stainless steel TMI-2 Canister SSCs stored in the TMI-2 ISFSI. This is for the following three reasons:

1. The site ranking for chlorides is the lowest possible (See Section 3.8.3.3)
2. Humidity and temperatures are low during most of the year and condensation is only present in the wintertime. From Section 3.3.1.2.3 and Table 3-3, the maximum TMI-2 core debris temperature is under 80°F, which is well under the 140°F threshold temperature for initiation of SCC.
3. As described in Section 3.2.2.2.4, the SCC coupons in the IFSF with a similar environment to the TMI-2 ISFSI have shown no evidence of SCC.

Therefore, deterioration of the stainless steel TMI-2 Canister SSCs under atmospheric conditions due to SCC is not considered credible, and it follows that aging management is not required during the PEO.

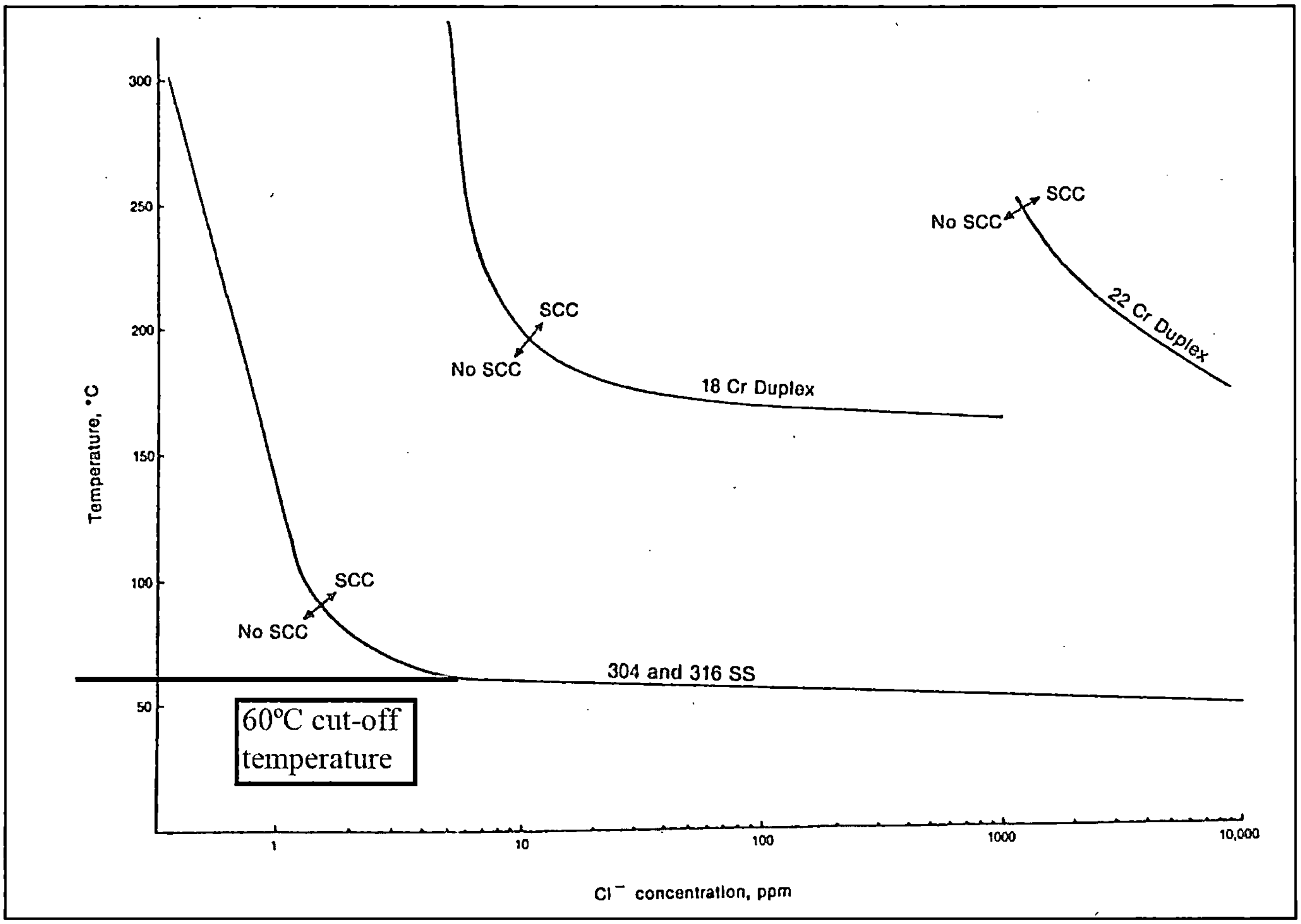

Figure 3-17: CISCC Resistance of 304 or 316 Stainless Steels as a Function of Temperature While in Water Environment [3.11.94]

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3.8.4.2.6 Intergranular Corrosion

Austenitic stainless steels become sensitized or susceptible to intergranular corrosion when heated in the temperature range of 1,100 to 1,600°F during such operations as welding, heat treatment, or metal fabrication. The most common reaction is formation of chromium carbide in the HAZ during welding, with the formula $Cr_{23}C_6$. When these carbides form along the grain boundaries, it is called "sensitization". Because the carbides require more chromium than is locally available, the carbon pulls chromium from the surrounding area around the carbon. The areas immediately adjacent to the precipitate are depleted in chromium. This leaves a low-chromium grain boundary zone and creates a new low-chromium alloy in that region. This causes a galvanic potential between the base metal and the grain boundary, so galvanic corrosion begins. The grain boundaries corrode, allowing the central grain and the chromium carbides to drop out, as if particles of rusty sand.

By lowering the content of carbon to below the saturation value for the solid solution, alloy sensitization is essentially avoided. Grades of stainless steel with this configuration are designated as "L" grades such as Types 304L, or 316L, with 0.03% carbon content maximum. The original specification documents for the TMI-2 Canisters specifically called for the 304L or 316L grade stainless steel materials, due to their low carbon content, and to avoid problems due to sensitization from welding operations [3.11.95]. These grades are very common since the development of argon oxygen decarburization refining. Almost all stainless steel is made using this method since it allows very precise control of the alloying elements, and it is possible to routinely obtain carbon levels of approximately 0.025%, a level at which no chromium carbide particles form in the HAZ during welding. The original documentation packages for the TMI-2 Canisters confirmed the carbon content was less than 0.030%, typically in the range of 0.016 - 0.028% [3.11.64] [3.11.100]. Despite reducing carbon content, TMI-2 Canister SSCs could still be impacted if a part is to be used continuously at temperatures generally ranging from 800 to 1,500°F, as it will still sensitize over time (pg. 266 of [3.11.96]). The temperature of the stainless-steel TMI-2 Canisters has remained nearly ambient for their entire lifetime, except during the heated vacuum drying process where TMI-2 Canister heating temperatures reached up to 900°F for a period of approximately 12 hours (Appendix D of [3.11.97]). However, 900°F is below the temperature for sensitization of the low-grade 304L and 316L stainless steels as is shown in Figure 8 (Chapter 6) of [3.11.99]. This was also validated by conclusions determined regarding this aging mechanism in 1997 [3.11.155]. Therefore, sensitization during those operations is not considered credible. Finally, there has been no evidence of intergranular corrosion on the IFSF 304L corrosion coupons or the stainless-steel structures within the IFSF [3.11.90] [3.11.91]. As such, it is not deemed reasonable that the TMI-2 ISFSI, which has a similar environment, will have intergranular corrosion on the TMI-2 Canister stainless steel SSCs. Therefore, this form of corrosion will not be considered any further in the LRA as a credible aging mechanism for the stainless steel TMI-2 Canister SSCs during the PEO.

3.8.4.2.7 Creep

Creep is a time-dependent strain (deformation) in metals occurring under constant load at constant temperature. There are three stages of creep during which the shear and elastic moduli of the material decrease, and the Poisson ratio increases. An increase in either stress or temperature accelerates creep. If stress or temperature is increased beyond certain levels, the increased deformation can eventually result in failure.

Metallic materials are generally considered to be subject to creep under conditions of extended exposure to stress and temperature in excess of a homologous temperature of $0.4T_m$, where T_m is the metal melting point in degrees Kelvin. With a melting point of 1,698 K (2,597 °F), temperatures of at least 679 K (763 °F) are required to initiate creep in austenitic stainless steels [3.11.76].

As indicated in Section 3.8.3.2, the maximum internal temperatures of the average decay heat load TMI-2 Fuel Canister are under 80°F. Since maximum operating temperatures are well below 763°F, creep is not considered a viable degradation mechanism for the TMI-2 ISFSI. Therefore, creep will not be considered further and aging management is not required on the TMI-2 Canister SSCs during the PEO.

3.8.4.2.8 Thermal Fatigue

Thermal fatigue is the progressive and localized structural damage that occurs when a material is subjected to cyclic loading associated with thermal cycling. The only source of potential thermal fatigue of the TMI-2 Canister SSCs is ambient seasonal and daily temperature fluctuations. The TMI-2 Canister does not experience the full amplitude of ambient temperature cycles, and a gradual, long-term temperature decrease occurs during the PEO. Thermal fatigue is the result of cyclic stresses caused by variations in temperature. Damage is in the form of cracking that may occur anywhere in a metallic component where relative movement or differential expansion is constrained, particularly under repeated thermal cycling.

Key factors affecting thermal fatigue are (1) the magnitude of the temperature swing, (2) the rate at which the temperature swings (rapid changes result in stresses in the material due to thermal gradients), (3) the presence of stress concentration points (i.e., notches, sharp corners, etc.), and (4) the number of temperature swings (number of cycles). Time to failure is a function of the magnitude of the stress and the number of cycles and decreases with increasing stress and increasing cycles. There is no set limit on temperature swings; however, as a practical rule, cracking in stainless steel is not detectable if the temperature swings drop below about 212°F (100°C) (Figure 2 of [3.11.101]).

Therefore, for the following two reasons thermal fatigue is not considered a credible issue for the TMI-2 Canister SSCs. (1) The TMI-2 ISFSI is typically exposed to temperature ranges less than 100°F on an annual cycle (winter and summer temperatures). In Section 3.5.4.2.3, the annual seasonal variability was determined to be 83°F. On a daily cycle, the maximum temperature swing as determined in Section 3.5.4.2.3 was 50°F. Both temperature swings are well below the 212°F temperature range minimum indicated above. (2) The TMI-2 Canisters are exposed to temperature swing rates that are slow, minimizing postulated thermal fatigue stresses. Thus, thermal fatigue in the stainless steel TMI-2 Canister SSCs is not an applicable aging mechanism for the duration of the PEO and will not be considered further.

3.8.4.2.9 Thermal Embrittlement (Thermal Aging)

Thermal embrittlement is a mechanism by which the mechanical properties (i.e., fracture toughness and impact energy) of a material are affected by prolonged exposure to high temperature or by improper cooling after such exposures. The ferrite present in austenitic stainless steel welds can transform by spinodal decomposition to form Fe-rich alpha and Cr-rich alpha prime phases, and further aging can produce an intermetallic G-phase [3.11.76]. The spinodal decomposition and the formation of the intermetallic G-phase takes place during extended exposure to temperatures between 572 and 752°F (Section 3.2.2.8 of [3.11.76]). The maximum expected temperature of TMI-2 core debris SNF material was estimated to be 174°F at the beginning of dry storage (UFSAR, Section 8.1.3.2.1.B [3.11.2]. As indicated in Section 3.8.3.2, the maximum internal temperatures of the average decay heat load TMI-2 Fuel Canister are under 80°F. These temperatures will decrease during the PEO as the materials decay.

The only time the TMI-2 Canisters were exposed to a higher temperature was prior to dry storage during the short duration of the heated vacuum drying process, where temperatures approached 900°F for up to 12 hours and where temperatures above 600°F occurred for up to 30 hours (Appendix D of [3.11.97]). However, any potential reduction in material properties due to thermal embrittlement would not be evident until at least a few hundred or thousands of hours at these temperatures [3.11.76], [3.11.144], and [3.11.145].

Based on these temperature estimates, SSCs located inside the TMI-2 Canister and near the TMI-2 core debris will not be near the temperature (572°F) required for these phase changes. Therefore, thermal embrittlement is not credible because the stainless steel TMI-2 Canister SSCs are typically exposed to temperatures of maximum 80°F (Section 3.8.3.2), well below the 572°F temperature range discussed above. Thus, change in material properties owing to thermal embrittlement is not an applicable aging mechanism during the PEO for the TMI-2 Canister stainless steel SSCs and therefore will not be considered further in this LRA.

3.8.4.2.10 Irradiation Embrittlement

High neutron radiation can cause loss of fracture toughness in steel (i.e., increases in the nil-ductility temperature) (pg. 653 of [3.11.82]). In general, the neutron fluence seen by the metal components of DSSs is generally orders of magnitude lower than that required to produce any adverse effect, so neutron radiation is unlikely to be an applicable aging mechanism for the stainless steel TMI-2 Canister SSCs. The total neutron fluence on the TMI-2 Canister shell assembly is calculated to be 5.06×10^{14} neutrons/cm^2 with the Am-Be-Cm startup source, integrated over an assumed 60-year period (See Section 3.8.3.1). In addition, integrated over an assumed 60-year period (See Section 3.8.3.2), the total neutron fluence on the inner stainless steel shroud for the BORAL® is calculated to be 1.77×10^{15} neutrons/cm^2 due to the Am-Be-Cm startup source. Both of these values are well below the level of concern for embrittlement of the stainless steel at 1×10^{18} neutrons/cm^2 [3.11.24]. The energy deposition values for the Am-Be-Cm neutron source model on the internal metallic subcomponents bounds the design basis source because neither the TMI-2 Knockout nor Filter Canister contains this source.

Regarding gamma radiation effects on the properties of stainless steel, the evaluation [3.11.24] described in Section 3.3.1.2.2 includes energy deposition tallies for the steel with absorbed gamma energy on the TMI-2 Canister shell. Per Section 3.8.3.1, the bounding gamma energy deposition is 2.00×10^9 rad with the distributed gamma source over the 60-year period. However, no limit on gamma radiation damage applicable to stainless steel has been identified, which is consistent with the Standardized NUHOMS® System LRA (Section 3.5.4.2 of [3.11.25]). Therefore, change in material properties due to irradiation embrittlement is not an aging mechanism requiring management for TMI-2 Canister SSCs.

3.8.4.2.11 Wear

As discussed in Section 3.4.4.2.12, the aging mechanism termed *"Wear"* simply means erosion or the displacement of a material from its original form. Wear is a mechanically assisted form of degradation that may involve both a wear mechanism and then subsequent corrosion mechanism. There are different forms of wear degradation processes. The only potential type of wear on TMI-2 Canister SSCs is adhesive wear from the original insertion of the TMI-2 core debris into the TMI-2 Fuel Canister and insertion of the TMI-2 Canisters into the DSC (basket). No additional wear mechanisms are applicable since all SSCs of the ISFSI are static and do not move while in storage. This is substantiated by the original ASME BPVC life calculations [3.11.114], "The canisters are not subjected to flow conditions that cause any significant corrosion, erosion or wear." The TMI-2 Canister was loaded vertically into the DSC. As such, there will likely be negligible wear to the TMI-2 Canister shell.

As far as postulated wear on the inner skin BORAL® shroud surfaces, this would be event driven occurring during initial core debris loading at TMI-2. An evaluation of the resistance of the shroud inner wall to puncture or tearing during placement of debris within the TMI-2 Fuel Canister was performed as part of the original drop testing inspections (pg. 26 of [3.11.34]). "Examinations of the drop test shrouds showed no penetrations and indicate the inner wall is very resistant to debris impacts and scrapes."

Therefore, since the beginning of storage in 1999, potential wear mechanisms on the shroud surfaces as previously evaluated in the design basis would not adversely affect the capability of the SSCs to perform their intended functions. This would not change during the PEO. In any event, any postulated wear caused by TMI-2 core debris loading will not change the corrosive performance capability of the stainless steel while stored in the ISFSI, as the passive protective oxide film will still be intact on the shroud internal surfaces [3.11.95]. As a result, the aging mechanism of wear on the TMI-2 Canister SSCs will not be considered further.

3.8.4.2.12 Radiation Induced Localized Corrosion

As discussed in Section 3.8.4.2.2 and Section 3.8.4.2.5, localized corrosion processes such as pitting, crevice and SCC were evaluated as potential aging mechanisms. These aging mechanisms were considered not to be credible and therefore did not require aging management activities. This section discusses the potential for promotion of radiation-induced localized corrosion processes due to the presence of gamma radiation and its interaction with water within the TMI-2 Canisters. Consideration is given to the interaction of gamma radiation with water possibly generating radiolytic oxidizing decomposition byproducts (e.g., hydrogen peroxide (H_2O_2), nitric acid (HNO_3)) which may affect these corrosion processes. This irradiation-assisted corrosion effect was also reviewed in DSC-RAI-17 with respect to the 1004 CoC renewal when considering higher heat loads and dose rates than the TMI-2 Canister environment [3.11.224]. As discussed below, production of H_2O_2 or HNO_3 from radiolytic processes within the TMI-2 Canisters will be limited due to the low dose rates and as such, will not credibly propagate any existing corrosion processes to sustain deleterious effects adversely influencing the TMI-2 Canister intended functions.

The intended functions within scope for the internal TMI-2 Canister stainless steel SSCs are sub-criticality, radiation shielding, structural integrity, and in some cases heat removal capability. Any of the localized corrosion processes evaluated will have negligible reduction on the intended functions of sub-criticality, radiation shielding, or heat removal capability since any such corrosion processes are localized in nature. Thus, these intended functions are not adversely influenced by such aging effects as localized cracking or pinhole progression. In addition, such aging effects will have a marginal to minor impact on structural integrity, unless such mechanism evolves to a gross failure. Therefore, irradiation-assisted localized corrosion effects are verified for their possible influence on either crevice corrosion or SCC, which could lead to gross failure of the TMI-2 Canister internal structure.

The potential exists for chemical reactions in the TMI-2 Canister free volume because of irradiation. Exposed to ionizing radiation, water decomposes into both oxidizing and reducing species, such as OH, H_2O_2, O_2, etc., whose net interactions with stainless steels can vary. In a constant radiation field, these radiolysis products achieve low, but steady state levels that can dictate the aqueous redox conditions and thus corrosion reactions [3.11.220]. As discussed in Section 3.3.1.2.1, radiolytic production of H_2 was considered indistinguishable from corrosion processes, only producing on average approximately 0.04% annually (shown in Figure 3-6). As stated in Section 3.3.1.2.1, a maximum of 3.2 liters of water is considered to exist within the TMI-2 Canister after the 40-year licensing period. This includes bound water within the TMI-2 Core debris, unbound (free) water, and reacquired moisture. This amount of moisture compares with the approximate 186-liter volume within the TMI-2 Canister (See Section 3.3.1.2.1). In a humid-air gaseous environment, resultant radiolytic byproduct species of irradiation may include nitrogen molecules, such as N_2O, NO_2, and HNO_3. In addition, gamma irradiation of liquid water droplets could produce oxidants such as H_2O_2. In lieu of H_2O_2 production, if the water within the TMI-2 Canister is considered gaseous and mixed with air as water vapor, another byproduct, HNO_3, may be generated due to irradiation effects.

In terms of H_2O_2 and its ability to generate an oxidizing environment that could lead to corrosion of stainless steel, it is generally thought that H_2O_2 when exposed to radiation is the oxidant most responsible for generating an oxidizing environment [3.11.223]. An experimental study of a low dose source on either stainless steel powder or bars in a H_2O_2 aqueous solution was conducted at room temperature (i.e., 77°F) [3.11.223]. The consumed concentration of H_2O_2 remained constant over time, whereas with stronger oxidants such as potassium permanganate and iridium hexachloride, the oxidant showed gradual consumption over time. After a period of approximately 3-4 days of exposure in the irradiated H_2O_2 solution, the water and stainless steel samples were then analyzed to quantify the amount of dissolved metal ions (i.e., reactants from chemical processes such as corrosion). None of the samples showed any sign of dissolution into their base metallic ions (e.g., Iron, Nickle, Chromium). The result is that stainless steel near room temperature is shown to be inert and very resistant to hydrogen peroxide while in an ionizing radiation environment.

At PEO initiation, maximum gamma dose rate exposure for the TMI-2 Canister Internal Environment is relatively low, conservatively maximized at 1745 rad/hr (See Section 3.8.3.2). In one particular study, when exposed to a much greater radiation field (9×10^5 rad/hour) and in pure water with a neutral pH of 6, H_2O_2 concentration remained relatively constant over time (Figure 3 of [3.11.220]). In either a neutral to slightly basic solution (i.e., pH 6 to pH 8.5), which would be similar to the TMI-2 Canister Internal Environment, the H_2O_2 concentration varies only slightly with exposure time. The study also provides useful data because it shows the variation in H_2O_2 concentration as a function of applied dose rate at different pH levels. Figure 7 from [3.11.220] shows the concentration in moles/liter for various radiolytic products (including H_2O_2) of a de-oxygenated water sample that has been irradiated at a range of dose rates. The analyzed dose rates in the [3.11.220] study are significantly higher than the TMI-2 Canister environment, ranging from 3.6×10^5 rad/hour to 3.6×10^8 rad/hour. Extrapolating Figure 7, "pH 6" chart (similar pH to TMI-2 Canister Environment) for H_2O_2 concentration down to the 1745 rad/hour range, gives an approximate 2×10^{-7} mole/liter concentration of H_2O_2. For conservatism, if we assume all 3.2 liters of the hypothetical maximum TMI-2 Canister moisture was liquid water, not moist air, and that the full amount reacts to form H_2O_2, then 6.4×10^{-7} moles or 2.2×10^{-5} grams of H_2O_2 could exist in the TMI-2 Canister over the entire 40-year TMI-2 ISFSI licensing period. With an H_2O_2 density of 1.42 grams/milliliter, this converts to only 1.5×10^{-5} milliliter within the TMI-2 Canister. Given the approximate 186-liter internal volume of the TMI-2 Canister, even localizing this concentration of H_2O_2 could not reasonably provide adequate reactant to affect adversely the gross structural integrity of the stainless steel SSCs. In conclusion, there is no expectation that any minimal H_2O_2 byproduct created from radiolytic processes would reasonably nurture any substantive increase in localized corrosion processes within the TMI-2 Canister.

The ability of nitric acid to affect adversely the structural integrity of the stainless steel SSCs within the TMI-2 Canister is reviewed next. Due to the heated vacuum drying process, the expectation for the interior of the TMI-2 Canisters is dry air. For dry air, the long-term products of gamma radiation are nitrous oxide (N_2O) and nitrogen dioxide (NO_2). No HNO_3 formation was observed in dry air and air/nitrogen oxide systems [3.11.222]. However, to be conservative, moist air is assumed within the TMI-2 Canister. In moist air and oxygen gaseous environments under high dose rates, both HNO_3 and ozone (O_3) may be produced. In order to determine whether the radiation field present is sufficient to generate significant quantities of reactive radiolytics (e.g., NO_2, and HNO_3), it is necessary to look at the magnitude of the radiation field and its ability to fixate elemental nitrogen to sustain reactions resulting in such byproducts. With a closed system, the gas phase composition will approach a steady state condition with a balance between the formation and decomposition of nitrogen oxides. This composition is primarily a function of the dose rate, initial gas phase composition, and temperature. Steady state concentrations of radiolysis byproducts have approximately a square root dependence on dose rate [3.11.220]. In addition, corrosion rates depend on the concentration of a reactant, not on the total amount of the reactant introduced into the reaction system over the entire reaction time [3.11.219]. It follows that the extent of corrosion damage possible from such concentrations depends on the dose rate. Therefore, the dose rate must be adequate to allow for a sufficient concentration of radiolytic products to both initiate and propagate any localized corrosion process.

A nitric acid mass estimate is determined to verify whether the applied gamma radiation field is sufficient to support significant corrosion processes. Nitric acid production fundamentally depends on the ability of the system to form elemental nitrogen from air molecules. The fixation of nitrogen to other elements is secondary and is caused by the direct interaction of ionizing radiation with nitrogen. Yield values for the formation and decomposition of HNO_3, N_2O, and NO_2 are determined as a function of the initial mole percent composition of oxygen [3.11.221]. Oxygen availability may be limited in the TMI-2 Canister interior, because any postulated corrosive process will consume oxygen. The final reaction step for the nitric acid molecule is as follows: $NO_2 + OH \rightarrow HNO_3$. Nitric acid formation continues until the water vapor is depleted from the gas phase. Of note, it is estimated that less than 0.1% of the gamma energy deposited within the TMI-2 Canister interior will be absorbed by the gas phase present and therefore contribute to changes in the composition of the gas phase (Page 3 of [3.11.221]).

