United States Nuclear Regulatory Commission

Protecting People and the Environment

NUREG-1927
Revision 1

Standard Review Plan for Renewal of Specific Licenses and Certificates of Compliance for Dry Storage of Spent Nuclear Fuel

Final Report

Office of Nuclear Material Safety and Safeguards

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Final Report

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ABSTRACT

This Standard Review Plan is intended for use by the U.S. Nuclear Regulatory Commission (NRC) reviewer. It provides guidance for the safety review of renewal applications for specific licenses of independent spent fuel storage installations and certificates of compliance (CoCs) of dry storage systems, as codified in Title 10 of the *Code of Federal Regulations* (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."

This Standard Review Plan provides guidance for the review of general information, scoping evaluation information, and aging management information, included in a renewal application. The guidance provides information on review of time-limited aging analyses and aging management programs (AMPs), including learning AMPs that consider and respond to operating experience. The guidance provides example AMPs for welded stainless steel canisters, reinforced concrete structures, and a high burnup fuel monitoring and assessment program. It also provides guidance on considerations for CoC renewals and the general license framework, including guidance on general licensees' implementation of AMPs.

The NRC expects to periodically revise and update this Standard Review Plan to clarify the content, correct errors, and include new information, knowledge, and experience regarding aging management considerations. Comments, suggestions for improvement, and notices of errors or omissions should be sent to the Director, Division of Spent Fuel Management, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001.

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CONTENTS

ABSTRACT ..... **iii**

LIST OF FIGURES ..... **vii**

LIST OF TABLES ..... **vii**

ABBREVIATIONS ..... **ix**

INTRODUCTION **1**

1. GENERAL INFORMATION REVIEW **7**
- 1.1 Review Objective 7
- 1.2 Areas of Review 7
- 1.3 Regulatory Requirements 7
- 1.4 Review Guidance 8
  - 1.4.1 General Information 8
  - 1.4.2 Financial Information 8
  - 1.4.3 Environmental Report 9
  - 1.4.4 Application Content 9
  - 1.4.5 Timely Renewal 11
  - 1.4.6 Amendment Applications Submitted during the Renewal Review or after the Renewal Is Issued 11
  - 1.4.7 Terms, Conditions, and Specifications for Specific Licenses and CoCs in the Period of Extended Operation 12
- 1.5 Evaluation Findings 14

2. SCOPING EVALUATION **15**
- 2.1 Review Objective 15
- 2.2 Areas of Review 15
- 2.3 Regulatory Requirements 15
- 2.4 Review Guidance 16
  - 2.4.1 Scoping Process 16
  - 2.4.2 Structures, Systems, and Components within the Scope of Renewal 18
    - 2.4.2.1 Scoping of Fuel Assemblies 19
    - 2.4.2.2 Scoping of Structures, Systems, and Components, Depending on Individual Design Bases 19
  - 2.4.3 Structures, Systems, and Components Not within the Scope of Renewal 19
- 2.5 Evaluation Findings 20

3. AGING MANAGEMENT REVIEW **21**
- 3.1 Review Objective 21
- 3.2 Areas of Review 21
- 3.3 Regulatory Requirements 23
- 3.4 Materials, Service Environments, Aging Mechanisms and Effects, and Aging Management Activities 25
  - 3.4.1 Review Guidance 25
    - 3.4.1.1 Identification of Materials and Environments 25
    - 3.4.1.2 Identification of Aging Mechanisms and Effects 26
    - 3.4.1.3 Aging Management Activities 28
    - 3.4.1.4 Aging Management Review for Fuel Assemblies 28
  - 3.4.2 Evaluation Findings 29