The equations on Page 25 of [3.11.222] are applied, assuming that the internal volume within the TMI-2 Canister has sufficient reactants (e.g., water, nitrogen dioxide, oxygen, etc.) to support nitric acid production. The maximum dose rate of 1745 rad/hour at PEO initiation is assumed in order to determine an annual nitric acid total mass. Given the 186-liter TMI-2 Canister volume, approximately 0.44 grams of HNO_3 are produced on an annual basis. However, in order to support continued HNO_3 production, the numbers of molecules produced for every 100eV of absorbed radiation energy (i.e., G-value) may also decrease. This is due to decreases in either the available water or oxygen concentration. NO_2 will also have an influence on the production of HNO_3. Initially, NO_2 enhances the production of HNO_3, but as it builds up, it actually prevents further formation of HNO_3. Simultaneously, as equilibrium is approached, irradiation will convert the HNO_3, forming water, and NO_2.

The production of such minor, non-localized masses of HNO_3 would not reasonably be able to initiate and propagate local corrosive processes leading to gross failure of TMI-2 Canister SSCs, such that it reduces their structural integrity intended function. Given much more severe conditions and environments, austenitic stainless steels are quite resistant to attack by HNO_3. Stainless steel equipment used for handling HNO_3 is widely used in industry, including use in the pickling process to passivate metal surfaces. Ironically, nitric acid bath dipping is used to remove impurities, passivating the surface by enhancing the development of a more effective passive oxide layer. The corrosion rate of 304L stainless steel in 20% HNO_3 solution at a temperature of 130°C is only 4 mils per year (Page 29 of [3.11.222]). For these particular conditions, both a much higher HNO_3 concentration and temperature environment were used than actually exists within the TMI-2 Canister. In conclusion, the possible presence of miniscule quantities of non-localized, mild nitric acid within the TMI-2 Canister free volume is not reasonably anticipated to lead to deleterious localized corrosion aging effects, which could adversely affect the structural integrity of the TMI-2 Canister stainless steel SSCs.

Regarding the specific aging mechanism of irradiation-assisted crevice corrosion, irradiation favors passivation of the steel because of the production of more effective oxidants [3.11.98]. The rate of crevice corrosion is determined by a deficiency of oxygen in the crevice and a consequent damage to the steel's passivation. Thus, irradiation should inhibit crevice corrosion due to the more effective oxidants produced. Figure 6 on page 59 in [3.11.225] provides a crevice coupling potential estimate over time for 304L stainless steel exposed to a 1000 rad/hour dose rate in a 10 μg/g Cl- aqueous solution at 86°F. For this particular study [3.11.225], it showed the crevice corrosion initiating around day 20, but ending with repassivation occurring around day 115 (i.e., crevice propagation limited). Of note, this experiment used a pre-existing very tight, shrink-fit crevice for studying crack propagation. As a result, under a constant radiation field, the irradiated system quickly reached a steady-state chemical equilibrium, in which the concentrations of radiolytic decomposition products of water stabilized at low levels. The study also showed that a dose rate 100 times that of the 1000 rad/hour rate (i.e., 10^5 rad/hour) could sustain propagation of the crevice corrosion mechanism [3.11.225]. Comparing environmental conditions to the Internal TMI-2 Canister Environment, maximum temperatures are similar (78°F from Section 3.8.3.2), containing considerably less available water that lacks the additional Cl- ion impurity, and having comparable dose rates. As seen in Figure 6 on page 59 of [3.11.225], crevice propagation could only be sustained temporarily at a dose rate of 1000 rad/hour. Neglecting the drier environment within the TMI-2 Canister, this makes it likely that a similar crevice corrosion process could only be sustained at a time frame marginally higher than the 115 days at a similar dose rate (e.g., 1745 rad/hour of the TMI-2 Canister).

Regarding the SCC aging mechanism, initiation of SCC was ruled out as a credible aging mechanism in Section 3.8.4.2.5. Irradiation-Assisted SCC refers to the acceleration of the SCC process by irradiation, rather than instigation of a new effect (i.e., cracking initiation because of the radiation field itself) [3.11.217]. "Sensitization" of the stainless steel is a required element of irradiation-assisted SCC growth (Section 4.1 of [3.11.218]). As discussed in Section 3.8.4.2.6, sensitization of the TMI-2 Canister 304L and 316L stainless steels was dismissed due to the low exposure temperatures the materials have experienced during their lifetime. Sensitized austenitic stainless steels in combination with creviced conditions and a high gamma dose rate are required for SCC to propagate. At PEO initiation, maximum gamma dose rates that the TMI-2 Canister Internal Environment is exposed to are relatively low, conservatively about 1745 rad/hr (See Section 3.8.3.2). Because of these factors and that irradiation-assisted SCC manifests only "as an acceleration rather than an inducement of a process", it is not considered a credible aging mechanism for initiation of a crack. Because irradiation-assisted SCC can only propagate a pre-existing crack and SCC itself was previously dismissed, then irradiation-assisted SCC is not a credible aging mechanism.

From the foregoing, the potential exists for various chemical reactions to occur within the TMI-2 Canister interior due to irradiation of its gaseous and liquid constituents. In spite of the chemistry reactions that may be occurring because of irradiation, no products are formed which will compromise the structural integrity of the stainless steel. This is due to several factors, but primarily that the low dose rates and the low temperatures present in the TMI-2 Canister interior do not promote the inducement of new or sustained progression of existing localized corrosion processes. In addition, irradiation at the low dose rates does not promote production of significant quantities of radiolytic decomposition products (e.g., nitric acid or hydrogen peroxide). Furthermore, the volume of residual water potentially available inside the TMI-2 Canisters is comparatively small with respect to the overall TMI-2 Canister size, and any such water would not be well concentrated and necessarily localized. Therefore, the availability of reactants necessary to support radiolytic reactions, which could then support localized corrosion processes, is likewise constrained. Thus, even the ability to produce such byproducts from irradiation would not sufficiently cause adverse reactions leading to deleterious localized corrosive aging effects. As a result, the radiation-induced localized corrosion aging mechanism is not considered credibly reasonable and does not require aging management.

3.8.4.3 Encased Environment TMI-2 SSCs

As described in Section 3.8.3.2.1, the second interior environment that TMI-2 Canister SSCs are exposed to is the Encased Environment. The interior surfaces of the poison tubes and BORAL® shroud, BORAL® and the Licon are the SSCs exposed to this environment. A separate SSC evaluation is described in Section 3.8.4.4 for the Boron Carbide neutron-absorber materials, including the BORAL®, but the premises discussed within this section apply for evaluating for a loss of material aging effect. In addition, the Licon in the TMI-2 Fuel Canister is reviewed separately in Section 3.8.4.5 for a review of its intended functions. Finally, The B_4C poison pellets sole intended function is sub-criticality control and this is discussed in Section 3.8.4.4 as well.

The remaining SSCs in the Encased Environment are the internal surfaces of the poison tubes, including the entirety of the central poison tube on the TMI-2 Knockout Canister, which is enclosed by the Center Tube (1154090C from Table 3-4). In addition, this environment encompasses the interior surfaces of the BORAL® shroud stainless steel skin. The Encased Environment is characterized as a dry, air-filled environment. Therefore, corrosion processes that occur within these enclosed volumes will be entirely limited by the quantity of any retained atmospheric condensation and will cease upon exhausting this electrolyte. As a result, corrosion processes are restricted within this environment and will not progress during the PEO.

In accordance with the UFSAR Section 3.3.4.2.C [3.11.2], "the canister models used for the criticality evaluation are very simple and use nominal dimensions. No attempt has been made to address the many simplifications contained in the canister models since the results of the evaluation are well below the accepted regulatory margin." Under dry storage static conditions, no reasonable aging mechanisms could invalidate this statement. For example, regarding the TMI-2 Fuel Canister BORAL® shroud, the criticality analysis predicted a k_{eff} of 0.26057 on pg. D.3 of the UFSAR, using an inner stainless steel skin 0.04-in. thick and an outer stainless steel skin 0.08-in. thick. These were the nominal dimensions of the skin materials. Using a lesser value, taking into account reasonable corrosion effects will not substantially alter the k_{eff} to such an extent as to result in a higher k_{eff} than the bounding criticality model of the TMI-2 Knockout Canister, a model that reports a k_{eff} of 0.60767 in Section 3.3.4.2.G of the UFSAR. Likewise, using alternate poison tube dimensions accounting for reasonable corrosion allowances will not change the k_{eff} sufficiently in order to exceed the regulatory margins. As a result, the limited degradation mechanisms and any postulated aging effects will not adversely affect the ability of the TMI-2 Canister SSCs within the Encased Environment in performing their intended functions during the PEO and therefore will not be managed.

3.8.4.4 Neutron Absorber Materials Evaluation

As discussed in Section 1.3.4, exemption 12c in the TMI-2 ISFSI license [3.11.113] eliminates the requirement to verify periodically the efficacy of the neutron absorber (i.e., BORAL® and B_4C pellets) due to the low neutron fluence. A separate evaluation on the radiation effects on the internal SSCs of the TMI-2 Fuel Canister was conducted in [3.11.24]. The results indicate that the maximum neutron fluence on the BORAL® shroud is calculated to be 1.77×10^{15} neutrons/cm^2 with the Am-Be-Cm startup source, integrated over an assumed 60-year period (See Section 3.3.1.2.2). This is well below the level of concern (1×10^{17} neutrons/cm^2) as outlined in Section 3.4.2.7 of [3.11.76] and [3.11.156]. This is in alignment with the conclusions in Section 1.3.4 and consistent with NRC's FONSI [3.11.112] supporting approval of the neutron-absorber efficacy exemption. The FONSI refers to UFSAR text (Section 3.3.4) [3.11.2] that states only 75% credit for neutron absorber was taken, and per the FONSI that the neutron fluence is low enough to "deplete only a small percentage of neutron absorbing material during several thousand years of exposure". Therefore, the loss of material aging effect has been addressed by the current design bases. Separately, as indicated in Section 3.8.3.2, gamma radiation effects on the properties of BORAL® were reviewed, with absorbed gamma energy of 1.96×10^9 rad integrated over the 60-year period (with internal hardware). These are below the 3.8×10^{11} rad level adversely affecting material properties of borated aluminum for gamma radiation exposure (Section 3.4.2.7 of [3.11.76]), [3.11.156].

Loss of material or reduction in strength would be the only aging effects of import on the BORAL® for reducing its structural integrity. One of the "Basic Assumptions" of the UFSAR criticality analyses is that the TMI-2 Fuel Canister does not experience any deformation or displacement of the poison shroud during accident conditions (Section 3.3.4.2.A of [3.11.2]). UFSAR, Section 8.2.5.2.A also states:

> *"The TMI-2 canisters were drop tested to 190g during their design program, as described in Reference 8.34, and can support the weight of all TMI-2 canister assemblies without affecting any of the criticality assumptions described in Section 3.3."*

As discussed in Section 3.8.4.3, there are no credible degradation mechanisms postulated on the poison shroud in the Encased Environment that will cause a loss of material. As indicated in Section 1.3.4 [3.11.112], the NRC reached the same conclusion:

> *"The neutron absorbing material (poison) is in a form that exposure to the ambient atmosphere of the DSC interior will not cause a significant deterioration of the structural properties of the material over the expected life of the facility."*

While no credit is taken for the BORAL® in the HSM surface dose rate shielding evaluation, the BORAL® poison plates were included in a model of the top end shielding dose rates per Section 7.3.2.2.D of the UFSAR [3.11.2] and therefore was scoped in as having a shielding function. Loss of material would be the only aging effect of import on the BORAL® for reducing its shielding capability. As discussed in Section 3.8.4.3, there are no credible degradation mechanisms postulated on the poison shroud in the Encased Environment that will alter the above assumptions about material integrity of the BORAL® poison plates. This is also corroborated by assessments made in Section 3.4.2 of [3.11.76].

In conclusion, the structural integrity and radiation shielding functions provided by the BORAL® poison plates remain unaffected during the PEO. Likewise, the sub-criticality function of the BORAL® in the TMI-2 Fuel Canister and the B_4C pellets in the TMI-2 Knockout and Filter Canisters remains unaffected during the PEO. Therefore, change in material properties and loss of material for the neutron absorbers is not an aging effect requiring management for TMI-2 Canister SSCs.

3.8.4.5 Licon Material Evaluation

As outlined in Section 2.3.2.3 and Table 2-3, the Licon was determined to provide the intended functions of radiation shielding, sub-criticality, heat-removal capability, and structural integrity. Each of these functions will be described below based on the UFSAR design bases and an evaluation describing postulated aging effects of loss of material, cracking, or reduction in material properties, as appropriate. Licon, an ultra-lightweight concrete was used in the annulus of the TMI-2 Canisters between the outer skin of the poison shroud and the inside surface of the TMI-2 Canister shell. During loading of the TMI-2 Canisters, the Licon prevented TMI-2 core debris particles from entering the annular void space between the TMI-2 Canister inner shell wall and the outer BORAL® shroud outer skin. In addition, the Licon provides lateral support for the BORAL® shroud.

- Radiation shielding

Licon was included in a model of the top end shielding dose rates, per Section 7.3.2.2.D of the UFSAR [3.11.2], and therefore was scoped in as having a shielding function. The relevant results are listed in the design-basis shielding model, Calculation 219-02.0403, "Top End Dose Rates for TMI-2 Canisters" [3.11.215]. In accordance with Section 7 of [3.11.215], "the dose rate directly above the HEPA filters is found to be 3.12 mrem/hr". Although the Licon was included in a top-end dose rate model, its inclusion, and therefore relative impact on shielding for gamma radiation will be negligible, with respect to the stainless steel and steel shielding function of the TMI-2 Fuel Canister and DSC SSCs, respectively. The reported dose rates were used from a volumetric source with a 19-year cooling time, which does not take into effect the initial 20-year storage period, but rather the cooling decay period from the initial accident date of 1979 to March 1998. At the beginning of the PEO in 2019, the source will have decayed further as discussed in Section 3.3.1.2. Measured dose rates in 2010 and 2012 were reported in the annual radiological monitoring survey reports [3.11.102] [3.11.103], respectively. As indicated in the survey reports, total maximum (gamma and neutron) radiation levels measured on the surface of the HSM rear access doors were ≤ 1 mrem/hr, and near the center of the DSC HEPA filter purge and vent port housings were ≤ 15 mrem/hr, satisfying respective total dose rate limits of 100 mrem/hr on the door and 1200 mrem/hr on the filter housing per TS LCO 3.2.2 [3.11.113]. Maximum combined radiation levels measured on the HSM rear access door surfaces are significantly less than the calculated peak dose rates listed in Table 7.3-1 of the UFSAR (i.e. 104.5 mrem/hr gamma and 0.235 mrem/hr neutron). Dose rates in compliance with the LCO 3.2.2 limits are maintained during the PEO even with the complete degradation of Licon. This is confirmed via a supporting supplemental calculation [3.11.216], which removes the Licon, excluding it from the top-end dose rate model and showing the 3.12 mrem/hr HEPA filter maximum dose rate increases to 55 mrem/hr. In addition, Appendix A of [3.11.216] shows that when combining Licon removal with complete basket degradation and resultant TMI-2 Canister rearrangement around the DSC vent port, the HEPA filter maximum dose rate increases to 314 mrem/hr. Both increased dose rates (55 mrem/hr and 314 mrem/hr) are below the 1200 mrem/hr dose rate LCO limit. As a result, any postulated aging effects on the Licon material will not credibly cause a spike in dose rates and will not credibly reduce the current shielding properties afforded by the Licon such that the LCO 3.2.2 limit is exceeded. Therefore, aging management of the Licon for reduction of the intended function of Radiation Shielding of the Licon during the PEO will not be considered further.

- Sub-criticality

The Licon material was also modeled as part of the criticality evaluation (pg. D.2 of UFSAR [3.11.2]), and therefore is scoped in for sub-criticality control. As indicated on pg. D.2 of the UFSAR, the Licon was modelled using water at a 29-weight percentage ratio of the overall Licon mass. This was the original constituent of the concrete composition before heated vacuum drying. Fundamentally, the system cannot be critical without significant addition of dense neutron moderating material, such as water or other hydrogen rich material. As described in Section 3.8.2.2, after drying of the TMI-2 Canister, much of the water of hydration was removed. Typically, water being a moderator of neutrons will tend to increase the fission rate and thus the k_{eff}, whereas the removal of water will decrease k_{eff}. The $k_{eff} = 0.26047$ reported in Section 6.1.1 of [3.11.105] for the TMI-2 Fuel Canister was bounded by the higher $k_{eff} = 0.60767$, reported in Section 3.3.4.2.G of the UFSAR for the TMI-2 Knockout Canister.

During storage, the Licon may act as a desiccant and water vapor could be reabsorbed from the atmosphere. EDF-797 [3.11.104] previously calculated a theoretical amount of water, which may enter the DSC over a 40-year period. The total calculated amount of water that could enter a DSC from all mechanisms was determined to be 10.32 kilograms, which if spread evenly over each of the 12 TMI-2 Canisters in a DSC would amount to 0.86 kg within each. Contrary to assumptions in [3.11.104], not all of this water would remain within the Internal DSC Environment, nor will all of this water be transported into the TMI-2 Canisters and be reabsorbed by the Licon. Nonetheless, to take into account the effect of adsorbed water on the criticality safety of the TMI-2 core debris fuel, a second criticality safety evaluation was completed, as described in Section 3.3.4.3 of the UFSAR and Section 6.4 of [3.11.106]. In this second criticality safety evaluation, the Licon water volume fraction was varied from 0-40%, in addition to full density water being substituted for the Licon. This evaluation showed that significant amounts of moderator (water) could remain in the TMI-2 Canisters without compromising criticality safety. Tables 17 and 18 from [3.11.106] show the calculated k_{eff} values. From the report, "The results show that 0.05 volume fraction water in the Licon is optimal, however the results with no water in the low-density concrete are statistically similar."

For the second criticality safety evaluation, the multiplication factor (k_{eff}) (including all biases and uncertainties at a 95% confidence level) was shown to remain below 0.95 under all credible normal, off-normal, and accident conditions. As a result, the Licon's criticality intended function in the TMI-2 Fuel Canister will be unaffected by any postulated change in material properties, notably the water-cement ratio.

Any credible aging mechanisms that could alter the Licon water content show sub-criticality requirements are maintained. A supplementary criticality analysis was conducted to confirm the approved FSAR design-basis criticality evaluation, INEEL/INT-99-00126 [3.11.106]. This supplementary criticality analysis is documented in Orano Federal Services Calculation CALC-3021788 [3.11.226]. The supplementary analysis, along with Table 18 of [3.11.106] shows that the Licon water absorption is determined to have a large, negative effect on storage system reactivity. When Licon water content is increased from zero to full density water (within full density Licon), the k_{eff} value decreases from 0.78954 to 0.67917 (Table 5-2 of [3.11.226]). Therefore, water absorption in Licon due to aging does not result in an increase in reactivity. The calculated applicable Upper Subcritical Limit in the supplementary criticality analysis is 0.9435.

For a complete loss of Licon in the TMI-2 Fuel Canister, the supplementary analysis also confirms the resultant subcritical limit is maintained. When Licon mass is reduced from full density to zero, the k_{eff} value decreases from 0.78954 to 0.77942 (Table 5-1 of [3.11.226]). This indicates a decrease in Licon density results in a slight decrease in k_{eff}, showing that the loss of Licon due to aging does not result in an increase in reactivity when structural effects are not taken into account. In addition, structural effects are evaluated, including collapse of the TMI-2 Fuel Canister outer shell (with no credit taken for the volume occupied previously by Licon material). The loss of Licon material, with structural effects, also has a small, negative effect on storage system reactivity over the no structural effects case. The collapse of the TMI-2 Fuel Canister outer shell decreases the k_{eff} value from 0.77942 to 0.77699 (Table 5-3 of [3.11.226]). However, the resultant reconfiguration of the 12 TMI-2 Fuel Canisters into the most reactive configuration (i.e., 4 × 3 rectangular array) increases reactivity, bounding both dimensional and tolerance-based effects of Licon material loss. Therefore, the loss of Licon material in the TMI-2 Fuel Canister (i.e., complete degradation) in addition to the resulting reconfiguration of the TMI-2 Fuel Canisters results in a positive effect on reactivity, increasing to a maximum k_{eff} of 0.85926 (Table 5-3 of [3.11.226]). Nevertheless, the Upper Subcritical Limit of 0.9435 is not exceeded in any condition for the TMI-2 Fuel Canister.

In conclusion, possible changes to the Licon material properties because of postulated aging effects will not compromise the subcriticality function. This includes total Licon material loss (i.e., complete degradation) as well as changes to the TMI-2 Fuel Canister geometry that could result due to the loss of Licon. Therefore, aging management of the Licon for reduction of the intended function of sub-criticality of the Licon during the PEO will not be considered further.

- Heat-removal capability

Licon was also included in the thermal model of the DSC in determination of the maximum fuel cladding temperatures on the TMI-2 core debris supporting UFSAR Section 3.3.7.1.1 and results in UFSAR Table 8.1-10 [3.11.2]. Therefore, the Licon is scoped in for heat removal capability. The HEATING 7 thermal model of the HSM is depicted in Figures 8.1-1 and 8.1-4 of the UFSAR. In accordance with Section 8.1.3.1.C of the UFSAR, the effective thermal conductivity of the Licon material, which is a part of the TMI-2 Fuel Canister, "is calculated for the material composition of 11 weight % without glass bubbles, 60 weight % without cement, and 29 weight % without water." The effective thermal conductivity of Licon was then determined to be 0.726 BTU/hr-ft°F as reported in UFSAR, Table 8.1-6. As discussed regarding sub-criticality above, the percentage of water in the overall Licon composition can vary after both the heated vacuum drying process and after a period in dry storage, due to the potential for Licon in reabsorbing atmospheric water vapor. However, according to the original NRC SER for the TMI-2 ISFSI (Section 6.5.4.1 of [3.11.4]):

> *"Small differences in the weight percent of the Licon constituents have negligible effect on the thermal analysis results of the core debris and canisters."*

In fact, if we substitute a high performing insulator, such as a blanket of air with a thermal conductivity of 0.015 BTU/hr-ft°F for the Licon in the model, the results of the analysis are still valid given the sizeable margins in UFSAR Table 8.1-10 between the maximum calculated TMI-2 core debris temperature and the acceptance criteria. Using a beyond credible change such as substituting for the thermal conductivity of air, along with the fact that the heat load values were reported at the beginning of storage, not the beginning of the PEO, any credible changes to the Licon effective thermal conductivity will not adversely affect the ability to comply with the TMI-2 core debris temperature limit described in UFSAR Section 3.3.7.1.1. Therefore, aging management of the Licon for reduction of the intended function of Heat-removal capability of the Licon during the PEO will not be considered further.

- Structural integrity

An 80-in. horizontal side drop and an oblique corner drop at an angle of 30° to the horizontal are evaluated accident drop conditions in Section 8.2.5.1.B of the UFSAR [3.11.2]. As stated in UFSAR Section 8.2.5.2.A, "the TMI-2 canisters could bear on the DSC shell", since the DSC basket may yield in the drop analyses. According to the TMI-2 ISFSI structural analysis [3.11.92], "The inertial forces from the contents of the DSC are applied to the DSC but the integrity of the contents themselves is not considered". During original TMI-2 Canister certification testing, a 30-foot horizontal drop test showed the Licon concrete supported the shroud and "prevented any significant deformation of the shroud" (Section 3.2.2.2 of [3.11.107]). According to the UFSAR criticality evaluation (Section 3.3.4.2.A), "The fuel canister does not experience any deformation or displacement of the poison shroud during accident conditions", indicating that the Licon role in providing support for the shroud walls is an important function. This was validated in Section 3.2.3 of [3.11.107], when after the 30-ft drop of the TMI-2 Fuel Canister it was concluded:

> *"The LICON cement provides excellent uniform support for the shroud walls. It will essentially eliminate cross-sectional deformations of the shroud. Only minor distortion of the shroud from square to slightly rhomboid was observed."*

Therefore, the Licon is scoped in for structural integrity. UFSAR, Section 8.2.5.2.A also states:

> *"The TMI-2 canisters were drop tested to 190g during their design program, as described in Reference 8.34, and can support the weight of all TMI-2 canister assemblies without affecting any of the criticality assumptions described in Section 3.3."*

One of the assumptions listed in the criticality section above was the role of varying the water volume fraction on the Licon and the acceptability on variations of k_{eff}. Consistent with the statement above about Licon's structural integrity during drop testing, this criticality assumption remains valid during the PEO given the 50-year design life of the ISFSI (See Section 1.3.1). The supplementary criticality analysis [3.11.226] described in the "-Sub-criticality" sub-section above has validated that Licon water absorption has a "large, negative effect on storage system reactivity". The [3.11.226] analysis also shows that with or without Licon, inclusive of structural loss of both the TMI-2 Fuel Canister shell and Licon and with subsequent TMI-2 Fuel Canister reconfiguration, the Upper Subcritical Limit is not exceeded.

In addition, from the following paragraph's radiation effects acceptance limits, there would be no adverse change in material properties for the Licon due to thermal or irradiation effects (specifically the compressive strength of 3,000 psi or the bulk density of 60 pcf as reported in [3.11.107]). This is validated by evaluations in [3.11.132], which says, "In concrete pressure vessels at present under construction for nuclear power plants, it has been found necessary to prevent the temperature of the concrete from rising above about 65°C. It is considered that at this temperature no marked changes in properties will take place, apart from slow drying." As indicated in Section 3.8.3.2, the TMI-2 core debris maximum temperatures during the PEO are less than 78°F (25.6°C), which indicates no adverse change in material properties of the Licon due to long-term temperature aging effects.

In terms of irradiation, the results from [3.11.24] indicate that the maximum neutron fluence on the Licon is calculated to be 9.83 x 10^{14} neutrons/cm^2 with the Am-Be-Cm startup source, integrated over an assumed 60-year period (See Section 3.3.1.2.2). Gamma radiation effects on the properties of Licon were reviewed, with absorbed gamma energy of 1.61 x 10^9 rad integrated over this 60-year period (See Section 3.8.3.2). These levels are below the 2.0 x 10^{19} neutrons/cm^2 and 1.0 x 10^{10} rad level [3.11.192], [3.11.149], [3.11.24] adversely affecting material properties of alumina-based concrete for neutron fluence and gamma radiation exposure, respectively. Of note, the TC, the TC internal spacers, and DSC would absorb the majority of the dynamic energy (UFSAR Table 8.2-3) [3.11.2] in an 80-in. drop event. Besides, a drop occurrence would be an event driven accident condition, not an age-related condition, and which could only occur during retrieval operations, since the ISFSI is completely loaded. Therefore, the original UFSAR conclusions on structural integrity of the Licon remain valid for the PEO and no aging management is required.

3.8.4.6 TMI-2 Fuel Canister Bolts

The TMI-2 Fuel Canister bolts are used to attach the upper head to the bulkhead on the TMI-2 Fuel Canister. They are made of a nickel alloy (Inconel 625). The bolts were originally sized for pressure loads from loading and dewatering operations and from postulated impact forces due to shifting of TMI-2 Canister contents during a transportation accident. According to Section 3.3.4 of the UFSAR [3.11.2], control methods for the prevention of criticality consist of geometric confinement of the fuel within the TMI-2 Canisters. This includes the upper head assembly, which would mitigate effects of collapsing the TMI-2 Canister shell. In addition, according to Section 8.2.5.2.A of the UFSAR for the Accident Drop Analyses "the TMI-2 canisters could bear on the DSC shell" in a lateral side drop or oblique corner drop case. As such, TMI-2 Canister structural integrity is an intended function, and includes providing load transfer through the upper head and into the closure head bolts. The upper head is also the interface with the TMI-2 Fuel Canister bulkhead and maintains a seal for gross geometric confinement within the TMI-2 Fuel Canister body. Although not a credited function (See Section 2.3.2.3), the shell boundary limits dispersion of fuel out of the TMI-2 Fuel Canister.

The performance with raised or missing bolts was evaluated as part of a 10 CFR 72.48 [3.11.52] evaluation and described in biennial update report 72-20/2001-01 [3.11.115] and deemed acceptable for these configurations. According to the biennial update report, "The TMI-2 Canisters affected by loose head bolts are now considered to be acceptable for a drop accident of 28 feet. Such a drop accident is not considered credible for the TMI-2 ISFSI, either during transfer or storage." The TMI-2 Fuel Canister bolts are loaded statically, and stress relaxation of bolting is not a concern for the closure forces needed to maintain the upper head attachment due to the low temperatures in the Internal DSC Environment (See Section 3.8.3.2). Consistent with Section 3.2.4 of [3.11.76], the nickel bolt material will not credibly be subjected to any other age-related degradation mechanisms that could adversely affect the structural integrity intended functions. As a result, aging management of the TMI-2 Fuel Canister bolts for reduction of the intended function of structural integrity during the PEO will not be considered further.

3.8.4.7 TMI-2 Canister Aging Effects Requiring Management

Postulated aging effects with mechanisms were evaluated for TMI-2 Canister SSCs in the foregoing subsections. As was discussed in these subsections, there are no credible aging effects requiring management for the duration of the PEO for the TMI-2 Canister SSCs.

3.8.5 Aging Management Activities for TMI-2 Canisters

(NUREG-1927, Section 3.2 and Section 3.4.1.3)

Because there are no applicable TMI-2 Canister aging effects, no AMAs are required. Therefore, no AMPs are needed during the PEO for the TMI-2 Canister SSCs. In addition, there are no TLAAs applicable to the TMI-2 Canister SSCs. Based on this evaluation, no further action is required for aging evaluations, monitoring programs, or other AMAs on the TMI-2 Canister SSCs during the PEO.

3.9 PERIODIC TOLLGATE ASSESSMENTS

(NUREG-1927, Section 3.6.1.10)

Industry guidance on the preparation of ISFSI LRAs is contained in NEI 14-03, "Format, Content and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management," [3.11.54]. This NEI document introduces the concept of "tollgates" and "tollgate assessments" and provides specific guidance in Section 3.6.5 and Appendix C of the document. DOE-ID will perform tollgate assessments during the PEO of the TMI-2 ISFSI, spanning the period from March 17, 2019 through March 17, 2039 or the date the last licensed material is removed from the TMI-2 ISFSI, whichever occurs sooner.

DOE-ID may choose to integrate the tollgate assessment into existing TMI-2 ISFSI assessment programs, while continuing to meet the underlying intent of the tollgate concept. Tollgate assessments for the TMI-2 ISFSI will be performed in accordance with Table 3-11.

Table 3-11: TMI-2 ISFSI Tollgates

TOLLGATE	DUE DATE	ASSESSMENT
1	3/17/2024	Evaluate information from the following sources and perform a written assessment of the aggregate impact of the information, including but not limited to applicable and relevant trends, corrective actions required, and the effectiveness of the AMPs with which they are associated: – Results, if any, of research and development programs focused specifically on aging-related degradation mechanisms identified as potentially affecting DSS ISFSIs; – Relevant domestic and international OE including research results on aging effects/mechanisms (including non-nuclear on an opportunistic basis); – Relevant results of domestic and international ISFSI and DSS performance monitoring; – Relevant results of domestic and international ISFSI and DSS inspections Topics of particular interest for the TMI-2 ISFSI tollgate assessment should include, the following: – Reinforced concrete degradation in general, and degradation of NUHOMS® HSMs in particular – Deterioration of carbon steel and coatings
2	3/17/2029	Evaluate additional information gained from the sources listed in Tollgate 1 along with any new relevant sources and perform a written assessment of the aggregate impact of the information. This evaluation should be informed by the results of Tollgate 1. The aging effects and mechanisms evaluated at this Tollgate, and the time at which it is conducted, may be adjusted based on the results of the Tollgate 1 assessment.
3	3/17/2034	Same as Tollgate 1, as informed by the results of Tollgates 1 and 2
4	3/17/2039	Same as Tollgate 1, as informed by the results of Tollgates 1, 2, and 3

In order to prepare the tollgate assessments effectively, DOE-ID will have access to the industry's Aging Management Institute of Nuclear Power Operations Database (AMID) via the NUHOMS® DSS vendor, TN Americas. DOE-ID will review the AMID to obtain and aggregate relevant information to support the preparation of the tollgate assessments and will prepare those assessments as recommended in NEI 14-03. AMP effectiveness will be reviewed as part of the tollgate assessment process and changes made, as appropriate, subject to the change controls of 10 CFR 72.48. DOE-ID will also enter information into AMID as directed by the AMP implementing procedures so that other ISFSI licensees performing tollgate assessments may use the information.

DOE-ID intends to use AMID to develop its tollgate assessment but wishes to give itself the flexibility to also use other sources of information in the future to augment AMID with relevant information. In particular, DOE-ID may wish to use aging-related material degradation information generated elsewhere in the DOE laboratory network that is relevant to the TMI-2 ISFSI materials and environments. Such information may or may not be available in AMID, based on the distribution restrictions applicable to the information.

It is important to note that the tollgate process is not a substitute for the other DOE-ID OE reviews or the DOE-ID corrective action program. OE and other information or events pertaining to ISFSI aging-related issues that DOE-ID becomes aware of will be reviewed for relevance to the TMI-2 ISFSI. As a result, actions will be taken in a timeframe commensurate with the safety significance of the issue. Relevant items will be addressed in the DOE-ID corrective action program, as appropriate.

The preparation of tollgate assessments during the PEO will be administratively controlled using the DOE-ID commitment management program.

3.10 RESERVED

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APPENDIX A: AGING MANAGEMENT PROGRAMS (AMPS)

(NUREG-1927, Section 3.6, Section 3.6.1 and Section 3.6.3)

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APPENDIX A1: Dry Shielded Canister AMP

A1.1 PROGRAM SCOPE

This appendix describes the DSC AMP that is designed to monitor and control the degradation of the DSC SSCs of the TMI-2 ISFSI. The DSC AMP core inspection criteria are summarized in Table A-1. The DSC AMP provides reasonable assurance that potentially detrimental aging effects are adequately managed so that the DSC intended functions are maintained consistent with the design basis for the PEO. This ensures that no aging effects will result in a loss of intended function of the SSCs that are within the scope of renewal during the PEO. The AMP is based on the results of the AMR for the DSCs presented in Section 3.4. The following recommended DSC AMP is consistent with the 10 program elements described in NUREG-1927 [A.1.1] and outlined below.

The scope of the DSC AMP consists primarily of a remote visual inspection of DSC SSCs in the Sheltered Environment. In addition, direct visual inspections of certain Sheltered Environment DSC SSCs accessible via the rear HEPA Filter door are conducted. Finally, as an additional defense-in-depth enhancement to the DSC AMP, engineering evaluations derived from both the routine radiation (both gamma and neutron) and hydrogen monitoring measurements are included as part of the DSC AMP scope.

Intended functions to be maintained are shown in Table 2-3. The AMP scope includes DSC SSCs shown in Table 3-4 with environments defined in Section 3.4.3 and materials defined in Section 3.4.2.

As identified in Section 3.4.4.6 and summarized in Table 3-5, the DSC SSCs in the Sheltered Environment require management for the following aging effects:

- Loss of Material due to General Corrosion
- Loss of Material due to Crevice Corrosion
- Loss of Material due to Pitting Corrosion
- Loss of Material due to Galvanic Corrosion for the DSC shell contacting dry film lubricant at the sliding rail surfaces
- Loss of Material due to Adhesive Wear on DSC Shell with potential for corrosion (of any type above)

In addition, as a defense-in-depth aging management function, the zinc-rich primer on the sheltered environment steel SSCs is included to assess loss of coating integrity due to blistering, cracking, flaking, peeling, or physical damage.

The normally non-accessible areas of DSC SSC remote visual inspections for loss of material include:

- The DSC shell, and in particular; crevice locations (i.e., where the shell sits on the support rail); fabrication welds of the confinement boundary and the associated HAZ (i.e., longitudinal and circumferential welds on the cylindrical shell)

The inaccessible areas of DSC SSC visual inspections for loss of material include:

- The upper surface of the DSC shell (i.e., where atmospheric particulates would settle)
- Outer Bottom Cover plate, Grapple Ring Assembly plates, their welds and HAZs

- Portions of the Outer Top Cover plate, HAZ and associated closure weld
- Internal surfaces of the DSC located in the Internal DSC Environment, including the Inner Bottom Cover Plate, Basket, Purge Port Block, Vent Port Shield Block, Shield Plug, Vent/Purge Port Sample Port Bolt

This program also visually inspects and monitors portions of DSC SSCs that may be subject to loss of material. The program scope includes the attached HEPA filters and fasteners as a defense-in-depth enhancement (See Section 3.4.4.4). The areas of direct visual inspections are the following Sheltered Environment DSC SSCs:

- Portions of Outer Top Cover plate, closure weld, and HAZ
- Vent and Purge Port HEPA Filter Housings
- Vent and Purge Port HEPA Filters (defense-in-depth inspection)
- Vent and Purge Port Filter Housing attachment fasteners (defense-in-depth inspection)

As indicated in Section 3.4.4.5, failure of the steel SSC coatings does not prevent the DSC SSCs from satisfactorily accomplishing their intended functions. Yet, it may disguise indications of corrosion of the underlying material for carbon steel SSCs. Therefore, as indicated in Section A1.2 for preventive purposes, this AMP will manage loss of coating integrity.

Periodic inspections are conducted by personnel qualified to monitor for the applicable aging effects, and may include those described in Section XI of the ASME BPVC [A.1.35] – "Rules for Inservice Inspection of Nuclear Power Plant Components"; and ASTM D4537 [A.1.24], "Standard Guide for Establishing Procedures to Qualify and Certify Personnel Performing Coating and Lining Work Inspection in Nuclear Facilities." Specifically, personnel performing visual examinations are qualified and certified consistent with ASME BPVC Section XI, Subarticle IWA-2300 [A.1.35]. In addition, consistent with Article VI-4000 of Section XI of the ASME BPVC [A.1.35], for welded steel structural connections, AWS certified welding inspectors or certified associate welding inspectors are required for evaluations of structural adequacy. As prescribed in 10 CFR 72.158 [A.1.11], qualifications under these programs, and any other DSC AMP qualifications are documented in the DOE-ID NLF Contractor training and qualification program in accordance with STI-NLF-QA-002, "Quality Assurance Program" [A.1.32].

A1.2 PREVENTIVE ACTIONS

The DSC AMP is primarily a condition-monitoring program that does not include additional preventive actions. However, it does include exceptions to this, such as the protective coating management program and data trending analysis of the two SRs identified below.

As discussed in Section 3.4.4.4, as a preventive measure for all DSC SSCs, existing radiation monitoring SRs provides an indirect indicator of possible adverse premature degradation. This would include LCO 3.2.2 [A.1.8] that requires the surface dose rate of each HSM rear access door and the purge/vent filter housings be surveyed on an annual basis. This is confirmed by statements outlined in the TS bases, "If the radiation field at the vent approaches the limits specified, the cause will be evaluated and corrective action taken" [A.1.9]. Therefore, the associated SR 3.2.2.1 provides data representative of potential increased dose measurements indirectly indicative of adverse degradation. An engineering evaluation as indicated in Section A1.4.4 is conducted on the raw radiation measurement data.

In addition, as described in Section 3.3.1.2.1, the hydrogen levels are monitored and tracked as part of the existing LCO 3.2.3 [A.1.8]. Monitoring these levels is an indirect indicator of corrosion occurring within the Internal DSC Environment. As a defense-in-depth enhancement of the DSC AMP, the gas concentration levels will be tracked and monitored to ensure monitored gas production and consumption trends remain within expected values. An engineering evaluation as indicated in Section A1.4.4 is conducted on the raw gas measurement data.

A1.3 PARAMETERS MONITORED OR INSPECTED

For each material/aging effect combination, the specific parameters monitored or inspected depend on the particular DSC SSC. Parameters monitored or inspected are commensurate with industry codes, standards, and guidelines and consider industry OE, as well as TMI-2 ISFSI OE. ASTM D7167 [A.1.20], Section XI of the ASME BPVC [A.1.18] and American Society of Civil Engineers Structural Engineering Institute SEI/ASCE 11-99 [A.1.4] provide a basis for selection of parameters to be monitored or inspected for steel structural elements.

As identified in Section A1.1, the DSC SSCs in the Sheltered Environment require management for the following aging effects:

- Loss of Material due to General Corrosion
- Loss of Material due to Crevice Corrosion
- Loss of Material due to Pitting Corrosion
- Loss of Material due to Galvanic Corrosion for the DSC shell contacting dry film lubricant at the sliding rail surfaces
- Loss of Material due to Adhesive Wear on DSC Shell with potential for corrosion (of any type above)

In addition, as a defense-in-depth aging management function, the zinc-rich primer on the sheltered environment steel SSCs is included to assess loss of coating integrity due to blistering, cracking, flaking, peeling, or physical damage.

The normally non-accessible areas of DSC SSC remote visual inspections for loss of material include:

- The DSC shell, and in particular; crevice locations (i.e., where the shell sits on the support rail); fabrication welds of the confinement boundary and the associated HAZ (i.e., longitudinal and circumferential welds on the cylindrical shell)

The inaccessible areas of DSC SSC visual inspections for loss of material include:

- The upper surface of the DSC shell (i.e., where atmospheric particulates would settle)
- Outer Bottom Cover plate, Grapple Ring Assembly plates, their welds, and HAZs
- Portions of the Outer Top Cover plate, HAZ, and associated closure weld
- Internal surfaces of the DSC located in the Internal DSC Environment, including the Inner Bottom Cover Plate, Basket, Purge Port Block, Vent Port Shield Block, Shield Plug, Vent/Purge Port Sample Port Bolt

This program also visually inspects and monitors portions of DSC SSCs that may be subject to loss of material. The program scope includes the attached HEPA filters and fasteners as a defense-in-depth enhancement (See Section 3.4.4.4). The areas of direct visual inspections are the following Sheltered Environment DSC SSCs:

- Portions of Outer Top Cover plate, closure weld and HAZ
- Vent and Purge Port HEPA Filter Housings
- Vent and Purge Port HEPA Filters (defense-in-depth inspection)
- Vent and Purge Port Filter Housing attachment fasteners (defense-in-depth inspection)

The DSC external surface's AMP consists of visual inspections to monitor for material degradation from the above aging effects. The parameters monitored ascertain the DSC SSCs general condition, including for evidence of water stains, discoloration, surface deposits, and coating degradation.

In addition, DSC SSCs are examined for the following conditions:

- DSC surfaces, welds, HAZs, and crevice locations near the DSC support rails are inspected for discontinuities and imperfections. Localized corrosion (e.g., pitting and crevice corrosion), stains or discolorations, if any, are documented.
- Appearance and location of atmospheric deposits on the DSC surfaces are recorded.
- HEPA Filter Housings are inspected for discontinuities and imperfections. Localized corrosion (e.g., pitting and crevice corrosion), and stains or discolorations, if any, are documented.

As indicated in Section 3.4.4.5, failure of the steel SSC coatings does not prevent the DSC SSCs from satisfactorily accomplishing their intended functions. Yet, it may disguise indications of corrosion of the underlying material for carbon steel SSCs. Therefore, as indicated in Section A1.2 for preventive purposes, this AMP will manage loss of coating integrity.

Monitoring for the above aging effects ensures that aging degradation leading to loss of intended functions will be detected and the extent of degradation determined.

A1.4 DETECTION OF AGING EFFECTS

Visual inspections, hydrogen monitoring, and radiation surveys are performed per DOE-ID NLF contractor procedures. DSC exterior inspections are consistent with industry guidelines for detecting, evaluating, and documenting aging effects (e.g., Section XI of the ASME BPVC [A.1.18] and ASTM D7167 [A.1.20]). The DSC AMP monitors aging effects for loss of material due to general, crevice, pitting, and galvanic corrosion, as well as monitoring coating integrity using visual inspections.

A1.4.1 Selection of SSCs for Inspection

Performance of remote visual inspections for aging effects on the normally non-accessible portions of DSC SSC surfaces in the Sheltered Environment is as discussed below. As indicated in Section 3.2.2.2.4, the initial examination of the Sheltered Environment DSC SSCs was performed on DOE12T-002 and the Overpack liner in HSM-15 in 2012. After entering the PEO, a substitute DSC is preselected in lieu of the Overpack liner for the baseline and any subsequent inspections. Inspection of DOE12T-002 and the substitute DSC is intended to be consistent throughout the duration of the PEO.

A desktop review of DSC documentation (e.g., design drawings, DSC fabrication packages) was considered for the substitute DSC selection indicated above, and is documented in EP-NLF-2017-001 [A.1.36]. The substitute DSC selected for inspection is based on a combination of factors and considerations, which may include, but is not limited to,

1. Time in service: Storage duration (time in service) is related to surface temperature and deposition of contaminants.
2. Initial Heat Load: DOE12T-002 was selected for initial inspection in 2012 due to its low heat load. Lower heat loads result in lower DSC shell surface temperatures, thus increasing condensation potential on the exterior of the DSC and relative humidity inside the HSM promoting incubation of ambient contaminants. The substitute DSC may be selected from the pool of DSC's with the highest heat loading, resulting in higher gross DSC shell surface temperatures, which may have a varied impact on surface coating conditions.
3. DSC Fabrication and Design Considerations: Fabrication weld maps, if available, should be reviewed to identify locations of the circumferential and longitudinal welds, and external configurations of the inner bottom cover-to-shell weld (e.g., ASME Figure NB-4243-1(f)) [A.1.12]. These features are verified against the DSC fabrication drawings for any DSCs under inspection consideration.
4. HSM array configuration relative to climatological and geographical features: Due to the prevailing nature of winds from the southwest, southwest HSMs/DSCs have more air infiltration than those more protected to the north and east. The highest DSC hydrogen and lowest DSC oxygen concentrations mostly depend on their position at the ISFSI, where the northeasterly DSCs are less exposed to winds that increase circulation through the HSMs. The wind therefore imposes more circulation through the west HSMs than the east, resulting in both increased hydrogen removal from the DSC and more convective heat dissipation.

Based on [A.1.36], the DSC slated for inspection is DOE12T-004, with the two predominant reasons for this selection being consideration 4 above and an event driven operational issue. The event-driven consideration for DOE12T-004 was that the DSC rotated during loading, potentially causing elevated degradation in the zinc-rich coating of the DSC shell over the affected area.

Inspections are also conducted on the accessible portions of DSC SSCs. Directly accessible areas of the DSC Sheltered Environment SSCs are those located in the rear of the HSM through the HEPA filter access door. The directly accessible areas in this location are accessible portions of the outer top cover plate, HAZ and associated closure weld SSCs. In addition, the Vent and Purge Port HEPA Filter Housings are included in this inspection. Also included in this inspection are defense-in-depth inspections of the Vent and Purge Port HEPA Filters and associated attachment fasteners.

Within the Sheltered Environment, certain surface areas of the DSC may be inaccessible by either direct or remote visual inspection. The DSC AMP addresses detection of aging affects upon SSCs located in inaccessible areas indirectly by monitoring the inspection findings in accessible areas. Therefore, inaccessible area inspections (See Table A-1) may only be necessitated because of the ISFSI corrective action program STI-NLF-QA-016 [A.1.13] to ensure the aging effect is adequately managed and that the SSCs intended function is maintained during the PEO. For example, accessibility to the Outer Bottom Cover plate may be limited during storage, but prior to transport, it can be inspected after the DSC is pulled into the TC. As stated above, the portion of the Outer Top Cover plate and the associated welds visible through the HEPA Purge and Vent Port Filter access door are inspected. The condition in these locations may be used to estimate the condition on the remainder (inaccessible locations) of the Outer Top Cover plate.

The AMR takes no credit for the prevention of aging affects by any coatings applied to carbon steel SSCs. However, although the DSC coating is a NITS component, it is considered an integral part of the in-scope SSC to which it provides protection from corrosion; whether credited for that protection or not. Therefore, aging management is performed on coating failure to determine if it could adversely affect the intended function of the coated DSC SSCs.

The SSC selection process described above provides the basis for selection of bounding DSCs for inspection. As described in Section A1.10.1, this is a learning AMP. The selection criteria described above will be updated if necessary to incorporate new information.

A1.4.2 Data Collection

The DSC AMP methods for data acquisition and documentation, including an inspection report shall be conducted per STI-NLF-QA-020 [A.1.7] and STI-NLF-QA-010 [A.1.34]. The recording of examination and test results provides a basis for evaluation and facilitates comparison with the results of subsequent examinations. Consideration of the data collection portion of the DSC AMP should be given to reporting criteria in Section XI of the ASME BPVC [A.1.18] and ASTM D7167 [A.1.20]) for evaluating and documenting aging conditions. Specifically, ASTM D7167 provides *"Reporting and Documentation"* guidelines in Section 11 and includes a sample coating performance data checklist in Figure 1.