3.5 Time-Limited Aging Analyses 30
3.5.1 Review Guidance....31
3.5.2 Evaluation Findings 32
3.6 Aging Management Programs 32
3.6.1 Review Guidance....33
3.6.1.1 Scope of Program 33
3.6.1.2 Preventive Actions 33
3.6.1.3 Parameters Monitored or Inspected 34
3.6.1.4 Detection of Aging Effects 34
3.6.1.5 Monitoring and Trending 35
3.6.1.6 Acceptance Criteria....36
3.6.1.7 Corrective Actions....36
3.6.1.8 Confirmation Process....37
3.6.1.9 Administrative Controls 37
3.6.1.10 Operating Experience 38
3.6.2 Commencement of AMP(s) for CoC Renewals 40
3.6.3 Implementation of AMP(s) 40
3.6.4 Evaluation Findings 40

4. CONSOLIDATED REFERENCES 43

5. GLOSSARY....47

APPENDIX A NON-QUANTIFIABLE TERMS A-1

APPENDIX B EXAMPLES OF AGING MANAGEMENT PROGRAMS....B-1

APPENDIX C [RESERVED] C-1

APPENDIX D SUPPLEMENTAL GUIDANCE FOR THE USE OF A DEMONSTRATION PROGRAM AS A SURVEILLANCE TOOL FOR CONFIRMATION OF INTEGRITY OF HIGH BURNUP FUEL DURING THE PERIOD OF EXTENDED OPERATION....D-1

APPENDIX E CONSIDERATIONS FOR RENEWALS OF CERTIFICATES OF COMPLIANCE E-1

APPENDIX F STORAGE TERMS F-1

LIST OF FIGURES

Figure A Specific-license and CoC renewal process 3
Figure 2-1. Flowchart of scoping evaluation process.....17
Figure 3-1. Flowchart of AMR process 22
Figure F-1. Flowchart for calculating storage terms F-2

LIST OF TABLES

Table 1-1. Relationship of Regulations and General Information Review 7
Table 2-1. Relationship of Regulations and Scoping Review 16
Table 3-1. Relationship of Regulations and Aging Management Reviews.....24
Table A-1. Screening Criteria for Non-Quantifiable Terms.....A-2
Table B-1. Example AMP for Localized Corrosion and Stress Corrosion Cracking of Welded Stainless Steel Dry Storage Canisters.....B-3
Table B-2. Example AMP for Reinforced Concrete Structures.....B-16
Table B-3. Example of a High Burnup Fuel Monitoring and Assessment Program.....B-24
Table B-4. Formal Evaluations of Aggregate Information on HBU Fuel Performance B-29

ABBREVIATIONS

ACI	American Concrete Institute
AMA	aging management activity
AMP	aging management program
AMR	aging management review
ANSI	American National Standard Institute
ASME	American Society of Mechanical Engineers
°C	degrees Celsius
CAP	Corrective Action Program
CFR	*Code of Federal Regulations*
CISCC	chloride-induced stress corrosion cracking
CLB	current licensing basis
CoC	certificate of compliance
CRIEPI	Central Research Institute of Electric Power Industry
DOE	U.S. Department of Energy
DSS	dry storage system
EPRI	Electric Power Research Institute
°F	degrees Fahrenheit
FSAR	final safety analysis report
GTCC	greater-than-Class-C
GWd/MTU	gigawatt days per metric ton uranium
HBU	high burnup
HDRP	HBU Dry Storage Cask Research and Development Project
ICSF	interim consolidated storage facility
ISFSI	independent spent fuel storage installation
ISG	Interim Staff Guidance
ITS	important to safety
kJ	kilojoule
LWR	light water reactor
m	meters
mol	mole
NDE	nondestructive examination
NEI	Nuclear Energy Institute
NMSS	Office of Nuclear Material Safety and Safeguards
NRC	U.S. Nuclear Regulatory Commission
OMB	Office of Management and Budget

PM	NRC Project Manager
ppm	parts per million
QA	quality assurance
s	second
SAR	safety analysis report
SER	safety evaluation report
SRP	Standard Review Plan
SSC	structure, system, and component
TEPCO	Tokyo Electric Power Company
TLAA	time-limited aging analysis
TS	technical specification
UFSAR	updated final safety analysis report

INTRODUCTION

This Standard Review Plan (SRP) is intended to provide guidance to the U.S. Nuclear Regulatory Commission (NRC) staff for the safety review of renewal applications for specific licenses of independent spent fuel storage installations (ISFSIs) and certificates of compliance (CoCs) of dry storage systems (DSSs), as codified in Title 10 of the *Code of Federal Regulations* (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."