A1.4.3 Method

Visual examinations follow procedures consistent with the ASME BPVC, Section XI, Subarticle IWA-2200 [A.1.18]. ASME BPVC, Section XI NDE standard is chosen since the DSC is designed to ASME BPVC, Section III, Division l, Subsection NB [A.1.12] criteria. ASME BPVC, Section XI, Paragraph IWA-2213 VT-3 visual examinations detect discontinuities and imperfections on the surface of components, including corrosion. VT-3 visual examinations are initially performed for the DSC surfaces on the Sheltered Environment SSCs. Additional VT-1 visual examinations are performed as described in Section A1.6.1 when indicated by the assessment of the VT-3 results.

VT-3 inspections of these normally non-accessible Sheltered Environment DSC SSC surfaces may be performed using a video camera, fiber-optic scope, or other remote inspection technology via existing access points of the HSM, such as the drainage outlet or HEPA Filter access door. Various remote visual inspection technologies may include inserting remote Pan-Tilt-Zoom (PTZ) cameras or fiber optics through the approximate 1-in. radial gap between the DSC outer radius and the HSM interior OD at the back end (i.e., 67.19-in. DSC OD versus 69.25-in. HSM opening).

In addition to the remote visual inspections, direct visual VT-3 inspections are conducted on all accessible DSC SSC surfaces as identified in Section A1.4.1. The coordination and timing of these inspections occurs in conjunction with SR 3.1.1.1, which requires periodic seal leak testing, as described in Section A1.5.1.

If aging effects are identified in accessible locations, further evaluation of the aging effects in inaccessible locations is conducted via the ISFSI corrective action program STI-NLF-QA-016 [A.1.13], to ensure the aging effect is adequately managed and that the SSCs' intended functions are maintained during the PEO.

As a point of reference, some inaccessible location inspections could be performed via visual inspection of a partially removed HSM Shield Door by mounting a camera on a pole. Such a method is consistent with inspections performed during Calvert Cliffs baseline inspections [A.1.5]. Such inspections may be conducted for some particularly inaccessible DSC SSCs, including the Outer Bottom Cover plate and Grapple Ring Assembly plates, which are not part of the confinement boundary, but their condition, ascertained prior to retrieval. Of note, as vertical surfaces out of the main path of airflow, these SSCs are the least susceptible to the effect of atmospheric deposits. Preliminary detection of potential adverse aging effects in these normally inaccessible locations and confirmation of inspection modes/methods in these areas may also be attained by evaluations of the Overpack liner HSM-15. Preliminary inspection dry runs using a spare HSM/DSC are consistent with using an empty DSC for inspections, similar to those conducted at the Calvert Cliffs ISFSI (a specific license using the NUHOMS® System) [A.1.5].

A1.4.4 Defense-in-Depth Enhancements

In addition, as discussed in Section A1.2, existing radiation monitoring SRs provides an indirect indicator of possible adverse premature degradation on DSC SSCs. This would include LCO 3.2.2 [A.1.8] that requires the surface dose rate of each HSM rear access door and the purge/vent filter housings be surveyed on an annual basis. This is confirmed by statements outlined in the TS bases, "If the radiation field at the vent approaches the limits specified, the cause will be evaluated and corrective action taken" [A.1.9]. Therefore, the associated SR 3.2.2.1 provides data representative of potential increased dose measurements indirectly indicative of age-related degradation. As a defense-in-depth enhancement, the annual results of SR 3.2.2.1 can be used opportunistically for routine tracking and trending of neutron and gamma radiation measurements at the locations identified in LCO 3.2.2. An engineering evaluation is conducted on the raw radiation measurement data, looking at the trends in the readings. During performance of the annual SR, DOE-ID will evaluate both the TMI-2 ISFSI on a holistic basis and DSCs on an individual basis. Given the AC in Section A1.6.2, should anomalous conditions be revealed then corrective actions would be taken, including determining if the cause of the condition is age-related degradation of ITS SSCs. Because the routine performance of SR 3.2.2.1 is required by the ISFSI Technical Specifications, NRC review and approval is required to change any portion of the SR. Therefore, this defense-in-depth enhancement regarding the SR results and their evaluation is opportunistic by definition and need not be included in the DSC AMAs described in Table A-1.

In addition, as discussed in Section A1.2, the hydrogen levels are monitored and tracked as part of the existing LCO 3.2.3 [A.1.8]. Monitoring these levels in accordance with SR 3.2.3.1 is an indirect indicator of corrosion occurring within the Internal DSC Environment, which is representative of aging effects occurring on the DSC SSCs. As a defense-in-depth enhancement, the annual results of SR 3.2.3.1 can be used opportunistically for tracking and monitoring hydrogen gas concentration levels in order to ensure production and consumption trends remain within expected values. An engineering evaluation is conducted on the raw gas measurement data, looking at the trends in the readings. During performance of the annual SR, DOE-ID will evaluate both the TMI-2 ISFSI on a holistic basis and DSCs on an individual basis. Given the AC in Section A1.6.2, if a significant increase in hydrogen gas concentration is revealed, then corrective actions would be taken, including determining if the cause of the condition is age-related degradation of ITS SSCs. Because the routine performance of SR 3.2.3.1 is required by the ISFSI Technical Specifications, it requires NRC review and approval to change any portion of the SR. Therefore, this defense-in-depth enhancement regarding the SR results and their evaluation is opportunistic by definition and need not be included in the DSC AMAs described in Table A-1.

A1.5 MONITORING AND TRENDING

Monitoring and trending is conducted per the DOE-ID NLF Contractor Corrective Action Program, STI-NLF-QA-016 [A.1.13], which includes provisions of the DOE-ID NLF contractor's 10 CFR Part 72, Subpart G [A.1.11] program. Conditions adverse to quality noted during the inspection and monitoring activities, such as non-conformances, failures, malfunctions, deficiencies, or deviations are entered into the corrective action program. Visual inspections, along with radiation and gas monitoring assessments appropriately consider cumulative OE from previous inspections and assessments, in order to monitor and trend the progression of aging effects over time.

STI-NLF-QA-016 includes trending of adverse conditions as well as a process to prevent recurrence. Consistent with STI-NLF-QA-016, any degradation warranting further evaluation and potential mitigative action is addressed using the DOE-ID NLF contractor deficiency tracking system to ensure timely resolution and implementation of potential mitigative actions. This monitoring and trending process applies to all inspections performed and allows for the monitoring of aging effects over time, ensuring the ability of the DSC SSCs to perform their intended functions during the PEO. Regarding inspections, Section A1.5.1 describes the process for identifying frequency and type of such inspections.

A1.5.1 Frequency and Timing of Inspections

Regarding the remote visual inspection frequency on DSC SSCs in normally non-accessible areas, performance of baseline AMP inspections occurs no later than two years after the effective date of the renewed license, with follow-on inspections at a 10 ± 2-year interval based on timing and results of preceding inspections (See Table A-1). The standard inspection frequency for DSC SSCs is at intervals of 10 ± 2 years. If preceding inspection AC has been exceeded and it is unclear what the trend from previous inspections indicates, the interval between inspections is decreased to 5 ± 1 year. These inspection frequencies would allow the inspections to be spaced out instead of performing two inspections in the same year. The justification for this interval is to reduce workload at the TMI-2 ISFSI, as an additional DSC is included in the inspection from the outset and not because of any adverse findings or applicable OE. The inspection interval of 10 years is consistent with ASME, BPVC Section XI, Subsubarticle IWA-2430 optional inspection program B (Paragraph IWA-2432) [A.1.18]. The ± 2 years is provided for DOE-ID NLF contractor's inspection planning and potential limited availability of vendor remote NDE equipment.

In the case of DOE12T-002, this first inspection after the effective date of the renewed license ascertains the condition of these Sheltered Environment DSC SSCs. Also, for the chosen substitute DSC inspection discussed in Section A1.4.1, the initial baseline inspection establishes the initial conditions for those SSCs. These baseline inspections are a key component of the monitoring and trending activities, such that the inspection results can be used for subsequent trending. For trending purposes, conditions of the DSC SSCs observed in baseline inspections establish the state of the SSCs, and these are compared with any future conditions observed. Deficiencies are documented, with results trended and corrected. Depending on significance, a more focused selective inspection (VT-1 level visual inspection as described in Section A1.6.1) may be required, to determine the extent of condition and determine if more frequent monitoring or inspection is required.

As described in Section 3.4.4.4, "Evaluation of DSC SSCs with an Exclusive Confinement Function,", portions of DSC SSCs are accessible on a 5-year basis as part of SR 3.1.1.1, which requires periodic seal leak testing. The portions of DSC SSCs directly accessible as identified in Section A1.4.1 are inspected in conjunction with these 5-year leak tests. These inspections are conducted on the same two DSC S/Ns completed from the normally non-accessible inspections above (i.e., DOE12T-002 and DOE12T-004). The initial baseline inspection of each DSC occurs after the effective date of the renewed license and ascertains the condition of these Sheltered Environment DSC SSCs for future inspections. For trending purposes, conditions of the DSC SSCs observed in baseline inspections establish the state of the SSCs, and these are compared with any future conditions observed. Depending on significance, a more focused selective inspection (VT-1 level visual inspection as described in Section A1.6.1) is required, if VT-3 AC is exceeded.

Performance of visual inspections on the DSC steel SSC coating is synchronized with inspections of DSC SSCs as specified herein, ensuring that the intended functions of the protected SSCs are maintained during the PEO.

A1.6 ACCEPTANCE CRITERIA

The DSC AMP calls for inspection results to be evaluated by qualified engineering personnel based on AC selected for each SSC. This ensures that the need for corrective actions is identified before loss of intended function occurs. The criteria are derived from design basis codes and standards that include ASME BPVC [A.1.18], SEI/ASCE 11-99 [A.1.4], and consider industry and facility OE (See Section A1.10). The criteria are directed at the identification and evaluation of degradation that may affect the ability of the DSC SSCs to perform their intended functions. Should inspection AC be exceeded, the identified issue requires further evaluation and is entered into the corrective action program, STI-NLF-QA-016 [A.1.13]. See Section A2.6.3 for specific definitions and AC of the protective coating.

A1.6.1 Visual Inspection

Visual examinations are based on a VT-3 examination (ASME BPVC, Section XI, Subsubarticle IWA-2210) [A.1.18]. As much of the DSC surface as can be accessed is examined by VT-3 to ascertain its general condition. After the VT-3 inspection and in accordance with Section A1.7, any indications of relevant degradation that could affect the SSCs' intended functions are evaluated through the DOE-ID NLF Contractor Corrective Action Program STI-NLF-QA-016 [A.1.13]. As a result, a VT-1 examination, as described below, is performed if the VT-3 assessment indicates it is needed based on the VT-3 AC being exceeded or if it is required based on prior inspection results and resulting corrective actions.

The VT-3 examination procedure is capable of resolving demonstration character heights of 0.105 inches, consistent with ASME BPVC, Section XI, Table IWA-2210-1 "Visual Examinations" [A.1.18]. VT-3 capable direct or remote visual inspection systems are qualified and demonstrated to have sufficient resolution capability and enhanced lighting to resolve the AC identified herein. Of note, the remote inspection camera resolution must meet VT-3 illumination, distance, and character height criteria for examination effectiveness. Cleaning of the DSC surfaces is not a condition of the VT-3 examination. Less than 100% coverage is acceptable if it can demonstrate that the areas sampled for inspection bound or are representative of the balance of the subject area.

Inspection AC for the VT-3 examination are: no indications of missing or degraded coating (i.e., blistering, cracking, flaking, rusting, and physical damage), or any indication of surface flaws as specified in Section XI, Subarticle IWB-3514.1 and summarized below.

In addition, Section A2.6.3 provides definitions and AC of the steel DSC SSCs protective coating. Identified coating integrity issues will be evaluated via the TMI-2 ISFSI Management QA Program, STI-NLF-QA-020 [A.1.7], to ensure the aging effect is adequately managed and that the underlying SSCs' intended functions are maintained during the PEO.

Inspection Acceptance Criteria for the VT-1 examination are as follows:

- No indications of pitting or crevice corrosion (localized corrosion)
- No indications of galvanic corrosion as evidenced by red-orange corrosion products emanating from crevice locations (e.g., support rail plate-to-DSC shell interface)
- No indications of corrosion products near crevices
- No indications of corrosion products on or adjacent to confinement boundary welds
- Section A2.6.3 provides definitions and AC of the steel DSC SSCs protective coating

ASME BPVC Section XI [A.1.18] provides specific rules for evaluating flaw indications that may be detected during the inspections. If flaw indications are found, the flaw geometry is determined from the inspection results, consistent with Section XI, Subarticle IWA-3300. The flaw dimensions are assessed and compared with the allowable flaw dimensions in Section XI, Paragraph IWB-3514 acceptance standards. Based on the results of the VT-3 examinations, if the flaw size is less than the maximum allowable flaw size in the IWB-3514.1 acceptance standards, and the DSC SSCs are determined to be free of any other indications of corrosion or other degradation that could lead to the loss of intended functions (i.e., coating degradation meets AC), then no further evaluation is required until the next inspection.

If the flaw size exceeds the maximum allowable VT-3 flaw size in the IWB-3514.1 acceptance standards, or coating degradation AC are exceeded, then a VT-1 examination is performed on the flaw indications. Based on the results of the VT-1 examinations, if the flaw size is less than the allowable flaw size in the IWB-3514.1 acceptance standards, and the DSC SSCs are determined to be free of any indications of localized corrosion aging effects or other degradation that could lead to the loss of intended functions (i.e., above AC exceeded for the VT-1 examination), no further evaluation is required until the next inspection. If the VT-1 examination reveals a localized corrosion flaw exceeds the allowable flaw size in the IWB-3514.1 acceptance standards, then procedures in Section A1.7.1 are followed. If the VT-1 examination reveals coating degradation does not meet AC, or other VT-1 AC listed above are exceeded, then procedures in Section A1.7 are followed.

A1.6.2 Defense-in-Depth Data Evaluation Enhancements

Annual radiation measurements performed pursuant to SR 3.2.2.1 are evaluated against the AC established in LCO 3.2.2 [A.1.8]. To support the defense-in-depth role of this SR in detecting potential age-related degradation, both an increasing dose rate trend and an anomalous dose rate reading would be identifiable considering the accuracy of the survey instrumentation. DOE-ID will define "increasing" and "anomalous" dose rate limits as part of the survey procedure. If either condition is exceeded, then a cause analysis would be conducted in accordance with Section A1.7 in order to determine if the condition indicates age-related degradation to ITS SSCs or NITS SSCs that support a safety function. Commensurate with the condition, appropriate corrective actions would be implemented should the cause be due to age-related degradation.

Annual hydrogen monitoring surveys performed pursuant to SR 3.2.3.1 are evaluated against the AC established in LCO 3.2.3 [A.1.8]. To support the defense-in-depth role of this SR in detecting potential age-related degradation, both an increasing trend and an anomalous hydrogen concentration reading would be identifiable considering the accuracy of the hydrogen monitoring instrumentation. DOE-ID will define "increasing" and "anomalous" hydrogen concentration limits as part of the survey procedure. If hydrogen gas concentration shows an increasing trend in producible gas levels (e.g., hydrogen) or if an anomalous reading is measured, then corrective actions including a cause analysis would be conducted in accordance with Section A1.7 in order to determine if the condition indicates age-related degradation of ITS SSCs or NITS SSCs that support a safety function. Commensurate with the condition, appropriate corrective actions would be implemented should the cause be due to age-related degradation.

A1.7 CORRECTIVE ACTIONS

As revealed by the visual inspections of the DSC SSCs, if it is determined there are confirmed or suspected indications of corrosion or degradation, then identification of these items is entered into the DOE-ID NLF contractor deficiency tracking system, consistent with STI-NLF-QA-016 [A.1.13]. Should inspection AC be exceeded, the identified issues require further evaluation per STI-NLF-QA-016 [A.1.13], in order to comply with the requirements of 10 CFR Part 72, Subpart G [A.1.11]. This ensures timely resolution and implementation of potential mitigative actions, including root cause determinations and prevention of recurrence. In accordance with NUREG-1927, Section 3.6.1.7 [A.1.1], any specific corrective actions identified in this AMP are recommended guidelines that may be finalized as necessary via the corrective action program.

Additional engineering evaluations are performed to demonstrate that the DSC SSCs will remain able to perform their intended functions until the next inspection. 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 basis. In addition, detection of evidence of loss of material from localized corrosion (pitting or crevice corrosion) requires the expanded corrective action standard outlined in Section A1.7.1.

As detailed in Section A1.4.1, for Sheltered Environment SSCs, confirmed aging effects in accessible locations may require expanded remote visual inspections in inaccessible locations. This would apply to DSC SSCs that do not meet Section A1.6.1 VT-1 AC for indications of corrosion or other degradation, which could lead to the loss of intended functions. In addition, if there is a high potential for progressive degradation or propagation to occur at its present or accelerated rate, the disposition considers the more frequent DSC SSC inspections as stated in Section A1.5.1. The increased inspection frequencies would be in effect until reasonable assurance is attained that signs of deterioration will be adequately detected and appropriately addressed, and degradation limits comply with the AC, such that the DSC SSCs continue performing their intended functions. Such evaluations should not preclude initiation of repair planning, but should help to mitigate its necessity.

An extent of condition investigation may further trigger additional inspections, which may be via a different method, more selective or focused inspections, expanded inspection sample size, or a combination thereof. Extent of condition disposition is commensurate with in-service inspection results.

A1.7.1 Disposition of DSC SSCs with Localized Corrosion Aging Effects

As part of the corrective actions, confirmed identification of loss of material from localized corrosion (pitting or crevice corrosion) requires an expanded corrective action standard to determine the extent of condition. Using a graded approach, DSC SSCs with these aging effects are further evaluated for remediation actions.

Based on ASME BPVC, Section XI [A.1.18], the following process would apply for corrective actions on loss of material due to localized corrosion, such as pitting or crevice corrosion:

1. Additional information may be required to evaluate defects, depending on the nature of the defects observed. This may be necessary when visual examinations detect evidence of localized corrosion, including near degraded coating (See Section A2.6.3). The coating is removed from the affected areas to allow for this further examination allowing a determination of the extent and depth of possible flaw penetration. For macroscopic corrosion conditions, such as crevice corrosion or concentrated pitting, the extent and depth of the corrosion indications are measured in order to determine the SSCs material conditions.
2. DSC SSCs that show evidence of localized corrosion that exceeds the acceptance standards in IWB-3514.1, but meets the AC identified in IWB-3650, including the required evaluation per IWB-3651(a), using the prescribed evaluation procedures are inspected and evaluated at 5-year intervals, per Section A1.5.1. An increase in sample size should also be considered to assess candidate DSCs with similar susceptibility assessments, as determined from the selection criteria in Section A1.4.1. In addition, an engineering evaluation is conducted to assess the as-found condition for the remainder of the PEO, and the SSCs continued performance of their intended functions.
3. DSC SSCs that show evidence of localized corrosion that exceeds AC identified in IWB-3650 shall only be permitted to remain in service if an engineering analysis is conducted showing that the SSCs will continue to perform their intended functions for the remaining duration of the PEO, and its projected design basis corrosion allowance will not be exceeded. In addition, the DSC inspection frequency shall be increased to a minimum of 5-year intervals per Section A1.5.1, and the DSC sample size shall be increased to assess candidate DSCs with similar susceptibility assessments, as determined from the selection criteria in Section A1.4.1.
4. Dependent on degree of flaw, as evaluated as part of the corrective action program STI-NLF-QA-016 [A.1.13], any repairs conducted consider the repair standard outlined in ASME BPVC, Section XI, Article IWA-4000 [A.1.18].
5. Following the evaluation (and repair if required) of the underlying surface, the protective coating is reapplied.

A1.8 CONFIRMATION PROCESS

All mitigative actions resulting from items entered into the DOE-ID NLF contractor deficiency tracking system for tracking to resolution are implemented consistent with the ISFSI Management QA Program (STI-NLF-QA-020 [A.1.7]), in order to meet the requirements of 10 CFR Part 72, Subpart G [A.1.11]. As stated in Section A1.7, conditions adverse to quality noted during the inspection and monitoring activities are entered into the DOE-ID NLF Contractor Corrective Action Program STI-NLF-QA-016 [A.1.13]. Thus, the effectiveness is monitored via the corrective action program as an element of STI-NLF-QA-020, including provisions for timely evaluation of adverse conditions, and implementation of any corrective actions required, such as root cause evaluations and actions to prevent recurrence. Procedural controls are in place to ensure the responses to corrective action assignments are reviewed and to verify the response adequacy. Condition reports are also reviewed for trending purposes.

A1.9 ADMINISTRATIVE CONTROLS

The DSC AMP is subject to the ISFSI Management QA Program (STI-NLF-QA-020 [A.1.7]), QA procedures, review and approval processes, and administrative controls. In addition, effectuation of procedure STI-NLF-QA-010 [A.1.34] assures the DSC AMP inspections are planned, performed, and documented to meet the necessary QA requirements. This procedure is implemented in accordance with the requirements of 10 CFR Part 72 [A.1.11] and will be applicable during the PEO. Appendix A of STI-NLF-QA-020 provides additional control procedures that define AMP implementing conditions such as: visual examination processes, instrument calibration and maintenance, inspector requirements, record retention requirements, and document control.

A1.10 OPERATING EXPERIENCE

Relevant OE used to inform the DSC AMP is discussed in Section 3.2 of the LRA. The OE supports an assessment that the effects of aging are adequately managed, such that the DSC SSCs' intended functions are maintained during the PEO. The OE provides justification for the effectiveness of the DSC AMP program elements discussed herein.

Some of the OE highlights relative to the DSC AMP are as follows:

- As part of the IFSF corrosion-monitoring plan, Section 3.2.2.2.2 discusses corrosion rate monitoring activities of the IFSF corrosion coupons. The OE from this collocated facility provides invaluable data on the corrosion rates occurring for similar materials in a similar environment, implicitly supporting the elements described in the DSC AMP.
- Section 3.2.2.1.3 discusses corrosion hydrogen sampling at the FSV ISFSI, which corresponds to current hydrogen sampling at the TMI-2 ISFSI - indirectly indicative of corrosion rates for the DSC SSCs, which are evaluated and trended as part of the AMP criteria.
- Section 3.2.3.1 discusses a method for remote inspection, which was developed and used in the pre-application inspections of Section 3.2.3.1.1. This detection method provides an OE precedent for future DSC AMP inspections.
- Proposed elements of the DSC AMP, including AC, previous inspection findings and trending data from pre-application inspections are provided in Section 3.2.3.1.1.
- Section 3.2.4.2.2 discusses the VSC-24 (carbon steel confinement boundary) historical occurrences of adverse aging effects on the top lid closure welds. Even though these issues are not applicable to the NUHOMS®-12T DSC (as described in the OE), additional inspections of corresponding areas of the DSC are in part conducted on a more frequent basis as a result (i.e., 5 years instead of 10).
- Section 3.2.4.2.3 discusses the VSC-24 AMP elements equivalent to the DSC SSCs. The examination frequency of 10 years is equivalent to the normally non-accessible portions of DSC SSCs inspected in the DSC AMP. In addition, the VSC-24 examination also consists of VT-3 visual inspections, which are the same techniques and methodology used with the DSC AMP.
- Section 3.2.4.1 includes OE similarity in terms of the Standard NUHOMS® DSC AMP for the TMI-2 ISFSI DSC AMP. This includes similarities in terms of selection of SSCs for inspection and the AC against which the need for corrective action will be evaluated.

A1.10.1 Learning AMP

The DSC AMP is a "learning" AMP. This means that this AMP will be updated, as necessary, to incorporate new information on degradation due to aging effects identified from TMI-2 ISFSI inspection findings, related industry OE, and related industry research. Future TMI-2 ISFSI and industry OE is captured through a review process, following the regulatory framework in LR-ISG-2011-05 [A.1.30], considering OE regarding aging management and aging-related degradation. As indicated in Section 3.9, periodic tollgate assessments are the result of this learning AMP process.

This tollgate assessment includes ongoing review of both TMI-2 ISFSI-specific and industry OE. This process will continue on a routine basis throughout the PEO, to ensure that the DSC AMP continues to be effective in managing the identified aging effects. Reviews of OE via the tollgate process in the future may identify areas where the DSC AMP should be enhanced or new programs developed. If enhancements or new programs are identified during the review of OE, then the pertinent procedures for DSC AMP implementation are revised as necessary to address any lessons learned. The DOE-ID NLF contractor will maintain the effectiveness of this process under the ISFSI Management QA Program (STI-NLF-QA-020 [A.1.7]), QA procedures, review and approval processes, and administrative controls.

Table A-1: DSC AMP Inspection Table

SSCs	Environment	Number of SSCs	Frequency	Inspection Type	Trending	Acceptance Criteria	Corrective Actions
The DSC shell, and in particular: crevice locations (i.e., where the shell sits on the support rail); fabrication welds of the confinement boundary and the associated HAZ (i.e., longitudinal and circumferential welds on the cylindrical shell including coatings) – Normally Non-Accessible Areas	Sheltered	2 DSCs (DOE12T-002 and DOE12T-004)	Baseline AMP inspection to be performed no later than two years after the effective date of the renewed license, then at 10-year intervals (with a 2-year grace period)*	Remote Visual (IWA-2210, VT-3 Inspection)	Same DSCs, Frequency decreased to 5 ± 1 year if exceed AC or evidence of adverse steel degradation	VT-3: ASME Section XI, Subarticle IWB-3514.1 and Section 10.2 of ASTM D7167 for coatings with limits on blistering, cracking, flaking, rusting and physical damage. VT-1 (as required): ASME Section XI, Subarticle IWB-3514.1 and -No indications of pitting or crevice corrosion (localized corrosion); -No indications of galvanic corrosion as evidenced by red-orange corrosion products emanating from crevice locations (e.g., support rail plate-to-DSC shell interface); -No indications of corrosion products near crevices; -No indications of corrosion products on or adjacent to confinement boundary welds; -Section 10.2 of ASTM D7167 for coatings with limits on blistering, cracking, flaking, rusting, and physical damage	Step 1: Perform VT-1 inspection on flaw indications if the VT-3 AC is exceeded or if it is required based on prior inspection results and resulting corrective actions dispositioned per deficiency tracking system in STI-NLF-QA-016 (See AMP Section A1.7). Step 2A: If the VT-1 examination reveals a localized corrosion flaw exceeds the allowable flaw size in the IWB-3514.1 acceptance standards, then procedures in Section A1.7.1 are followed. Step 2B: If the VT-1 examination reveals coating degradation does not meet AC or VT-1 AC are exceeded (i.e., other VT-1 AC limits indicated), then procedures in Section A1.7 are followed. If aging effects are confirmed, this may include more frequent inspections and performing inspections in inaccessible locations.
DSC SSCs (Steel including Coatings) in rear of HSM including the Vent and Purge Port HEPA Filters and Housings, and Vent and Purge Port Filter Housing attachment fasteners and portions of Outer Top Cover plate, closure weld and HAZ – Accessible Areas	Sheltered	2 DSCs (DOE12T-002 and DOE12T-004)	5 Years – synchronized with SR 3.1.1.1 with Baseline AMP inspection occurring after the effective date of the renewed license	Direct Visual (IWA-2210, VT-3 Inspection)	Same surfaces every five years	VT-3: ASME Section XI, Subarticle IWB-3514.1 and Section 10.2 of ASTM D7167 for coatings with limits on blistering, cracking, flaking, rusting and physical damage. VT-1 (as required): ASME Section XI, Subarticle IWB-3514.1 and -No indications of pitting or crevice corrosion (localized corrosion); -No indications of galvanic corrosion as evidenced by red-orange corrosion products emanating from crevice locations (e.g., support rail plate-to-DSC shell interface); -No indications of corrosion products near crevices; -No indications of corrosion products on or adjacent to confinement boundary welds; -Section 10.2 of ASTM D7167 for coatings with limits on blistering, cracking, flaking, rusting, and physical damage	Step 1: Perform VT-1 inspection on flaw indications if the VT-3 AC is exceeded or if it is required based on prior inspection results and resulting corrective actions dispositioned per deficiency tracking system in STI-NLF-QA-016 (See AMP Section A1.7). Step 2A: If the VT-1 examination reveals a localized corrosion flaw exceeds the allowable flaw size in the IWB-3514.1 acceptance standards, then procedures in Section A1.7.1 are followed. Step 2B: If the VT-1 examination reveals coating degradation does not meet AC or VT-1 AC are exceeded (i.e., other VT-1 AC limits indicated), then procedures in Section A1.7 are followed. If aging effects are confirmed, this may include more frequent inspections and performing inspections in inaccessible locations.
DSC SSCs (Steel including Coatings) including on upper surface of the DSC shell (i.e., where atmospheric particulates would settle); Outer Bottom Cover plate, Grapple Ring Assembly plates, their welds and HAZs; Portions of the Outer Top Cover plate, HAZ and associated closure weld – Inaccessible Areas	Sheltered	As required per scheduled inspection findings and STI-NLF-QA-016 corrective actions	In accordance with Corrective Actions, AMP Section A1.7	Direct or Remote Visual or both	In accordance with Corrective Actions, AMP Section A1.7	Via the TMI-2 ISFSI corrective action program STI-NLF-QA-016, to ensure the aging effect is adequately managed and that the SSCs intended function is maintained during the PEO	Further evaluation and disposition per deficiency tracking provided by STI-NLF-QA-016 (See AMP Section A1.7), including more frequent inspections and if detection of evidence of loss of material from localized corrosion (pitting or crevice corrosion), the expanded corrective action standard outlined in Section A1.7.1.

* The interval "clock" starts as of the due date of the prior inspection. For example, if the ten-year inspection is due on 01/01/2025 and performed on 05/30/2026 (within the two-year grace period), the next inspection is still due on 01/01/2035 and must be performed no later than 01/01/2037.

APPENDIX A2: Horizontal Storage Module AMP

A2.1 PROGRAM SCOPE

This appendix describes the HSM AMP that is designed to monitor and control the degradation of the HSM SSCs of the TMI-2 ISFSI. The HSM AMP core inspection criteria are summarized in Table A-2. The HSM AMP provides reasonable assurance that potentially detrimental aging effects are adequately managed so that the HSM intended functions are maintained consistent with the design basis for the PEO. This ensures that no aging effects will result in a loss of intended function of the SSCs that are within the scope of renewal during the PEO. The AMP is based on the results of the AMR for the HSMs presented in Section 3.5. The following recommended HSM AMP is consistent with the 10 program elements described in NUREG-1927 [A.1.1] and outlined below.

The scope of the HSM AMP consists primarily of a visual inspection of HSM SSCs (including remote visual of HSM SSCs in the Sheltered Environment). Intended functions to be maintained are shown in Table 2-3. The AMP scope includes HSM SSCs shown in Table 3-4 with environments defined in Section 3.5.3 and materials defined in Section 3.5.2.

As identified in Section 3.5.4.6 and summarized in Table 3-5, the reinforced concrete HSM SSCs require management for the following aging effects:

- Loss of concrete through spalling and scaling from freeze-thaw cycles and shrinkage
- Concrete cracking from freeze-thaw cycles and shrinkage
- Reduction of concrete strength, modulus, and pH from leaching of calcium hydroxide
- Increase in concrete porosity and permeability from leaching of calcium hydroxide
- Loss of material of embedded components from corrosion

The HSM SSC concrete includes the cementitious grouting filler materials used during original fabrication and subsequent repairs. The concrete matrix is monitored such that the overall integrity of the continuous matrix is maintained. For the chemical grouting filler materials and sealants used during repairs, parameters monitored include the following aging effects identified in Section 3.5.4.6:

- Adhesive and cohesive failure of concrete repair chemical grout fillers and sealants from premature degradation, including UV exposure and irradiation

In addition, as a defense-in-depth aging management function, the silane water repellent coating on the concrete is included to assess for physical damage on the steel coatings and inhibition of moisture penetration and rebar corrosion on HSM SSCs.

As identified in Section 3.5.4.6 and summarized in Table 3-5, the in-scope steel HSM SSCs require management for the following aging effects:

- Loss of material due to corrosion (general, crevice, pitting)

In addition, as a defense-in-depth aging management function, the zinc-rich primer on the coated steel SSCs is included to assess loss of coating integrity due to blistering, cracking, flaking, peeling, or physical damage.

Periodic inspections are conducted by personnel qualified to monitor for the applicable aging effects, and may include those described in the ACI Standard 349.3R-02, "Evaluation of Existing Nuclear Safety-Related Concrete Structures" [A.1.2]; ACI 201.1R, "Guide for Making a Condition Survey of Concrete in Service" [A.1.3]; ASME BPVC, Section XI – "Rules for Inservice Inspection of Nuclear Power Plant Components" [A.1.35]; and ASTM D4537, "Standard Guide for Establishing Procedures to Qualify and Certify Personnel Performing Coating and Lining Work Inspection in Nuclear Facilities" [A.1.24]. As prescribed in 10 CFR 72.158 [A.1.11], qualifications under these programs and any other HSM AMP qualifications are documented in the DOE-ID NLF Contractor training and qualification program, consistent with STI-NLF-QA-002, "Personnel Training and Qualification" [A.1.32].

Inspections are segregated into internal and external inspection processes. The HSM SSCs within scope of the AMP are summarized from Table 3-5 as follows:

- Reinforced Concrete Base Module, Roof Slab, and End Shield Wall
- Concrete Reinforcement Steel for Base Module, Roof Slab, and End Shield Wall
- Embedment Assemblies (i.e., Rail Extension, Seismic Retainer, HSM Roof Slab to Base Module, Front DSC Support Structure Attachment, TC Restraint, End Shield Wall, Shield Door Attachment)
- Nuts and Bolts for attachment of the End Shield Wall/Shield Door/HEPA Filter Door
- Shield Door Assembly
- HEPA Filter Door Assembly
- Washer Plates for End Shield Wall, Shield Door, and Roof Protective Bolt Cover
- End Shield Wall Support Bolts/Nuts
- End Shield Wall Tie Plate and Embedded Attachment Bolt
- Nuts and bolts for attachment between Front DSC Support Structure Attachment Assembly and HSM
- DSC Support Structure Assemblies (i.e., Front and Rear Mounting Plates, Stiffener Plates, DSC Stop Plate, Support Rails, Beams)
- DSC Support Structure Attachment Assemblies
- Rear DSC Support Structure Lug Plate
- Seismic Retainer
- Roof Protective Bolt Cover and Roof Anchor Attachment Bolt & Nut
- Cementitious Grout for the End Shield Wall Panels, Roof Slab Lifting Strand Pockets, and Mounting Holes & Embedment Voids in the Base Module
- Sealant used for End Shield Wall Panel Lifting Strand Pockets
- Roof Slab Bolt Hole Foam Filler and Gasket
- Protective Steel and Concrete Coatings

A2.2 PREVENTIVE ACTIONS

The HSM AMP is a condition-monitoring program. Based on the condition of the SSCs being monitored, preventive actions are taken to maintain the SSCs such that they continue to perform their intended functions throughout the PEO. Preventive actions will include such things as concrete crack and spalling repairs and reapplication of protective coatings on degraded surfaces. Based on historical OE at the TMI-2 ISFSI, inspections of the Roof Protective Bolt Cover assemblies as described in Section A2.4.3 is a preventive action in order to preclude any future freeze-thaw cracking of concrete SSCs.

A2.3 PARAMETERS MONITORED OR INSPECTED

For each material/aging effect combination, the specific parameters monitored or inspected depend on the particular HSM SSC. Parameters monitored or inspected are commensurate with industry codes, standards, and guidelines and consider industry OE as well as TMI-2 ISFSI OE. ACI 349.3R-02 [A.1.2], ACI 201.1R [A.1.3], ASTM D7167 [A.1.20], Section XI of the ASME BPVC [A.1.18], and SEI/ASCE 11-99 [A.1.4] provide a basis for selection of parameters to be monitored or inspected for concrete and steel structural elements.

For concrete SSCs of the HSM, parameters monitored include those aging effects identified in Section 3.5.4.6:

- Loss of concrete through spalling and scaling from freeze-thaw cycles and shrinkage
- Concrete cracking from freeze-thaw cycles and shrinkage
- Reduction of concrete strength, modulus, and pH from leaching of calcium hydroxide
- Increase in concrete porosity and permeability from leaching of calcium hydroxide
- Loss of material of embedded components from corrosion

The HSM SSC concrete includes the cementitious grouting filler materials used during original fabrication and subsequent repairs. The concrete matrix is monitored such that the overall integrity of the continuous matrix is maintained. For the chemical grouting filler materials and sealants used during repairs, parameters monitored include the following aging effects identified in Section 3.5.4.6:

- Adhesive and cohesive failure of concrete repair chemical grout fillers and sealants from premature degradation, including UV exposure and irradiation

In addition, as a defense-in-depth aging management function, the silane water repellent coating on the concrete is included to assess for physical damage on the steel coatings and inhibition of moisture penetration and rebar corrosion on HSM SSCs.

For steel SSCs of the HSM, parameters monitored include those aging effects identified in Section 3.5.4.6. These aging effects on in-scope steel SSCs of the HSM include:

- Loss of material due to corrosion (general, crevice, pitting)

In addition, as a defense-in-depth aging management function, the zinc-rich primer on the coated steel SSCs is included to assess loss of coating integrity due to blistering, cracking, flaking, peeling, or physical damage.

As indicated in Section 3.5.4.4, failure of the steel and concrete SSC coatings will not prevent the SSCs from satisfactorily accomplishing their intended functions. Yet, it may disguise indications of corrosion of the underlying material for carbon steel SSCs. In addition, a water-repellent coating on the concrete SSCs affords a defense-in-depth function, providing long-term water repellency and inhibiting both moisture penetration and embedded steel corrosion. Therefore, as indicated in Section A2.2 for preventive purposes, this AMP will manage loss of coating integrity.

The above monitored aging effects are selected to ensure that aging degradation leading to loss of intended functions will be detected and the extent of degradation determined.

A2.4 DETECTION OF AGING EFFECTS

Visual inspections and concrete coating water repellent testing are performed per DOE-ID NLF contractor procedures. HSM exterior and interior inspections are consistent with industry guidelines for detecting, evaluating, and documenting aging effects (e.g., ACI 349.3R/Section 3.5.1 [A.1.2], ACI 224.1R [A.1.10], ACI 201.1R [A.1.3], Section XI of the ASME BPVC [A.1.18]).

A2.4.1 Selection of SSCs for Inspection

Performance of visual inspections for aging effects on HSM SSC surfaces in the Sheltered Environment is coordinated and synchronized with the frequency of inspections of DSC SSCs as specified in Section A1.5.1. As discussed in Section 3.2.2.2.4, the initial examination of the Sheltered Environment HSM SSCs was performed on HSM-16 and the Overpack HSM-15 in 2012. After entering the PEO, a substitute HSM is preselected in lieu of HSM-15 for the baseline and any subsequent inspections. Inspection of HSM-16 and the substitute HSM is intended to be consistent throughout the duration of the PEO. Selection criteria for the substitute HSM Sheltered Environment SSC inspections is based on a combination of factors which may include: the particular DSC choice selected in Section A1.4.1, fabrication history of the HSM SSCs, heat loading characteristics, and the specific HSM location within the ISFSI.

A desktop review of HSM documentation (e.g., design drawings, HSM fabrication packages) was considered for the substitute HSM selection indicated above, and is documented in EP-NLF-2017-001 [A.1.36]. Based on [A.1.36], the HSM slated for inspection is HSM-5. The predominant reason for this selection is the potential for aging degradation from the freeze-thaw cracking aging effect. Concrete cracks from freezing water in the Roof Slab bolt holes were rated on the severity levels in EDF-9897, Appendix D [A.1.37]. Inspection of a HSM with the highest level of severity is performed to ensure that no cracking is present in the corners adjacent to the Roof Slab bolt holes. Therefore, HSM-5, located in the south row is pre-selected for the substitute HSM Sheltered Environment SSC inspections.

Inspections of the Sheltered Environment HSM SSCs for the Roof Protective Bolt Cover assembly are conducted separately from those within the HSM interior. The SSCs of this assembly include the cover assemblies, roof attachment bolt and nut, washer plate, polyurethane gasket, and polyurethane filler foam, along with surrounding concrete surfaces. Due to the OE history of freeze/thaw cracking at the TMI-2 ISFSI and the unique polyurethane materials used for these SSCs (See Section 3.5.4.5), a minimum inspection standard for the normally non-accessible portions of the Roof Protective Bolt Cover assemblies is established. Since all 116 Roof Protective Bolt Cover assemblies were installed at the same time, with the same materials of construction, there is reasonable assurance that equivalent degradation would occur at each assembly location. Therefore, the sample size is limited to two assemblies per year, assuming no evidence of adverse concrete degradation.

Visual inspection for aging effects is performed on all accessible HSM SSCs in the Outdoor Environment, which is consistent with ACI 349.3R and current ISFSI operations previously committed to the NRC [A.1.6].

The AMR takes no credit for the prevention of aging affects by any coatings applied to carbon steel SSCs. However, although the steel coating is a NITS component, it is considered an integral part of the in-scope SSC to which it provides protection from corrosion; whether credited for that protection or not. Therefore, aging management is performed on steel coating failure to determine if it could adversely affect the intended function of the HSM zinc-coated steel SSCs.

Similarly, aging management of the silane water repellent coating integrity and functionality during the PEO provides continued protection of the underlying HSM concrete SSCs. A minimum of two areas on both a HSM vertical and horizontal surface, and minimum one vertical surface on a HSM End Shield Wall are tested as described in Section A2.4.3. The same locations on vertical and horizontal HSM concrete surfaces and vertical End Shield Walls are re-evaluated for water repellency in subsequent annual inspections.

The HSM AMP addresses detection of aging effects upon SSCs located in inaccessible areas indirectly, by monitoring the inspection findings in accessible areas. If aging effects are identified in accessible locations, further evaluation of the aging effects in inaccessible locations is conducted. Therefore, these inaccessible area inspections (See Table A-2) may only be necessitated because of the ISFSI corrective action program STI-NLF-QA-016 [A.1.13], in order to ensure the aging effect is adequately managed and that the SSCs' intended functions are maintained during the PEO. Such inaccessible areas would include the Seismic Retainer, backside of HSM Shield Door and HSM Shield Door opening.

A2.4.2 Data Collection

The HSM AMP methods for data acquisition and documentation, including an inspection report shall be conducted consistent with STI-NLF-QA-020 [A.1.7] and STI-NLF-QA-010 [A.1.34]. The recording of examination and test results provides a basis for evaluation and facilitates comparison with the results of subsequent examinations. Consideration of the data collection portion of the HSM AMP should be given to reporting criteria in ACI 349.3R/Section 3.5.5 [A.1.2], Section XI of the ASME BPVC [A.1.18] and ASTM D7167 [A.1.20]) for evaluating and documenting aging conditions. Specifically, ASTM D7167 provides "Reporting and Documentation" guidelines in Section 11 and includes a sample coating performance data checklist in Figure 1.

A2.4.3 Method

As appropriate, direct or remote visual inspections utilizing ACI 349.3R, Section 3.5.1 [A.1.2] are conducted for HSM Concrete SSCs in both the Sheltered and Outdoor Environments, allowing for detection of aging effects from Section A2.3. Consistent with Section 10 of ASTM D7167 [A.1.20] and Subsubarticle IWA-2210 of the ASME BPVC [A.1.18] on visual examination techniques, VT-3 direct or remote visual inspections are utilized for general inspections for HSM steel SSCs, depending upon whether the SSCs are accessible or normally non-accessible, respectively. VT-3 visual examinations are performed for steel surfaces, detecting aging effects from Section A2.3, while identifying and assessing discontinuities and imperfections on the surface of components. As much of the HSM steel SSC surfaces as can be accessed is examined by VT-3 to ascertain their general condition. In addition, two roof protective bolt cover assemblies are disassembled and a direct VT-3 visual inspection is performed on the steel SSCs, with the remaining SSCs inspected in accordance with ACI 349.3R, Section 3.5.1.

Inspection of the normally non-accessible interior surfaces of concrete SSCs may be performed using a video camera, fiber-optic scope, or other remote inspection technology via existing access points of the HSM, such as the drainage outlet or HEPA filter access door. The remote inspection system is qualified and demonstrated to have sufficient resolution capability and enhanced lighting to resolve the AC identified in Section A2.6.2.

For HSM concrete SSCs, crack maps with a photographic record and physical dimensions are developed (using ACI 224.1R guidance [A.1.10]), monitored, and trended as a means of identifying progressive growth of defects that may indicate degradation due to specific aging effects, such as freeze-thaw or rebar corrosion. Crack maps and photographic records are compared with those from previous inspections to identify accelerated degradation of SSCs during the PEO. Similarly, dimensioning is documented in photographic records by inclusion of a tape measure/crack gauge, a crack comparator, or both.

For HSM SSCs in inaccessible areas, various remote visual inspection technologies may include inserting remote PTZ cameras or fiber optics through the approximate 1-in. radial gap between the DSC outer radius and the HSM interior OD at the back end (i.e., 67.19-in. DSC OD versus 69.25-in. HSM opening). Optionally, direct inspections may be performed through a partially removed Shield Door by mounting a camera on a pole. Such a method is consistent with inspections performed during Calvert Cliffs baseline inspections [A.1.5]. Preliminary detection of potential adverse aging effect locations and confirmation of inspection modes/methods in these normally inaccessible areas may also be attained by evaluations of the Overpack HSM-15. Preliminary inspection dry runs using a spare HSM are consistent with using an empty HSM for inspections conducted at Calvert Cliffs (a site-specific NUHOMS® system) [A.1.5].

For the water repellency tests on HSM concrete surfaces, testing protocol uses a RILEM Tube Test as previously recommended by the coating manufacturer [A.1.14]. RILEM Test Method II.4 [A.1.15] provides a means for measuring the rate at which water moves through the concrete surface [A.1.16]. The RILEM Tube Test method is justified over the spray bottle method previously used (See Section 3.2.3.2.2), as water beading on a surface does not correlate with actual absorption (except immediately after treatment). This is because water may not absorb into a concrete substrate that exhibits surface beading [A.1.16].

A2.5 MONITORING AND TRENDING

Monitoring and trending is conducted consistent with DOE-ID NLF Contractor Corrective Action Program STI-NLF-QA-016 [A.1.13], which includes provisions of the DOE-ID NLF contractor's 10 CFR Part 72, Subpart G [A.1.11] program. Conditions adverse to quality noted during the inspection and monitoring activities, such as non-conformances, failures, malfunctions, deficiencies, or deviations are entered into the corrective action program. Visual examinations appropriately consider cumulative OE from previous inspections and assessments in order to monitor and trend the progression of aging effects over time. STI-NLF-QA-016 includes trending of adverse conditions as well as a process to prevent recurrence. Consistent with STI-NLF-QA-016, any degradation warranting further evaluation and potential mitigative action is addressed using the DOE-ID NLF contractor deficiency tracking system, ensuring timely resolution and implementation of potential mitigative actions. This monitoring and trending process applies to all inspections performed (including internal and external) and allows for the monitoring of aging effects over time, ensuring the ability of the HSM SSCs to perform their intended functions during the PEO. Regarding inspections, Section A2.5.1 describes the process for identifying frequency and type.

A2.5.1 Frequency and Timing of Inspections

Regarding the remote visual inspection frequency on HSM SSCs in normally non-accessible areas, performance of baseline AMP inspections occurs no later than two years after PEO commencement, with follow-on inspections at a 10 ± 2-year interval based on timing and results of preceding inspections. Therefore, the standard inspection frequency for HSM SSCs is at intervals of 10 ± 2 years. Timing for the HSM remote visual inspections may be synchronized with DSC inspections from the DSC AMP, as outlined in Section A1.5.1. If preceding inspection AC has been exceeded and it is unclear what the trend from previous inspections indicates, the interval between Sheltered Environment HSM SSC inspections is decreased to 5 ± 1 year. These inspection frequencies would allow the inspections to be spaced out instead of performing two inspections in the same year. The justification for this interval is to reduce workload at the TMI-2 ISFSI, as an additional HSM is included in the inspection from the outset and not because of any adverse findings or applicable OE. The inspection interval of 10 years is consistent with ASME, BPVC Section XI, Subsubarticle IWA-2430 optional inspection program B (Paragraph IWA-2432) [A.1.18]. The ± 2 years is provided for DOE-ID NLF contractor's inspection planning and potential limited availability of vendor remote NDE equipment.

In the case of HSM-16, the first inspection upon entering the PEO ascertains the condition of these Sheltered Environment HSM SSCs (i.e., baseline). Also, for the chosen Sheltered Environment SSC inspection of HSM-5 discussed in Section A2.4.1, the initial baseline inspection establishes the initial condition of those SSCs. For trending purposes, the conditions of the HSM SSCs observed in subsequent inspections are compared with these baseline conditions of the HSM SSCs. Depending on significance, a more focused, selective inspection (VT-1 level visual inspection as described in Section A2.6.2 on HSM Steel SSCs) may be required to determine the extent of condition, and determine if more frequent monitoring or inspection is required.