To renew a specific license, an applicant (i.e., the licensee) must submit a license renewal application at least 2 years before the expiration of the license, in accordance with the requirements of 10 CFR 72.42(b). To renew a CoC, an applicant (i.e., CoC holder, user, or user's representative) must submit a renewal application at least 30 days before the expiration of the associated CoC in accordance with the requirements of 10 CFR 72.240(b). The NRC may renew a specific license or a CoC for a term not to exceed 40 years, in accordance with 10 CFR 72.42(a), or 10 CFR 72.240(a), respectively.

The NRC-approved DSSs listed in 10 CFR 72.214, "List of Approved Spent Fuel Storage Casks," may be used by any 10 CFR Part 72 general licensee in accordance with 10 CFR 72.212, "Conditions of General License Issued Under § 72.210." The term of a general license is tied to the term of the CoC being used. Within the general license term, each DSS has its own storage term that begins when that DSS is placed into service at the ISFSI (see Appendix F for a discussion of storage terms). When a CoC is renewed, the associated users' general licenses are also renewed. If the CoC holder chooses not to apply for the renewal of a particular CoC or is no longer in business, a licensee, licensee's representative, or another certificate holder may apply for renewal of the CoC in place of the CoC holder.

Both the specific-license and the CoC renewal applications must contain requirements and operating conditions (fuel storage, surveillance and maintenance, and other requirements) for the ISFSI or DSS that address aging mechanisms and aging effects that could affect structures, systems, and components relied upon for the safe storage of spent fuel. Renewal applications must include (1) time-limited aging analyses, if applicable, that demonstrate that structures, systems, and components important to safety will continue to perform their intended function for the requested period of extended operation, and (2) aging management programs for management of issues associated with aging that could adversely affect structures, systems, and components important to safety. Licensees and applicants are encouraged to meet with the NRC staff at public pre-application meetings to discuss their proposed plans for the renewal application.

The technical review of the renewal application is primarily a materials engineering effort. The materials discipline should coordinate its review of the renewal application with other disciplines, such as the structural, radiation protection, thermal, criticality, and quality assurance disciplines, as appropriate, to help ensure that relevant aspects of the application and review have been addressed.

This SRP defines an acceptable method for the NRC staff to review and determine if the applicant demonstrates that the specific-licensed ISFSI or the certified DSS will continue to meet the applicable regulatory requirements of 10 CFR Part 72 during the period of extended operation. The reviewer should be aware that additional interim staff guidance may have been issued to clarify or address issues following the publication of this guidance. This SRP defines

an acceptable method for satisfying the applicable regulatory requirements; it is not a regulatory requirement. An applicant may propose alternate means for satisfying the appropriate regulatory requirements. However, deviation from this guidance in whole or in part may result in an extended NRC staff review schedule.

The NRC expects to periodically revise and update this SRP to clarify the content, correct errors, and include new information, knowledge, and experience regarding aging management considerations. Comments, suggestions for improvement, and notices of errors or omissions will be considered by, and should be sent to the Director, Division of Spent Fuel Management, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001.

The guidance document is not intended to be used for the review of other 10 CFR Part 72 renewal applications, such as those for wet storage facilities or monitored retrievable storage installations.

This guidance document is also not intended to be used as the sole guidance for the review of a specific license application for an "interim consolidated storage facility" (ICSF), where a DSS structure, system, and component (SSC) has been in storage at one location for some period of time and then is transported to a second location (ICSF) for subsequent storage. Guidance for review of an application for a 10 CFR Part 72 specific license is located in NUREG-1567, "Standard Review Plan for Spent Fuel Dry Storage Facilities." However, as the DSS SSCs that will be in storage at a potential ICSF enter the period of extended operation, this guidance document is applicable to the aging management of such DSS SSCs.