For the HSM SSCs in the Outdoor Environment, the pre-application visual inspections were performed in 2012 [A.1.14] after the concrete repairs were completed in 2011 (See Section 3.2.3.2.1). Since 2012, these inspections occurred on an annual basis, establishing the condition of the Outdoor Environment HSM SSCs at the beginning of the PEO. During these annual inspections, no deleterious aging effects have been observed since repairs were made in 2011. The 2016 inspection (See Section 3.2.3.2.2) showed no deleterious aging effects (except for spalling at the base of the end shield walls) and no active degradation based on conditions from the 2015 inspections. As such, this establishes the state of the SSCs upon entering the PEO. Therefore, a 5-year inspection interval on these HSM SSCs is justified during the PEO, which is consistent with ACI 349.3R, Table 6-1 [A.1.2]. A 1-year grace period is provided for on the 5-year inspection interval (see Table A-2). Depending on significance at these 5-year inspections, an evaluation on a case-by-case basis, using a graded approach may address specific areas of concern warranting further evaluation or increased inspection intervals. The baseline inspection for the HSM SSCs in the Outdoor Environment shall be conducted within the first two years of the license renewal effective date. For trending purposes upon entering the PEO, the conditions of the HSM SSCs observed in subsequent inspections are compared with this initial condition of the Outdoor Environment HSM SSCs established during this first baseline inspection.

The durability of the water repellent silane coating on the HSM concrete is evaluated over the PEO. As discussed in Section A2.4.1, the same concrete surface areas of RILEM testing are repeated on an annual basis to trend the ability of the coating to repel moisture (with a 3-month grace period) (see Table A-2). This frequency is justified, because silane sealer molecules are very small, typically resulting in low coverage rates. In order to achieve protection benefits, the concrete surface needs to be heavily saturated with sealer or the sealer must be applied multiple times with a high-solid silane sealant. It is unclear of the extent of previous sealant coverages and their efficacy, including that of the sealer applied in 2011. Therefore, routine testing, with comparison to results from successive tests, provides an indication whether treatments are still effective [A.1.16]. The baseline inspection for the HSM's silane coating shall be conducted within the first year of the license renewal effective date.

Due to the history of freeze-thaw cracking and the unique materials used (See Section 3.5.4.5), the normally non-accessible Sheltered Environment Protective Bolt Cover assemblies are routinely inspected. Two discrete Roof Protective Bolt assemblies are selected each year for the first 5 years for inspection. For trending purposes, in the sixth year, inspection of the first set is repeated. For the remainder of the PEO, the five sets of assemblies are inspected on a rolling five-year cycle; one set per year repeating once every 5 years. The baseline inspection for the first set of Roof Protective Bolt Cover assemblies shall be conducted within the first year of the license renewal effective date, with the 2nd, 3rd, 4th, and 5th set baseline inspections occurring in the subsequent years. If aging degradation of the limited samples were to exceed the Section A2.6 AC, then increased sampling size or other corrective action (in accordance with STI-NLF-QA-016 [A.1.13]) assesses the extent of condition. A record of the assemblies inspected is retained and used for trending and data evaluation. A grace period of 3 months may be applied for the due date of each baseline and AMP inspection (see Table A-2).

Performance of visual inspections on the coated HSM steel SSC surfaces is synchronized with inspections of HSM SSCs as specified previously in this section, ensuring that the intended functions of the protected SSCs are maintained during the PEO.

A2.6 ACCEPTANCE CRITERIA

The HSM AMP for external and internal surfaces calls for inspection results to be evaluated by qualified engineering personnel based on AC selected for each SSC. This ensures that the need for corrective actions is identified before loss of intended function occurs. The criteria are derived from design basis codes and standards that include ACI 349.3R [A.1.2], ASME BPVC [A.1.18], SEI/ASCE 11-99 [A.1.4], and consider industry and facility OE (Section A2.10). The criteria are directed at the identification and evaluation of degradation that may affect the ability of the HSM SSCs to perform their intended functions. Should inspection AC be exceeded, the identified issue requires further evaluation and is entered into the corrective action program, STI-NLF-QA-016 [A.1.13].

Loose or cracked attachment hardware (e.g., bolts, nuts, etc.), including loose Roof Protective Bolt Covers are not acceptable unless approved by engineering evaluation.

A2.6.1 HSM Concrete

Inspection and evaluation personnel specified in Chapter 7 of ACI 349.3R [A.1.2] are judged acceptable qualifications of HSM concrete and concrete reinforcement for evaluations to the AC identified below. Consistent with Section 3.5.1 of ACI 349.3R, visual examination techniques as specified therein are utilized for general inspections for HSM concrete SSCs. Chapter 5 of ACI 349.3R specifies criteria for acceptance of HSM concrete SSCs as: "Acceptance without further evaluation" (termed first-tier criteria), "Acceptance after review" (termed second-tier criteria), and "Conditions requiring further evaluation" (degradations exceeding second-tier criteria). Degradation acceptance limits are specified by second-tier criteria. Second-tier criteria signify that an SSC may contain "inactive degradation" and remains able to perform its intended function until the next inspection or repair activity. Second-tier AC represent condition limits for observed degradation that has been determined to be inactive. Inactive degradation is determined by the quantitative comparison of current observed conditions with that of prior inspections (See Section A2.5). For concrete fillers including chemical grouts, second-tier acceptance criterion includes conditions in Section 5.2.4 of ACI 349.3R. These consist of lack of any signs of separation within the filler or between the filler and the substrate or any other signs of water leakage or environmental attack, such that the intended functions of the HSM concrete matrix are maintained. Degradations exceeding second-tier criteria are entered into the DOE-ID NLF contractor deficiency tracking system, consistent with STI-NLF-QA-016 [A.1.13] to ensure timely resolution and implementation of potential mitigative actions.

A2.6.2 HSM Steel Components

SEI/ASCE 11-99 [A.1.4], Section 4.3, identifies some causes of structural steel deterioration. Inspections are directed at the identification and evaluation of degradation that may affect the ability of the HSM steel SSCs from satisfactorily performing their intended functions. Training, qualification, and certification of inspectors are consistent with the provisions of Section XI, Subarticle IWA-2300 of the ASME BPVC [A.1.35]. In addition, consistent with Article VI-4000 of Section XI of the ASME BPVC [A.1.35], for welded steel structural connections, AWS certified welding inspectors or AWS certified associate welding inspectors are required for visual examinations. As indicated in Section A2.1, these qualifications are documented in the DOE-ID NLF Contractor training and qualification program.

Consistent with Subsubarticle IWA-2210 of the ASME BPVC on visual examination techniques, VT-3 inspections in accordance with IWF-3400 are utilized for general inspections for HSM steel SSCs. Consistent with the DOE-ID NLF contractor inspection procedures and via an engineering evaluation, the VT-3 inspection provides evidence of an indication (i.e., flaw) in the base metal as defined by any of the following:

- Corrosion and material wastage (loss of material)
- Crevice and pitting corrosion (loss of material)
- Worn, flaking, or oxide-coated surfaces (loss of material)
- Corrosion stains on adjacent components and structures (loss of material)
- Stains caused by leaking rainwater

If any of the above items are identified by the VT-3 inspection, all identified items are to be considered as exceeding second tier-criteria (ACI 349.3R [A.1.2]), requiring further evaluation through the DOE-ID NLF Contractor Corrective Action Program, STI-NLF-QA-016 [A.1.13]. This may include performing a more detailed VT-1 visual examination of the flaws. Standards for visual inspection evaluations, including flaw characterization are provided on HSM steel SSCs, by Section XI, Article IWF-3000, and Subarticle IWA-3100 of the ASME BPVC. As revealed by the visual inspections, if the HSM SSCs are determined to contain confirmed or suspected indications of corrosion or degradation, then identification of these items is entered into the DOE-ID NLF contractor deficiency tracking system, per STI-NLF-QA-016, ensuring timely resolution and implementation of potential mitigative actions. Mitigative corrective actions are identified in Section A2.7.

A2.6.3 Coatings

ASTM D5144 [A.1.31] provides a standard guide for use of protective coating standards in nuclear power plants, and is used to develop DOE-ID NLF Contractor procedures for conducting coating inspections. Personnel performing inspections of coating systems should be knowledgeable personnel, with consideration given to meeting the criteria of ASTM D4537 [A.1.24]. These qualifications are documented in the DOE-ID NLF Contractor training and qualification program. Using the general AC below, against which the need for corrective action will be evaluated, the coating inspector evaluates the coating to ensure that the intended functions of the protected SSC are maintained during the PEO.

For the HSM concrete silane water repellent coating discussed in Section A2.4.3, performance is as outlined in the RILEM water penetration test (outlined in [A.1.15] and [A.1.16]) and is considered acceptable when water absorption is reduced by 80% or more [A.1.17]. Less than an 80% water repellency acceptance criterion is considered as exceeding second tier-criteria (ACI 349.3R [A.1.2]) that requires further evaluation.

Steel coating AC are established consistent with Section 10.2 of ASTM D7167 [A.1.20]. Coatings are evaluated for their degree of: flaking (peeling or delamination), blistering, cracking, rusting, and physical damage. ASTM D4538 [A.1.21] and EPRI 1019157 [A.1.22] provide standard definitions of degradation mechanisms.

AC limits are as follows:

- Blistering: formation of bubbles in the coating (reference ASTM D714 [A.1.25])
- Cracking: formation of breaks in the coating that extend through to the underlying base metal
- Flaking or Scaling: detachment of pieces of the coating from itself (i.e., delamination) or the base metal (i.e., peeling) (reference ASTM D772 [A.1.23])
    - Peeling: separation of one or more coats or layers of the coating from the base metal
    - Delamination: separation of one coat or layer from another coat or layer or from the base metal
- Rusting: corrosion that occurs when the applied coating thickness is insufficient to completely or adequately cover steel surfaces (See paragraph below)
- Physical Damage: removal or reduction of thickness of coating by mechanical damage

Any of above identified items are to be considered as exceeding second tier-criteria (ACI 349.3R [A.1.2]), requiring further evaluation. In addition to determining the source of the coating degradation, noted degradation shall be trended and entered into the DOE-ID NLF contractor deficiency tracking system, consistent with STI-NLF-QA-016 [A.1.13], ensuring timely resolution and implementation of potential mitigative actions.

As stated in the CoC 1004 LRA [A.1.26], application of ASTM D610 [A.1.19] is one acceptable method for characterizing and quantifying the amount of corrosion products (rust) present on a painted steel surface. This standard covers the evaluation of the degree of rusting (spot rusting, general rusting, pinpoint rusting, and hybrid rusting), using visual standards and descriptions of 11 rust grades (Grade 0 to Grade 10). In this method, Rust Grade 10 corresponds to no rust or less than 0.01% of surface rusted, Rust Grade 4 corresponds to rusting greater than 3% to the extent of 10% of surface rusted, and Rust Grade 2 corresponds to approximately 33% of surface rusted. Except if shown unacceptable for the underlying SSCs intended functions, then for any type of rust distribution, Rust Grade 4 is an acceptable limit for coated SSCs in the Sheltered Environment, while Grade 2 is an acceptable limit for coated SSCs in the Outdoor Environment. These AC limits are meant to enhance the inspection when assessing for rusting conditions, and based on the qualified inspector's evaluation may be further limited, in order to ensure the intended function of the protected SSC is maintained during the PEO. As discussed in Section A2.7, conditions exceeding the AC are noted and tracked per STI-NLF-QA-016 [A.1.13], and timely resolutions and implementation of potential mitigative actions taken. As a result, a lesser grade rusting condition may be deemed acceptable, such that the intended function of the underlying SSC is maintained during the PEO.

A2.7 CORRECTIVE ACTIONS

Should inspection AC be exceeded, the identified issue requires further evaluation and is entered into the corrective action program STI-NLF-QA-016 [A.1.13], in order to comply with the requirements of 10 CFR Part 72, Subpart G [A.1.11]. This ensures that conditions adverse to quality are promptly identified and resolved, including root cause determinations and prevention of recurrence. 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 the current licensing basis. In accordance with NUREG-1927, Section 3.6.1.7 [A.1.1], any specific corrective actions identified in this AMP are recommended guidelines that may be finalized as necessary via the corrective action program.

In conjunction with the monitoring and inspection frequency escalations from Section A2.5.1, if there is a high potential for progressive degradation or propagation to occur at its present or accelerated rate, then the disposition should consider more frequent or selective inspections of specific SSCs of interest. In addition, as detailed in Section A2.4.1, for Sheltered Environment SSCs, confirmed aging effects in accessible locations requires expanded remote visual inspections in inaccessible locations. Inspections that are more frequent would be in effect until reasonable assurance is attained that signs of deterioration are adequately detected and appropriately addressed, and degradation limits comply with the AC, such that the HSM SSCs continue performing their intended functions. Such evaluations should not preclude initiation of repair planning, but should help to mitigate its necessity. An extent of condition investigation may further trigger additional inspections, which may be via a different method, more selective or focused inspections, expanded inspection sample size, or a combination thereof. Extent of condition disposition is commensurate with in-service inspection results.

Repair, rehabilitation, or corrective action of an unacceptable condition should be performed consistent with DOE-ID NLF contractor repair procedures, as developed via appropriate rehabilitation standards such as: ACI 224.1R [A.1.10], ACI 546.3R [A.1.27], ACI 364.1R [A.1.28] and ACI 562 [A.1.29] and Article IWA-4000 of ASME BPVC [A.1.18].

In accordance with Section A2.6.1, concrete conditions exceeding second tier criteria require further evaluation. This is the approach of Section 5.3 of [A.1.2] regarding exceeding second tier degradation conditions. This evaluation is conducted in order to have the HSM concrete's structural and functional integrity characterized and assessed in the areas of degradation. This evaluation makes a comparison with the as-found condition, determines the need for further testing regimes, and ascertains potential root causes of the degradation. DOE-ID is pre-defining this approach and making a further refinement, in order to have the degradation initially verified that ASR is not an initiating factor in its apparent or root cause.

In addition, for the HSM concrete water repellent silane coating, if AC identified in Section A2.6.3 are exceeded or adverse trending necessitates (e.g., microcrack monitoring indicates increasing crack dimensions), then the water repellent is re-applied and retesting of the water repellency using the RILEM test methodology follows the reapplication.

A2.8 CONFIRMATION PROCESS

All mitigative actions resulting from items entered into the DOE-ID NLF contractor deficiency tracking system for tracking to resolution are implemented consistent with the ISFSI Management QA Program (STI-NLF-QA-020 [A.1.7]), in order to meet the requirements of 10 CFR Part 72, Subpart G [A.1.11]. As stated in Section A2.7, conditions adverse to quality noted during the inspection and monitoring activities are entered into the DOE-ID NLF Contractor Corrective Action Program STI-NLF-QA-016 [A.1.13]. Thus, the effectiveness is monitored via the corrective action program as an element of STI-NLF-QA-020, including provisions for timely evaluation of adverse conditions, and implementation of any corrective actions required, such as root cause evaluations and actions to prevent recurrence. Procedural controls are in place to ensure the responses to corrective action assignments are reviewed and to verify the response adequacy. Condition reports are also reviewed for trending purposes.

A2.9 ADMINISTRATIVE CONTROLS

The HSM AMP is subject to the ISFSI Management QA Program (STI-NLF-QA-020 [A.1.7]), QA procedures, review and approval processes, and administrative controls. In addition, effectuation of procedure STI-NLF-QA-010 [A.1.34] assures the DSC AMP inspections are planned, performed, and documented to meet the necessary QA requirements. This procedure is implemented in accordance with the requirements of 10 CFR Part 72 [A.1.11] and will be applicable during the PEO. Appendix A of STI-NLF-QA-020 provides additional control procedures that define AMP implementing conditions such as: visual examination processes, instrument calibration and maintenance, inspector requirements, record retention requirements, and document control.

A2.10 OPERATING EXPERIENCE

Relevant OE used to inform the HSM AMP is discussed in Section 3.2 of the LRA. The OE supports an assessment that the effects of aging are adequately managed, such that the HSM SSCs intended functions are maintained during the PEO. The OE provides justification for the effectiveness of the HSM AMP program elements discussed herein.

Some of the OE highlights relative to the HSM AMP are as follows:

- Section 3.2.2.2.2 discusses the corrosion rate monitoring activities conducted at the IFSF, including on the corrosion coupons. The OE from this collocated facility provides invaluable data on the corrosion rates occurring for similar materials in a similar environment, implicitly supporting the elements described in the HSM AMP for the DSC Support Structure SSCs and other metallic SSCs.
- Section 3.2.2.1 provides AMAs for the FSV ISFSI, which has relevance to the HSM AMP for the TMI-2 ISFSI, and provides justification for the effectiveness of the AMP program elements.
- Section 3.2.2.1.4 discusses concrete monitoring activities occurring at the FSV ISFSI, which corresponds directly to the current HSM concrete monitoring.
- In addition, Section 3.2.2.1.4 discusses FSV ISFSI similarities in terms of AC for concrete conditions and training and qualification programs for inspectors, along with similarities in terms of inspection frequencies, which are in-place for the TMI-2 ISFSI and the HSM AMP.
- Section 3.2.3.1 discusses a method for remote inspection, which was developed and used in the pre-application inspections of Section 3.2.3.1.1. This detection method provides an OE precedent for future HSM AMP inspections of the DSC Support Structure and HSM interior SSC surfaces.
- Section 3.2.3.1.1 provides proposed elements of the HSM AMP, including AC, previous inspection findings, and trending data from pre-application inspections on the Sheltered Environment DSC Support Structure and HSM interior SSC surfaces.
- Proposed elements of the HSM AMP, including AC, previous inspection findings and trending data from pre-application, and follow-on annual inspections on the Outdoor Environment HSM exterior SSC surfaces, are provided in Sections 3.2.3.2.2 and 3.2.3.2.3.
- Section 3.2.4.1 discusses other NUHOMS® based systems OE, including historical occurrences of adverse aging effects on like SSCs. Such OE provides valuable insight used for informing AC selection (ACI 224.2R; ACI 349.3R, Chapter 5 acceptance standards).
- NRC Information Notice 2013-07 [A.1.33] in Section 3.2.4.3 informed visual inspection criteria selection for the HSM AMP, addressing water intrusion and damage.

A2.10.1 LEARNING AMP

The HSM AMP is a "learning" AMP. This means that this AMP will be updated, as necessary, to incorporate new information on degradation due to aging effects identified from TMI-2 ISFSI inspection findings, related industry OE, and related industry research. Future TMI-2 ISFSI and industry OE is captured through a review process, following the regulatory framework in LR-ISG-2011-05 [A.1.30], considering OE regarding aging management and aging-related degradation. As indicated in Section 3.9, periodic tollgate assessments are the result of this learning AMP process.

This tollgate assessment includes ongoing review of both TMI-2 ISFSI-specific and industry OE. This process will continue on a routine basis throughout the PEO, to ensure that the HSM AMP continues to be effective in managing the identified aging effects. Reviews of OE via the tollgate process in the future may identify areas where the HSM AMP should be enhanced or new programs developed. If enhancements or new programs are identified during the review of OE, then the pertinent procedures for HSM AMP implementation are revised as necessary to address any lessons learned. The DOE-ID NLF contractor will maintain the effectiveness of this process under the ISFSI Management QA Program Plan (STI-NLF-QA-020 [A.1.7]), QA procedures, review and approval processes, and administrative controls.

Table A-2: HSM AMP Inspection Table

SSCs	Environment	Number of SSCs	Frequency	Inspection Type	Trending	Acceptance Criteria	Corrective Actions
HSM SSCs (Concrete including Fillers/Sealants) – Normally accessible areas	Outdoor	All 29 HSMs	Baseline AMP inspection to be performed no later than two years after the license renewal effective date, and at 5-year intervals thereafter (with a 1-year grace period)*	Direct Visual (ACI 349.3R, Section 3.5.1)	All HSMs	ACI 349.3R – Second Tier (including Section 5.2.4 for Sealants, Chemical Grouts)	Disposition per deficiency tracking system in STI-NLF-QA-016 (See AMP Section A2.7). For any concrete conditions exceeding 2nd tier criteria, a technical evaluation of degradation assessing whether ASR is an apparent or root cause.
HSM SSCs (Steel including Coatings) – Normally accessible areas	Outdoor	All 29 HSMs	Baseline AMP inspection to be performed no later than two years after the license renewal effective date, and at 5-year intervals thereafter (with a 1-year grace period)*	Direct Visual (IWA-2210, VT-3 Inspection on Steel Hardware)	All HSMs	VT-3: ASME Section XI, Subarticle IWF-3400 and Section 10.2 of ASTM D7167 for coatings with limits on blistering, cracking, flaking, rusting and physical damage and with flaws defined by any of the following: -Corrosion and material wastage (loss of material) -Crevice and pitting corrosion (loss of material) -Worn, flaking, or oxide-coated surfaces (loss of material) -Corrosion stains on adjacent components and structures (loss of material) -Stains caused by leaking rainwater	Disposition per deficiency tracking system in STI-NLF-QA-016 (See AMP Section A2.7), including a more detailed VT-1 visual examination of flaws identified
HSM SSCs (Silane Coating)	Outdoor	Two Areas on two HSMs (1 Vertical and 1 Horizontal Surface) and 1 vertical surface on HSM End Shield Wall	Baseline AMP inspection to be performed no later than 1 year after the license renewal effective date, and at 1-year intervals thereafter (with a 3-month grace period)*	RILEM Tube Test (Test Method II.4)	Same surfaces each year	ACI 349.3R – Second Tier (≥ 80% water repellency)	Reapply water repellent coating and re-test water repellency using RILEM Tube Test (Test Method II.4)
HSM SSCs – Normally non-accessible (Protective Bolt Covers and Polyurethane Gasket and Filler and surrounding concrete, Attachment Bolt, Nut and Washer Plate)	Sheltered	Two Bolt Cover Assemblies – If no evidence of adverse concrete degradation	Baseline AMP inspection on the first set of Roof Protective Bolt Cover assemblies are to be performed within the first year after the license renewal effective date. The 2nd, 3rd, 4th, and 5th sets of baseline inspections are due in the subsequent 1-year intervals. A grace period of 3 months may be applied for the due date of each baseline and AMP inspection*	Direct Visual (IWA-2210, VT-3 Inspection on Steel Hardware) with Direct Visual on remaining SSCs (ACI 349.3R, Section 3.5.1)	New set of Two Each Year on Rolling Five Year Basis (i.e., Repeat Set One on Year 6, Set Two on Year 7, etc.)	ACI 349.3R – Second Tier (including Section 5.2.4 for Polyurethane components) For steel components, VT-3: ASME Section XI, Subarticle IWF-3400 and as applicable Section 10.2 of ASTM D7167 for coatings with limits on blistering, cracking, flaking, rusting and physical damage and with flaws defined by any of the following: -Corrosion and material wastage (loss of material) -Crevice and pitting corrosion (loss of material) -Worn, flaking, or oxide-coated surfaces (loss of material) -Corrosion stains on adjacent components and structures (loss of material) -Stains caused by leaking rainwater	Disposition per deficiency tracking system in STI-NLF-QA-016 (See AMP Section A2.7), including for steel components a more detailed VT-1 visual examination of flaws identified. For any concrete conditions exceeding 2nd tier criteria, a technical evaluation of degradation assessing whether ASR is an apparent or root cause.
HSM SSCs (Concrete) – Normally non-accessible areas	Sheltered	2 HSMs (HSM-16 and HSM-5)	Baseline AMP inspection to be performed no later than two years after the license renewal effective date, then at 10 year intervals thereafter, with a 2-year grace period*	Remote Visual (ACI 349.3R, Section 3.5.1)	Same HSMs, decreased to 5 ± 1 year if exceed AC or evidence of adverse concrete degradation	ACI 349.3R – Second Tier	Disposition per deficiency tracking system in STI-NLF-QA-016 (See AMP Section A2.7), including if aging effects are confirmed, it may warrant more frequent inspections or performing inspections in inaccessible locations. For any concrete conditions exceeding 2nd tier criteria, a technical evaluation of degradation assessing whether ASR is an apparent or root cause.
HSM SSCs (Steel including Coatings) – Normally non-accessible areas	Sheltered	2 HSMs (HSM-16 and HSM-5)	Baseline AMP inspection to be performed no later than two years after the license renewal effective date, then at 10 year intervals thereafter, with a 2-year grace period*	Remote Visual (IWA-2210, VT-3 Inspection on Steel Hardware)	Same HSMs, decreased to 5 ± 1 year if exceed AC or evidence of adverse steel degradation	Article IWF-3000 and Subarticle IWA-3100 (Section 10.2 of ASTM D7167 for coatings with limits on blistering, cracking, flaking, rusting and physical damage)	Disposition per deficiency tracking provided by STI-NLF-QA-016 (See AMP Section A2.7) including if aging effects are confirmed, it may warrant more frequent inspections or performing inspections in inaccessible locations
HSM SSCs – Inaccessible Areas including the Seismic Retainer, backside of HSM Shield Door and HSM Shield Door opening	Sheltered	As required per scheduled inspection findings and STI-NLF-QA-016 corrective actions	In accordance with Corrective Actions, AMP Section A2.7	Direct or Remote Visual or both	In accordance with Corrective Actions, AMP Section A2.7	Via the TMI-2 ISFSI corrective action program STI-NLF-QA-016 to ensure the aging effect is adequately managed and that the SSCs intended function is maintained during the PEO	Further evaluation and disposition per deficiency tracking provided by STI-NLF-QA-016 (See AMP Section A2.7), including more frequent inspections.

* The interval "clock" starts as of the prior inspection due date. For example, if a 5-year inspection is due on 01/01/2025 and performed on 05/30/2025 (within the 1-year grace period), the next inspection is still due on 01/01/2030 and must be performed no later than 01/01/2031.

APPENDIX A3: Transfer Cask Aging Management

The TMI-2 ISFSI UFSAR describes the use of a TC to move DSCs into and out of the HSMs. Thus, the TC is required to retrieve a DSC and is in-scope for aging management under the renewed TMI-2 ISFSI license, as described in Chapter 2 of this LRA. DOE-ID does not possess an authorized design basis TC associated with the TMI-2 ISFSI license at the INL Site. In addition, as stated in Chapter 2, DOE-ID has proposed new license condition 20 prohibiting use of an MP187 TC aged greater than 20 years at the TMI-2 ISFSI. On the other hand, for an OS197 TC aged greater than 20 years, DOE-ID incorporates by reference (IBR) the portions of renewed Standardized NUHOMS® CoC 1004 pertaining to the OS197 TC, as identified in the Standardized NUHOMS® UFSAR [A.1.38] and LRA [A.1.26]. These references document the NUREG-1927 [A.1.1] OS197 TC scoping evaluation, aging management review (AMR), time-limited aging analyses (TLAAs), and aging management programs (AMP). The AMR and TLAAs are identified in Section 3.6. Details regarding OS197 TC maintenance, including implementation of the AMP at the TMI-2 ISFSI are discussed below.

When one is needed at the TMI-2 ISFSI, DOE-ID will acquire access to a TC via an important-to-safety purchase order. A determination will be made at that time as to the method of obtaining access, but in all cases, it will be developed under a procurement process using the DOE-ID QA program. DOE-ID will ensure compliance with these procurement requirements under the DOE-ID QA program, STI-NLF-QA-020 [A.1.7].

A future TC supplier may choose to provide a new TC or a TC aged less than the 20-year TMI-2 ISFSI initial licensing period, rather than a TC greater than 20 years old. Thus, the selected TC SSCs may, or may not require any aging management. Because it is unknown until the time of procurement whether the TC provided under that quality order will require any aging management, those activities, if any are required, will be coordinated with the TC supplier. Requirements for the supplier to perform all required maintenance, tests, and inspection activities (including AMPs, if applicable) of the TC prior to use at the TMI-2 ISFSI will be included in the procurement documents. Further, procedures for operation of the TC will be developed or revised as appropriate, prior to use by the entity actually performing DSC transfer operations. Such procedures will comply with all applicable requirements in the TMI-2 license, technical specifications, and UFSAR.

For an OS197 TC aged greater than 20 years, compliance with the Standardized NUHOMS® UFSAR [A.1.38] and LRA [A.1.26] pertaining to the OS197 TC will be specified in the procurement requirements. This will include specifying any maintenance and aging management requirements. Such procurement requirements will be consistent with applicable license commitments for the OS197 TC, including IBR the program elements from Appendix 6A (Section 6A.7) of the Standardized NUHOMS® CoC 1004 renewal application and verifying that prior to use all program elements requiring prior implementation (i.e., inspections, monitoring and trending activities, etc.) have been completed.

APPENDIX A4: TMI-2 Canister Aging Management

There are no AMPs required for the TMI-2 Canister SSCs for this LRA.

A.1 REFERENCES (APPENDIX A)

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A.1.3 American Concrete Institute, ACI Standard ACI 201.1R-08, "Guide for Conducting a Visual Inspection of Concrete in Service," 2008, Farmington Hills, MI.

A.1.4 SEI/ASCE-11-99, "Guideline for Structural Condition Assessment of Existing Buildings," Structural Engineering Institute American Society of Civil Engineers, 1999, Reston, VA.

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A.1.6 U.S. Department of Energy, Letter EM-FMDP-12-042, "Response to Three Mile Island Unit-2 Independent Spent Fuel Storage Installation - Horizontal Storage Module Concrete Monitoring Plans (Docket 72-20) (EM-FMDP-12-042)," June 26, 2012, NRC Accession Number ML12193A104.

A.1.7 SpectraTech Inc., STI-NLF-QA-020, Revision 1, "Quality Assurance Program for ISFSI Management," November 4, 2016.

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A.1.17 Professional Products of Kansas, Inc., "RILEM II.4 Summary/Testing & Technical," Available at http://watersealant.com/index.php/003/, August 9, 2013, Wichita, KS, Web page visited November 10, 2016.

A.1.18 ASME Boiler and Pressure Vessel Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," 1992 edition with 1993 addenda, The American Society of Mechanical Engineers, New York, NY.

A.1.19 ASTM D610-08, "Standard Practice for Evaluating Degree of Rusting on Painted Steel Surfaces," ASTM International, 2008, West Conshohocken, PA.

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A.1.21 ASTM D4538-05, "Standard Terminology Relating to Protective Coating and Lining Work for Power Generation Facilities," ASTM International, 2005, West Conshohocken, PA.

A.1.22 Electric Power Research Institute Report 1019157, "Plant Support Engineering: Guideline on Nuclear Safety-Related Coatings, Revision 2 (Formerly TR-109937 and 1003102)," December, 2009.

A.1.23 ASTM D772-86, "Standard Test Method for Evaluating Degree of Flaking (Scaling) of Exterior Paints," ASTM International, 1986, West Conshohocken, PA.

A.1.24 ASTM D4537-12, "Standard Guide for Establishing Procedures to Qualify and Certify Personnel Performing Coating and Lining Work Inspection in Nuclear Facilities," ASTM International, 2012, West Conshohocken, PA.

A.1.25 ASTM D714-02, "Standard Test Method for Evaluating Degree of Blistering of Paints," ASTM International, 2002, West Conshohocken, PA.

A.1.26 AREVA TN Americas, "Renewal Application for the Standardized NUHOMS® System, Certificate of Compliance No. 1004, Revision 3," September 29, 2016, NRC Accession Number 16279A371 (Submittal Enclosure 3, Proprietary Version) and ML16279A372 (Submittal Enclosure 4, Public Version).

A.1.27 American Concrete Institute, ACI Standard ACI 546.3R-14, "Guide to Materials Selection for Concrete Repair," June, 2014, Farmington Hills, MI.

A.1.28 American Concrete Institute, ACI Standard ACI 364.1R-07, "Guide for Evaluation of Concrete Structures before Rehabilitation," May 2007, Farmington Hills, MI.

A.1.29 American Concrete Institute, ACI Standard ACI 562-16, "Code Requirements for Assessment, Repair, and Rehabilitation of Existing Concrete Structures and Commentary," American Concrete Institute, June 2016, Farmington Hills, MI.

A.1.30 U.S. Nuclear Regulatory Commission, "Final License Renewal Interim Staff Guidance, LR-ISG-2011-05, Ongoing Review of Operating Experience," March 9, 2012, NRC Accession Number ML12044A215.

A.1.31 ASTM D5144-08, "Standard Guide for Use of Protective Coating Standards in Nuclear Power Plants," ASTM International, 2008, West Conshohocken, PA.

A.1.32 SpectraTech Inc., STI-NLF-QA-002, Revision 1, "Quality Assurance Program," November 4, 2016.

A.1.33 U.S. Nuclear Regulatory Commission, NRC Bulletin 96-04, "Chemical, Galvanic, or other Reactions in Spent Fuel Storage and Transportation Casks," July 5, 1996.

A.1.34 SpectraTech Inc., STI-NLF-QA-010, Revision 1, "Inspection," November 4, 2016.

A.1.35 ASME Boiler and Pressure Vessel Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," 2015 edition, The American Society of Mechanical Engineers, New York, NY.

A.1.36 SpectraTech Inc., Engineering Path Forward or Engineering Position, EP-NLF-2017-001, Revision 0, "Selection of SSCs for Remote Inspection," January 26, 2017.

A.1.37 Idaho National Laboratory Engineering Design File, EDF-9897, Revision 0, "TMI-2 ISFSI 2010 HSM and Base Mat Concrete Evaluation," April 5, 2011, Idaho Falls, ID, NRC Accession Number ML11220A140.

A.1.38 TN Americas LLC, "Updated Final Safety Analysis Report (UFSAR) for the Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel," Revision 17, March 2018, Docket No. 72-1004, NRC Accession Number 18079A008 (Proprietary Version) and ML18079A007 (Public Version).

APPENDIX B: TIME-LIMITED AGING ANALYSES (TLAAS)

(NUREG-1927, Section 3.5)

The following are summary descriptions of the TLAAs and other supplemental evaluations that were identified and prepared based on the TMI-2 ISFSI AMRs.

- As documented in Section 3.4.5.1.1, a TLAA identified in Section 8.3.2 of the UFSAR evaluates the effects of cyclic thermal loading (fatigue) on the mechanical properties of DSC materials of the TMI-2 ISFSI.
- As documented in Section 3.5.5.1.1, a TLAA identified in Section 8.1.1.5.D of the UFSAR evaluates the effects of irradiation on the mechanical properties of HSM concrete materials of the TMI-2 ISFSI.
- As documented in Appendix 3B to Revision 3 to the Standardized NUHOMS® CoC 1004 renewal application[1], an OS197 TC TLAA evaluates the effects of fatigue on the mechanical properties of the OS197 materials. This TLAA is Incorporated By Reference herein.

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[1] AREVA TN Americas, "Renewal Application for the Standardized NUHOMS® System, Certificate of Compliance No. 1004, Revision 3," September 29, 2016, NRC Accession Number 16279A371 (Submittal Enclosure 3, Proprietary Version) and ML16279A372 (Submittal Enclosure 4, Public Version).

APPENDIX C: FSAR SUPPLEMENT AND CHANGES

(NUREG-1927, Figure 3-1, Section 3.6.1.9, Section 1.4.4 and Section 1.4.7)

APPENDIX C : TABLE OF CONTENTS

C.1 INTRODUCTION

This appendix provides a proposed supplement to the TMI-2 ISFSI UFSAR to summarize the AMAs applicable to the TMI-2 ISFSI for the PEO. Section C.2 of this appendix contains a proposed new section for the TMI-2 ISFSI UFSAR to be added under Chapter 9, "Conduct of Operations." Section C.2 of this appendix identifies changes to the existing TMI-2 ISFSI UFSAR that are necessary to reflect the PEO.

Proposed new TMI-2 ISFSI UFSAR Section 9.8, "Aging Management," contains subsections that summarize the following aging management elements applicable to the TMI-2 ISFSI:

- Scoping evaluation and results
- AMR and results
- AMPs
- TLAAs
- Tollgate assessments

For the sake of clarity, certain information to be included in the TMI-2 ISFSI UFSAR that resides elsewhere in this LRA (e.g., tables) is cross-referenced in the subsections below, rather than repeating the information. This intra-document cross-referencing ensures configuration control of the tabular information throughout the NRC review process by having it reside in one place in the LRA.

The final UFSAR supplement, including other pertinent information residing elsewhere in this LRA, and changes resulting from NRC's review, will be included in an updated TMI-2 ISFSI UFSAR in accordance with 10 CFR 72.70(c). This update will occur within 90 days following issuance of the renewed TMI-2 ISFSI license.

C.2 PROPOSED NEW TMI-2 ISFSI FSAR SECTION

The following aging management information to be included in the TMI-2 ISFSI UFSAR is extracted from Sections 2.0 and 3.0, and Appendices A and B of this LRA and any applicable reference documents. Please refer to those sections/appendices and reference documents for additional details. All references to chapter and section numbers in the proposed UFSAR text below refer to current UFSAR chapters and sections unless otherwise noted.

C.2.1 FSAR Section 9.8 – Aging Management

To provide reasonable assurance that the structures, systems, and components (SSCs) of the TMI-2 ISFSI will continue to perform their intended functions for the period of extended operation (PEO), DOE-ID performed certain aging management activities (AMAs) in support of the renewal of the ISFSI license. These activities involved performing a scoping evaluation to identify those SSCs that required an aging management review (AMR) and performance of those AMRs. The result of the AMRs determined whether in-scope SSCs required a time-limited aging analysis (TLAA) or an aging management program (AMP) to provide reasonable assurance of functionality through the PEO. The process used to perform these AMAs is described in NUREG-1927, "Standard Review Plan for Renewal of Specific Licenses and Certificates of Compliance for Dry Storage of Spent Nuclear Fuel" [C.4.1] and NEI 14-03, "Format, Content, and Implementation Guidance for Dry-Cask Storage Operations-Based Aging Management" [C.4.2]. DOE-ID's license renewal application (LRA) [C.4.3] provides additional details, including technical bases for the AMAs at the TMI-2 ISFSI.

The first activity in addressing aging management for an ISFSI is to identify the in-scope SSCs based on safety classification and function, as described in NUREG-1927, Section 2.0. Once the TMI-2 ISFSI SSCs that were in-scope for aging management were identified, an AMR was performed to identify the aging effects and aging mechanisms requiring management for each SSC, as described in Section 3.0 of NUREG-1927, augmented by the information in Section 3 of NEI 14-03.

The first step of the AMR for each SSC was to identify the applicable materials subject to aging, along with their service environments. Then, the aging effects and mechanisms requiring management for each SSC were identified. Lastly, either a TLAA or an AMP was developed for each in-scope SSC. The subsections below describe the performance and results of the scoping evaluation, AMRs, TLAAs, and AMPs applicable to the TMI-2 ISFSI SSCs.

C.2.2 FSAR Section 9.8.1 - Scoping Evaluation Methodology

The scoping evaluation performed for the TMI-2 ISFSI license renewal followed the guidance in NUREG-1927, Section 2.0. An SSC is in-scope for aging management if it meets either of the following two criteria:

1. The SSC is classified as Important to Safety (ITS)
2. The SSC is classified as Not-Important-To-Safety (NITS) but, according to the design bases, its failure could prevent fulfillment of a function that is ITS.

NUREG-1927, Section 2.4.2.1 also addresses scoping as it relates to fuel assemblies and other contents stored in the dry storage system (DSS). For simplicity, the TMI-2 LRA used Section 2.4.2.1 of NUREG-1927 to identify a third scoping criterion to address spent nuclear fuel (SNF) assemblies and other contents stored in the DSS (i.e., the payload):

3. Payload contents, including the TMI-2 canisters and the TMI-2 core debris, if relied upon in the safety analysis to maintain geometric configuration

The scoping evaluation was performed in two phases. The first phase of the scoping evaluation was performed at the SSC major component level based on a review of safety classifications and design bases functions described herein, as well as design documents such as drawings. DSS contents were also considered in this phase. A major component was considered in-scope if it met one of the three scoping criteria. The second phase of the scoping evaluation was performed on a SSC subcomponent level using the Updated Final Safety Analysis Report (UFSAR) and design drawings to make a final determination on in-scope SSCs that would require AMRs. SSC subcomponents not meeting one of the three scoping criteria were scoped out for the AMR.

C.2.3 FSAR Section 9.8.2 - Results of Aging Management Scoping Evaluation – Major Components

The results of the first phase of the scoping evaluation are shown in Table C-1 (New ISFSI UFSAR Table 9.8-1), which shows both in-scope and out-of-scope major components and DSS contents.

The major in-scope components for aging management and the scoping criterion met are as follows:

- The Dry Shielded Canisters (DSCs) – Criterion 1
- The Horizontal Storage Modules (HSMs), except HSM-15 – Criterion 1
- The Transfer Cask (TC) – Criterion 1
- The ISFSI Basemat and Approach Slabs – Criterion 2
- The TMI-2 Canisters – Criterion 3

C.2.3.1 FSAR Section 9.8.2.1 - Dry Shielded Canister (DSC)

The DSC is scoped in as a major component because it performs or supports the following intended functions throughout the PEO:

- Confinement
- Radiation Shielding
- Heat-removal Capability
- Structural Integrity
- Retrievability

Detailed descriptions of the specific design functions performed by the DSC in the above areas may be found in Sections 3.1 through 3.4 of this UFSAR (Section 3.4.1, in particular) and Chapter 8.

C.2.3.2 FSAR Section 9.8.2.2 - Horizontal Storage Module (HSM)

The HSM is scoped in as a major component because it performs or supports the following intended functions throughout the PEO:

- Radiation Shielding
- Heat-removal Capability
- Structural integrity
- Retrievability

Detailed descriptions of the specific design functions performed by the HSM in the above areas may be found in Sections 3.1 through 3.4 of this UFSAR (Section 3.4.2, in particular) and Chapter 8.

C.2.3.3 FSAR Section 9.8.2.3 - Transfer Cask

The TC is scoped in as a major component because it is classified as an ITS component and supports retrieval of the DSC from the HSM. The TC is not used during normal storage operations and has no other storage intended function, besides retrievability throughout the PEO. However, it is used for both structural support (protecting the DSC) and radiation shielding during transfer operations.

Detailed descriptions of the specific design functions performed by the TC may be found in Sections 3.1 through 3.4 of this UFSAR (Section 3.4.4, in particular) and Chapter 5, and Appendix E.

C.2.3.4 FSAR Section 9.8.2.4 - ISFSI Basemat and Approach Slabs

The ISFSI basemat and approach slabs are scoped in because they support retrievability of the DSC from the HSM. Detailed descriptions of the specific design functions performed by the ISFSI basemat and approach slabs may be found in Section 3.4.3 of this UFSAR.

C.2.3.5 FSAR Section 9.8.2.5 - TMI-2 Canister

The TMI-2 Canister is scoped in because it performs or supports the following intended functions throughout the PEO:

- Shielding
- Criticality prevention
- Decay heat removal
- Structural integrity

Detailed descriptions of the specific design functions performed by the three types of TMI-2 Canisters may be found in Sections 3.1 through 3.4 of this UFSAR (Section 3.1.1, in particular) and Chapter 8.

C.2.4 FSAR Section 9.8.3 - Results of Aging Management Scoping Evaluation – Subcomponents

In the second phase of the scoping evaluation, the design functions performed or supported by each of the subcomponents of the major components were evaluated. Subcomponent SSCs were scoped in if they performed or supported one or more of the intended functions performed by the associated major component. This phase of the scoping evaluation was primarily conducted from a review of the fabrication drawings and bill of materials.

Table C-2 (new ISFSI FSAR Table 9.8-2) lists the in-scope subcomponent SSCs for each in-scope major component and the intended function performed or supported by the subcomponent. Subcomponents of in-scope major components not listed in Table 9.8-2 are out of scope for aging management.

C.2.5 FSAR Section 9.8.4 - Aging Management Reviews – Materials and Environments

C.2.5.1 FSAR Section 9.8.4.1 - Materials

The major components and subcomponents of SSCs that are in-scope for aging management are fabricated from the following materials:

- Reinforced concrete
- Carbon steel
- Stainless steel
- Carbon/boron steel
- Alloy steel
- Quenched carbon steel
- Ferritic steel
- Inconel 625
- Boron carbide
- BORAL®
- E70XX weld filler
- Polyurethane plastic
- Elastomeric (neoprene) seal material
- Zinc-rich inorganic coating
- Cementitious Grout
- Silicone Sealant (Chemical Grout)
- Lightweight concrete (LICON)

C.2.5.2 FSAR Section 9.8.4.2 - Environments

The ambient environment at the TMI-2 ISFSI is described in detail in Chapter 2. A review of the information presented in Chapter 2 was performed to assess the environmental conditions to which the in-scope SSCs are normally exposed. The environments to which the TMI-2 ISFSI in-scope SSCs are exposed depend on the characteristics of the TMI-2 ISFSI site environment, as well as the SSC location within the DSS.

The environments considered in the AMR are the environments that the TMI-2 ISFSI in-scope SSCs and associated subcomponent SSCs normally experience. Environmental stressors that are conditions not normally experienced (such as extreme heat or cold), or that may be caused by a design or fabrication condition, are considered event driven and are not aging related. Such event-driven situations would be evaluated and corrective actions, if any, implemented at the time of the event.

The HSMs contain the DSCs, which are ventilated to the HSM internal space through HEPA filters. The DSCs contain the TMI-2 Canisters, which are ventilated to the DSC internal space.

The five service environments for the major components of SSCs that are in-scope for aging management include:

- **Outdoor** – An environment exposed to all local ambient weather conditions at the INL Site, including seasonal and daily temperature and humidity variations, exposure to sunlight, wind, and precipitation. The HSM exterior surfaces, including hardware, access doors, roof bolt protective covers, etc. are exposed to the Outdoor Environment.
- **Sheltered** – This is a protected ambient environment with no direct exposure to sunlight, wind, or precipitation. The sole source of moisture is natural humidity and small amounts of wind-blown rain entering through the vent holes in the rear access door. Temperature inside the Sheltered Environment is a function of outdoor temperature and, to a lesser extent, any heat produced by the TMI-2 core debris inside the DSCs. The DSC exterior surfaces are exposed to the Sheltered Environment. The Sheltered Environment on the DSC shell exterior surface may range from ambient air temperature to slightly above ambient. SSCs located in the Sheltered Environment are also exposed to neutron and gamma radiation fields. However, sources of heat and radiation inside the DSC will decrease over the PEO due to radioactive decay of the TMI-2 core debris.
- **Internal DSC** – The Internal DSC Environment is that located within the DSC cylindrical storage cavity. The TMI-2 Canister exterior surfaces, the inside surfaces of the DSC shell and interior shell assembly subcomponents (e.g., inner top and bottom cover plates and top shield plug) are exposed to the Internal DSC Environment. This environment communicates with the Sheltered Environment via a combination of four HEPA filters on the DSC vent port and a single HEPA filter on the DSC purge port. The ventilation and off gas system for the NUHOMS®-12T storage system is completely passive and is designed to allow diffusion of small amounts of hydrogen generated inside the DSC through the HEPA filter vents. This environment experiences neutron and gamma fluence higher than the Sheltered Environment. The environment inside the DSC is nearly ambient since it is vented and decay heats levels are low.
- **Internal TMI-2 Canister** - The Internal TMI-2 Canister Environment is that located within the TMI-2 Canister storage cavity. This environment is even more protected from outdoor ambient conditions than either the Sheltered or Internal DSC Environments. The TMI-2 Canister interior structure, the inside surfaces of the TMI-2 Canister shell and interior TMI-2 Canister subcomponents are exposed to the Internal TMI-2 Canister Environment. It is a similar environment to the Internal DSC Environment, except that it is exposed to slightly higher temperatures and higher neutron and gamma fluence.
- **Embedded or Encased** - This environment applies for materials that are embedded or encased (sealed) inside another material. This includes, but is not limited to, items such as concrete reinforcing bars, anchorages, and shield plugs between the inner and outer DSC cover plates. In addition, it includes the BORAL® neutron poison material enclosed between the inner and outer skin on the TMI-2 Fuel Canister, and Boron Carbide pellets encased in the TMI-2 Knockout and TMI-2 Filter Canister poison rod tubes. Embedded or Encased Environments are exposed to radiation. The heat load source decreases over the PEO.

Tables C-3 through C-5 (new ISFSI FSAR Tables 9.8-3 through 9.8-5) provide the combinations of materials and environments considered in the AMR for each in-scope subcomponent SSC, except for the TC. See Section C.2.6.3 (FSAR Section 9.8.5.3) for additional information on aging management of the TC.

C.2.6 FSAR Section 9.8.5 – Results of Aging Management Reviews

After the materials and environments for in-scope major component and subcomponent SSCs were identified, the potential applicable aging effects and mechanisms requiring management for each were determined. Those aging effects and mechanisms were then reviewed with respect to the materials and service conditions for each subcomponent to determine which required aging management at the TMI-2 ISFSI during the PEO. Then, a determination as to whether a TLAA or other engineering evaluation or alternately an AMP was employed to address or manage the aging effect. The subsections below summarize the results of the AMRs for each major component.