Figure A is a flowchart of the specific-license and CoC renewal process.

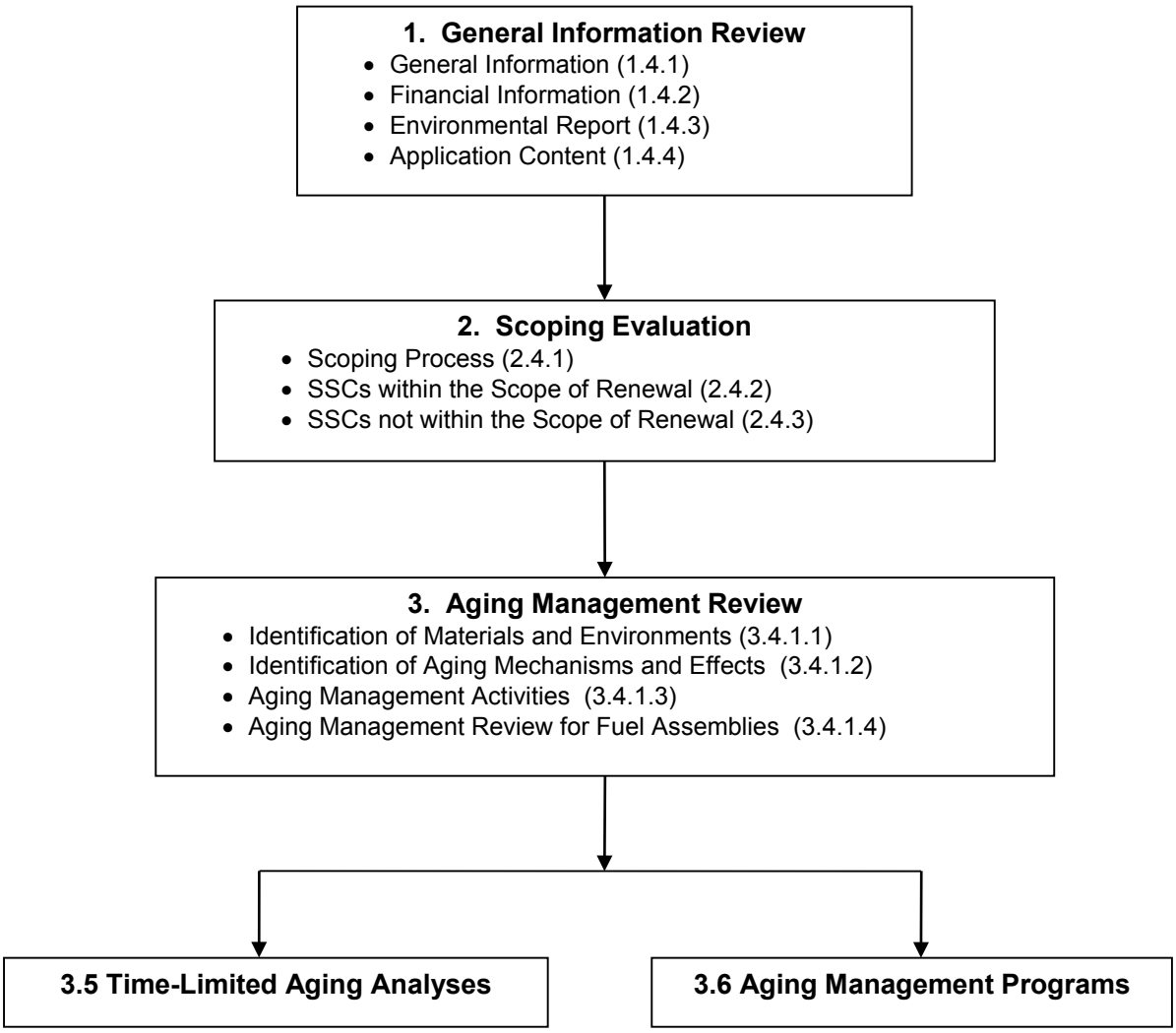

Figure A. Specific-license and CoC renewal process

Revision 1

Based on lessons learned from reviews of specific-license and CoC renewal applications and input received from the public and industry, the NRC staff proposed changes to NUREG-1927, Revision 0, to add greater detail and clarity. The staff held public meetings, including a public meeting on July 14–15, 2014, to solicit stakeholder input on the staff's considerations for revisions to the guidance. The staff subsequently took stakeholder input into consideration and developed the draft NUREG-1927, Revision 1, which was published for public comment on July 7, 2015 (80 FR 38780). The staff considered public comments received on the draft guidance in preparing the final NUREG-1927, Revision 1. The public comments are located in the Agencywide Documents Access and Management System (ADAMS) Package Accession No. ML15356A560. The staff also prepared responses to the public comments, at ADAMS Accession No. ML16125A534.

This revision of NUREG-1927 focuses on expanding guidance on application content, scoping evaluation, aging management review, time-limited aging analyses, and elements of an aging management program (AMP), including evaluation of AMPs and ensuring these programs respond to operating experience to remain adequate throughout the period of extended operation (i.e., learning AMPs). This revision of NUREG-1927 also includes new guidance in the areas of: (1) timely renewal, (2) amendment applications submitted during renewal reviews and after the renewal is issued, (3) use of terms, conditions, and specifications for ensuring AMPs remain adequate during the period of extended operation, (4) commencement of AMPs for CoC renewals and implementation of AMPs, (5) example AMPs, (6) use of a demonstration program as a surveillance tool for high burnup fuel performance, and (7) storage terms (and calculation of length of time that a dry storage system can remain loaded).

This revision to NUREG-1927 was developed in parallel with an ongoing effort by the Nuclear Energy Institute (NEI) to develop guidance for the industry in the preparation of applications for renewal of specific licenses and CoCs. NEI 14-03, Revision 1, "Format, Content and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management" (ADAMS Accession No. ML15272A329), includes guidance on the continued evaluation of