C.2.6.1 FSAR Section 9.8.5.1 – Results of AMR – DSC

The potential aging effects and related aging mechanisms that were evaluated in the AMR for the in-scope DSC subcomponent SSCs are:

a) Potential Aging Effect: Loss of material

   Associated Potential Aging Mechanisms:

   - General corrosion
   - Crevice corrosion
   - Pitting corrosion
   - Galvanic corrosion
   - Microbiologically Induced Corrosion
   - Adhesive, abrasive, and erosive wear

b) Potential Aging Effect: Cracking

   Associated Potential Aging Mechanisms:

   - Stress Corrosion Cracking
   - Thermal Fatigue
   - Hydrogen Damage

c) Potential Aging Effect: Change in material properties

   Associated Potential Aging Mechanisms:

   - Intergranular Corrosion
   - Creep
   - Thermal Aging
   - Irradiation Embrittlement
   - Hydrogen Damage

The AMR conducted for the DSC evaluated the likelihood of the above potential aging mechanisms to cause the related potential aging effect for the DSC subcomponent SSCs and determined that the following aging effect and causative aging mechanisms required a TLAA or AMP for the DSC:

Aging effect: Loss of material

Aging Mechanisms:

- General, crevice, pitting, and galvanic corrosion
- Adhesive wear

In addition, as a defense-in-depth aging management function, the zinc-rich primer on the Sheltered Environment steel SSCs is included to assess loss of coating integrity due to blistering, cracking, flaking, peeling, or physical damage.

See Sections C.2.7.1 and C.2.8 (FSAR Sections 9.8.6.1 and 9.8.7) for summary descriptions of the TMI-2 ISFSI DSC AMPs and TLAAs, respectively.

C.2.6.2 FSAR Section 9.8.5.2 – Results of AMR – HSM

The potential aging effects and related aging mechanisms that were evaluated during AMR for the in-scope HSM subcomponents are:

a) Potential Aging Effect: Loss of concrete material via spalling or scaling

Associated Potential Aging Mechanisms:

- Freeze-thaw cycles
- Aggressive chemical attack
- Fatigue
- Irradiation
- Reaction with aggregates
- Shrinkage

b) Potential Aging Effect: Concrete cracking

Associated Potential Aging Mechanisms:

- Freeze-thaw cycles
- Aggressive chemical attack
- Fatigue
- Irradiation
- Reaction with aggregates
- Shrinkage
- Elevated temperatures

c) Potential Aging Effect: Reduction of concrete strength and modulus

Associated Potential Aging Mechanisms:

- Irradiation
- Aggressive chemical attack
- Reaction with aggregates
- Leaching of calcium hydroxide
- Elevated temperatures
- Creep

d) Potential Aging Effect: Loss of material of embedded SSCs

Associated Potential Aging Mechanism:

- Corrosion

e) Potential Aging Effect: Increase in concrete porosity and permeability

Associated Potential Aging Mechanism:

- Leaching of calcium hydroxide

f) Potential Aging Effect: Reduction of concrete pH

Associated Potential Aging Mechanisms:

- Aggressive chemical attack
- Leaching of calcium hydroxide

g) Potential Aging Effect: Premature degradation of concrete repair chemical grout fillers and sealants

Associated Potential Aging Mechanism:

- Ultra-violet (UV) exposure
- Irradiation

In addition, as a defense-in-depth aging management function, the silane water repellent coating on the concrete is included to assess for physical damage on the steel coatings and inhibition of moisture penetration on HSM concrete SSCs and rebar corrosion on HSM steel SSCs.

h) Potential Aging Effect: Loss of material in HSM steel SSCs

Associated Potential Aging Mechanisms:

- General corrosion
- Crevice corrosion
- Pitting corrosion

i) Potential Aging Effect: Loss of strength in HSM steel SSCs

Associated Potential Aging Mechanisms:

- Irradiation
- Fatigue

j) Potential Aging Effect: Cracking in HSM steel SSCs

Associated Potential Aging Mechanisms:

- Irradiation
- Fatigue
- Stress Corrosion Cracking

In addition, as a defense-in-depth aging management function, the zinc-rich primer on the coated steel HSM SSCs is included to assess loss of coating integrity due to blistering, cracking, flaking, peeling, or physical damage.

The AMR conducted for the HSM evaluated the likelihood of the above potential aging mechanisms to cause the related potential aging effect for the HSM SSCs and determined that the following aging effects and aging mechanisms required a TLAA or AMP for the HSM:

a) Aging Effect: Loss of concrete material via spalling or scaling

Associated Aging Mechanisms:

- Freeze-thaw cycles
- Shrinkage

b) Aging Effect: Concrete cracking

Associated Aging Mechanisms:

- Freeze-thaw cycles
- Shrinkage

c) Aging Effect: Reduction of concrete strength and modulus

Associated Aging Mechanism:

- Leaching of calcium hydroxide

d) Aging Effect: Loss of material from embedded SSCs

Associated Aging Mechanism:

- Corrosion

e) Aging Effect: Increase in concrete porosity and permeability

Associated Aging Mechanism:

- Leaching of calcium hydroxide

f) Aging Effect: Reduction of concrete pH

Associated Aging Mechanism:

- Leaching of calcium hydroxide

g) Aging Effect: Premature degradation of concrete repair chemical grout fillers and sealants

Associated Aging Mechanism:

- Ultra-violet (UV) exposure
- Irradiation

In addition, as a defense-in-depth aging management function, the silane water repellent coating on the concrete is included to assess for physical damage on the steel coatings and inhibition of moisture penetration on HSM concrete SSCs and rebar corrosion on HSM steel SSCs.

h) Aging Effect: Loss of material in HSM steel SSCs

Associated Aging Mechanisms:

- General, crevice, and pitting corrosion

In addition, as a defense-in-depth aging management function, the zinc-rich primer on the coated steel HSM SSCs is included to assess loss of coating integrity due to blistering, cracking, flaking, peeling, or physical damage.

See Sections C.2.7.2 and C.2.8 (FSAR Sections 9.8.6.2 and 9.8.7) for summary descriptions of the TMI-2 ISFSI HSM AMPs and TLAAs, respectively.

C.2.6.3 FSAR Section 9.8.5.3 – Results of AMR – TC

The TMI-2 UFSAR describes the use of a TC to move DSCs into and out of the HSMs. Thus, the TC is required to retrieve a DSC and is in-scope for aging management under the renewed TMI-2 ISFSI license. DOE-ID does not possess a TC (either an MP187 or OS197 as authorized by the design basis) associated with the TMI-2 ISFSI license at the INL Site. Because use of an MP187 TC aged over 20 years is prohibited by a TMI-2 ISFSI license condition, no AMR was performed for the MP187 TC design. The AMR for the OS197 TC design is incorporated by reference (IBR) from the renewal application for Standardized NUHOMS® 10 CFR 72 Certificate of Compliance (CoC) 1004 [C.4.4]. Specifically, the following portions of the document "Renewal Application for the Standardized NUHOMS® System, Certificate of Compliance No. 1004, Revision 3," dated September 29, 2016, are IBR into the TMI-2 ISFSI licensing basis:

> Sections 1.2.2.3, 3.3.3, 3.4, 3.4.1, 3.4.2, 3.4.3, 3.7 and Appendices 1A-1K, 2C (pertaining to the OS197 TC); Appendix 2E (Table 2E-3 only); Appendix 3B (pertaining to the OS197 TC); and Appendix 6A (Section 6A.7 only)

DOE-ID will acquire access to an OS197 TC when one is needed at the TMI-2 ISFSI via an important-to-safety purchase order. A determination will be made at that time as to the method of obtaining access, but in all cases, it will be developed under a procurement process using a DOE-ID Quality Assurance program. Suitable procurement documents will specify the design, operating, and maintenance requirements for the TC for use in retrieving the TMI-2 DSCs from the HSM, consistent with applicable license requirements and commitments. Furthermore, if use of the TC used to retrieve the DSC requires the use of TC spacers, the spacers shall have been fabricated less than 20 years prior to their use at the TMI-2 ISFSI. DOE-ID will ensure compliance with these procurement requirements under the DOE-ID Quality Assurance program.

C.2.6.4 FSAR Section 9.8.5.4 – Results of AMR – Basemat and Approach Slab

The one aging effect evaluated for the ISFSI basemat and approach slab is differential settlement. Differential settlement can be because of subgrade consolidation or movement of soils upon which the structures are founded. The results of the AMR revealed that the potential aging mechanism that could cause differential settlement is not credible at the TMI-2 ISFSI for the duration of the PEO. Therefore, no TLAA or AMP is required.

C.2.6.5 FSAR Section 9.8.5.5 – Results of AMR – TMI-2 Canister

The aging effects and related aging mechanisms that were evaluated during the AMR for the in-scope TMI-2 Canister subcomponent SSCs are:

a) Aging Effect: Loss of Material

Associated Aging Mechanisms:

- General Corrosion
- Crevice Corrosion
- Pitting Corrosion
- Galvanic Corrosion
- Microbiologically Induced Corrosion
- Wear

b) Aging Effect: Cracking

Associated Aging Mechanisms:

- Stress Corrosion Cracking
- Thermal Fatigue

c) Aging Effect: Change in Material Properties

Associated Aging Mechanisms:

- Intergranular Corrosion
- Creep
- Thermal Aging
- Irradiation Embrittlement

Each of the above combinations of aging effect and aging mechanism was evaluated to determine the appropriate AMA for each TMI-2 Canister subcomponent SSC. The results of the AMR revealed that there are no credible aging effects requiring management for the TMI-2 Canisters at the TMI-2 ISFSI for the duration of the PEO. Therefore, no TLAAs or AMPs are required.

C.2.7 FSAR Section 9.8.6 – Aging Management Programs

The AMRs for the DSC and HSM resulted in the need to develop AMPs to manage the aging effects and mechanisms for the subcomponents comprising these major components. No other AMRs of in-scope components resulted in the need for AMPs. The AMPs summarized in the following subsections address the scope of the AMPs, the parameters monitored or inspected, the detection of aging effects, and the acceptance criteria (AC). DOE-ID will develop, implement, and maintain AMP implementing procedures for the duration of the PEO.

C.2.7.1 FSAR Section 9.8.6.1 – DSC Aging Management Program

DOE-ID will develop and maintain procedures to implement the DSC subcomponent AMPs shown in Table C-7 (new ISFSI FSAR Table 9.8-7).

C.2.7.2 FSAR Section 9.8.6.2 – HSM Aging Management Program

DOE-ID will develop and maintain procedures to implement the HSM subcomponent AMPs shown in Table C-8 (new ISFSI FSAR Table 9.8-8).

C.2.7.3 FSAR Section 9.8.6.3 – OS197 Transfer Cask Aging Management Program

The OS197 TC aging management program (AMP) was approved as part of the renewal of the Standardized NUHOMS® 10 CFR 72 and is IBR into this FSAR. Table 12.3-5 of Revision 17 to the Standardized NUHOMS® UFSAR [C.4.5] is repeated as Table C-9 herein (new ISFSI FSAR Table 9.8-9). This AMP is supported by additional information also IBR into the TMI-2 ISFSI licensing basis found in Section 6A.7 of Appendix 6 to Revision 3 of the CoC 1004 renewal application [C.4.4].

A future OS197 TC supplier may choose to provide a new OS197TC or an OS197 TC aged less than the 20-year TMI-2 ISFSI initial licensing period. Thus, the selected OS197 TC SSCs may, or may not require implementation of the AMP described in Table C-9 (new ISFSI FSAR Table 9.8-9). Because it is unknown until the time of procurement whether the OS197 TC provided under that procurement will require any aging management activities, if any are required, they will be coordinated with the OS197 TC supplier. As discussed in Section C.2.6.3 (FSAR Section 9.8.5.3), requirements for the supplier to perform all required maintenance, tests, and inspection activities (including AMPs) of the OS197 TC prior to use at the TMI-2 ISFSI will be included in the procurement documents. Further, procedures for operation of the OS197 TC will be developed or revised as appropriate, prior to use by the entity performing DSC transfer operations. Such procedures will comply with all applicable requirements in the TMI-2 ISFSI renewed license, technical specifications, and UFSAR.

C.2.8 FSAR Section 9.8.7 – Time-Limited Aging Analyses

C.2.8.1 FSAR Section 9.8.7.1 – DSC TLAA

A TLAA as documented in Section 8.3.2 evaluates the effects of cyclic thermal loading (fatigue) on the mechanical properties of DSC materials of the TMI-2 ISFSI and remains applicable during the PEO.

C.2.8.2 FSAR Section 9.8.7.2 – HSM TLAA

A TLAA as documented in Section 8.1.1.5.D evaluates the effects of irradiation on the mechanical properties of HSM concrete materials of the TMI-2 ISFSI and remains applicable during the PEO.

C.2.8.3 FSAR Section 9.8.7.3 – OS197 TC TLAA

The OS197 TC TLAAs approved as part of the renewal of the Standardized NUHOMS® 10 CFR 72 CoC are IBR into this FSAR. These TLAAs are summarized in Appendix 3B to Revision 3 to the Standardized NUHOMS® CoC 1004 renewal application [C.4.4].

C.2.9 FSAR Section 9.8.8 – Tollgate Assessments

Industry guidance on the preparation of ISFSI LRAs is contained in NEI 14-03 [C.4.2]. NEI 14-03 introduces the concept of "tollgates" and "tollgate assessments", and provides specific guidance in Section 3.6.5 and Appendix A of the document. DOE-ID performs tollgate assessments during the PEO of the TMI-2 ISFSI, spanning the period from March 17, 2019 through March 17, 2039, or the date the last licensed material is removed from the ISFSI, whichever occurs sooner.

DOE-ID may choose to integrate the tollgate assessment into existing ISFSI assessment programs, while continuing to meet the underlying intent of the tollgate concept. Tollgate assessments for the TMI-2 ISFSI will be performed as shown in Table C-6 (new ISFSI FSAR table 9.8-6).

C.3 PROPOSED REVISED TMI-2 ISFSI FSAR SECTIONS

The TMI-2 ISFSI UFSAR was reviewed for potential changes required to reflect an additional 20 years of operation beyond the initial license term. DOE-ID has determined that changes to the existing FSAR were required to reflect the proposed new license condition for the renewed license that prohibits use of an MP187 transfer cask during the PEO if that MP187 cask is aged over 20 years. The following is proposed to be added as a new first paragraph in FSAR Section 3.1.2 and as a new second paragraph in Sections 4.1 and 5:

> *As of the effective date of the renewed TMI-2 ISFSI license, a license condition prohibits the use of the MP187 transfer cask (TC) if that MP187 cask was fabricated 20 or more years prior to its proposed use at the TMI-2 ISFSI. Unless and until the TMI-2 ISFSI license is amended to remove or suitably modify this license condition, all activities involving the TC described in this FSAR may only be conducted using the OS197 TC as described in Appendix E of this FSAR. Furthermore, if use of the TC used to retrieve the DSC requires the use of TC spacers, the spacers shall have been fabricated less than 20 years prior to their use at the TMI-2 ISFSI.*

In addition to the above new paragraph, the following Appendix A DSC FSAR drawings have been revised:

- DSC Basket Assembly Drawing 219-02-2000
- DSC Shell Assembly Drawing 219-02-2001
- DSC Basket-Shell Assembly Drawing 219-02-2002
- DSC Main Assembly Drawing 219-02-2003
- DSC Purge Port/Filter Assembly Drawing 219-02-2010
- DSC Vent Assembly Drawing 219-02-2011

FSAR Section 3.1.2 has been revised to more accurately describe the normal storage, testing, sampling, purging, and transportation operations and configurations of the DSC and Section 4.3.10 has been revised to delete the reference to Figure 4.3-2.

In addition, two Figures in Chapter 4 are edited as follows:

1. FSAR Figure 4.3-1 has been modified to depict only the normal storage configuration
2. FSAR Figure 4.3-2 has been deleted

Table C-1 (New ISFSI FSAR Table 9.8-1)

Results of Component-Level and Contents Scoping Evaluation

[Insert Final LRA Table 2-1]

Table C-2 (New ISFSI FSAR Table 9.8-2)

In-Scope Subcomponents for Aging Management

[Insert Final LRA Table 2-3]

Table C-3 (New ISFSI FSAR Table 9.8-3)

Materials and Environments for DSC AMRs

[Insert Final DSC Section of LRA Table 3-4, "Component," "Item Description," Materials," and "Service Environments" Columns]

Table C-4 (New ISFSI FSAR Table 9.8-4)

Materials and Environments for HSM AMRs

[Insert Final HSM Section of LRA Table 3-4, "Component," "Item Description," Materials," and "Service Environments" Columns]

Table C-5 (New ISFSI FSAR Table 9.8-5)

Materials and Environments for TMI-2 Canister AMRs

[Insert Final “Knockout Canister,” “Filter Canister,” and “Fuel Canister” Sections of LRA Table 3-4, “Component,” “Item Description,” Materials,” and “Service Environments” Columns]

Table C-6 (New ISFSI FSAR Table 9.8-6)

TMI-2 ISFSI Tollgates

[Insert Final LRA Table 3-11]

Table C-7 (New ISFSI FSAR Table 9.8-7)

DSC Aging Management Program

[Insert Final LRA Table A-1]

Table C-8 (New ISFSI FSAR Table 9.8-8)

HSM Aging Management Program

[Insert Final LRA Table A-2]

Table C-9 (New ISFSI FSAR Table 9.8-9)

OS197 Transfer Cask Aging Management Program

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AMP Element	AMP Activity
Scope of Program	This program visually inspects and monitors the accessible TC subcomponent surfaces, including cask cavity surfaces (e.g., inner liner), and the OS197L supplemental shielding subcomponents, to ensure they are intact and free from loss of material due to general, crevice or pitting corrosion and loss of material due to wear.
Preventative Actions	The program is a condition-monitoring program. Demineralized water shall be used to fill the neutron shield, rather than municipal water. The neutron shield shall be drained before storage to prevent damage due to freezing and mitigate corrosion. When not in use the TC should be stored in a building or container that prevents direct exposure to precipitation. Tarpaulins, if used, should not be in contact with the TC surface to prevent accumulation of condensation. After fuel is loaded in the DSC and the cask is raised above the pool water surface, the cask is rinsed off with demineralized water.
Parameters Monitored or Inspected	Surface condition: wear, corrosion, and coating. Signs of leakage for the liquid neutron shield.
Detection of Aging Effects	
Method or Technique:	Visual inspection per VT-3. Any area of the TC exhibiting evidence of possible crevices, pits, water stains or discoloration during the VT-3 examinations is subjected to a VT-1 examination per IWA-2211. Fasteners are inspected for threaded parts condition, corrosion, and signs of wear or other degradation. PT Exams of the upper and lower trunnion bearing surface and the accessible upper and lower trunnion welds. VT-3 exam is also performed to detect any signs of neutron shield leakage (TC with liquid neutron shield only) with VT-1 employed if there are any signs of corrosion.
Frequency:	VT-3: once per five years VT-1 if indications of possible deterioration during VT-3 inspection PT: once per five years Liquid neutron shield: once per five years
Sample Size:	Each TC.
Data Collection:	Records of inspection. Photos or video. Records of any required corrective actions.

Table C-9 (New ISFSI FSAR Table 9.8-9)

OS197 Transfer Cask Aging Management Program

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AMP Element	AMP Activity
Timing of Inspections:	At frequency defined above. If the TC has not been used for more than 5 years, TC aging management is not required, but the inspection must be performed prior to next use of the TC.
Monitoring and Trending	A baseline inspection is performed as part of the monitoring and trending activities so that the inspection results can be used for subsequent trending.
Acceptance Criteria	• VT-3 and VT-1 examinations in accordance with Section XI IWA-2213 and IWA-2211, respectively. If corrosion on any of the transfer cask subcomponents or wear of the inner liner thickness are detected, the finding is entered into the licensee's corrective action program to determine, based on engineering evaluation, the extent and impact of the corrosion on the ability of the TC to perform its intended function. • PT exam acceptance of the trunnion bearing surfaces and accessible welds per ASME Section III, NC-5350. • Acceptable coatings are free of peeling or delamination. Blistering, cracking, flaking, rusting, and physical damage will be evaluated to determine acceptability.
Corrective Actions	Unsatisfactory degradation is entered in a corrective action program for resolution. Deficiencies are either corrected or are evaluated to be acceptable for continued service through engineering analysis. Extent of condition investigation per the licensee's corrective action program may trigger additional inspections via a different method, increased inspection frequency and/or expanded inspection sample size.
Confirmation Process	Confirmatory actions, as needed, are implemented as part of the CoC holder or licensee's corrective action program, as applicable.
Administrative Controls	Administrative controls under the CoC holder or licensee's QA procedures and corrective action program provide a formal review and approval process. Licensee individual events and conditions not rising to the level of NRC reportability based on the criteria in 10 CFR 72 are communicated to the CoC holder.
Operating Experience	The overall effectiveness of these inspections/activities in maintaining the condition and functionality of the casks is supported by the continued use of the transfer casks and their continued compliance with the certificate of compliance.

C.4 REFERENCES (APPENDIX C)

(to be added to UFSAR Chapter 9 references)

C.4.1 U.S. Nuclear Regulatory Commission, NUREG-1927, Revision 1, "Standard Review Plan for Renewal of Specific Licenses and Certificates of Compliance for Dry Storage of Spent Nuclear Fuel," June, 2016, NRC Accession Number ML16179A148.

C.4.2 Nuclear Energy Institute, NEI 14-03, Revision 2, "Format, Content and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management," December 2016, Washington D.C.

C.4.3 Department of Energy letter to the Nuclear Regulatory Commission EM-NRC-177-007, "Submittal of Application for the Renewal of 10 CFR Part 72 Materials License No. SNM-2508 for the Three Mile Island Unit 2 Independent Spent Fuel Storage Installation," Docket 72-0020.

C.4.4 AREVA TN Americas, "Renewal Application for the Standardized NUHOMS® System, Certificate of Compliance No. 1004, Revision 3," September 29, 2016, NRC Accession Number 16279A371 (Submittal Enclosure 3, Proprietary Version) and ML16279A372 (Submittal Enclosure 4, Public Version).

C.4.5 TN Americas LLC, "Updated Final Safety Analysis Report (UFSAR) for the Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel," Revision 17, March 2018, Docket No. 72-1004, NRC Accession Number 18079A008 (Proprietary Version) and ML18079A007 (Public Version).

APPENDIX D: PROPOSED LICENSE/TECHNICAL SPECIFICATION CHANGES

(NUREG-1927, Section 1.4.4 and Section 1.4.7)

D.1 INTRODUCTION

Both NUREG-1927 and NEI 14-03 recommend that ISFSI LRAs include proposed changes to the ISFSI license and/or technical specifications (TS) related to the renewed license. DOE-ID has reviewed the TMI-2 ISFSI license SNM-2508, including the TS in Appendix A, for potential changes because of license renewal. Proposed changes are discussed below.

D.2 PROPOSED LICENSE CONDITION CHANGES

D.2.1 Revised License Conditions

There are currently four approved exemptions applicable to the TMI-2 ISFSI license. They are listed in Condition 12 of the license. As discussed in Section 1.3.4 herein, the regulation for one of these exemptions has changed, requiring an editorial change to the license condition. The regulation for another exemption has been deleted, which removes the need for the exemption. Therefore, DOE-ID requests the following changes to License Condition 12 as administrative changes:

a) Revise License Condition 12(b) to change the cited regulation from 10 CFR 20.1501(c) to 10 CFR 20.1501(d)

b) Delete License Condition 12(d)

D.2.2 New License Conditions

DOE-ID proposes the following new conditions for the renewed TMI-2 ISFSI license:

17. Within 90 days after issuance of the license, DOE-ID shall submit an updated FSAR, to include the information from Appendix C to the LRA, as modified by any changes resulting from the renewal review.
18. DOE-ID shall revise or create a program document describing the infrastructure and timing for implementing the activities in the Aging Management Programs (AMPs) described in the ISFSI UFSAR within one year of the renewed license effective date.
19. HSM-15 and its integral DSC overpack shall not be used for normal spent fuel storage operations.
20. The MP187 described in the TMI-2 ISFSI FSAR is prohibited for use as a transfer cask at the TMI-2 ISFSI if the MP187 was fabricated 20 or more years prior to the proposed date of use.
21. TC spacers, if required for DSC retrieval, shall be fabricated fewer than 20 years before use.

D.3 PROPOSED TECHNICAL SPECIFICATION CHANGES

10 CFR Part 72.42 requires that an application for license renewal include any Technical Specification changes, or additions that are necessary to manage the effects of aging during the PEO. A review of the information provided in this LRA and the TMI-2 ISFSI Technical Specifications confirms that no changes to the ISFSI Technical Specifications are necessary to manage the effects of aging during the PEO. Thus, no changes to the TMI-2 ISFSI Technical Specifications are proposed.