operating experience (see Section 3.6.1.10 of NUREG-1927, Revision 1). One of the principles introduced in NEI 14-03 is the use of "tollgates" as a structured approach for assessing operating experience and data from applicable research and industry initiatives. In addition, NEI 14-03 describes an initiative to aggregate and disseminate aging-related operating experience, research results, monitoring feedback, and inspection data between licensees. The staff provided comments on NEI 14-03, Revision 0, "Guidance for Operations-Based Aging Management for Dry Cask Storage" (ADAMS Accession No. ML14266A225), to NEI on January 21, 2015 (ADAMS Accession No. ML15013A201). At the time of publication, the staff was continuing its review of NEI 14-03, Revision 1, for proposed NRC endorsement. However, until a time when NEI 14-03 may be endorsed by NRC, Section 3.6.1.10 of NUREG-1927, Revision 1, provides guidance to reviewers regarding information in NEI 14-03 that may be used or referenced by applicants for specific license or CoC renewals.

Standard Review Plan Structure

Each chapter of this SRP contains the following sections:

Review Objective: This section provides the purpose and scope of the review and establishes the major review objectives for the chapter. It also discusses the information needed, or coordination expected, from other NRC staff to complete the technical review.

Areas of Review: This section describes the structures, systems, and components; analyses, data, or other information; and their sequence in the discussion of acceptance criteria.

Regulatory Requirements: This section summarizes the regulatory requirements in 10 CFR Part 72 pertaining to the scoping process, aging management review, and aging management activities that include the time-limited aging analyses review. This list is not all-inclusive, and the reviewer should be aware that other parts of the regulations, such as 10 CFR Part 20, "Standards for Protection against Radiation," are assumed to apply to all licensees. The reviewer should read the complete language of the current version of 10 CFR Part 72 to determine the proper set of regulations for the section being reviewed.

Review Guidance: This section discusses the specific technical information that should be included in the application and reviewed for regulatory compliance. The review guidance can be supplemented by interim staff guidance, NUREGs, etc.

Evaluation Findings: This section provides sample summary statements for evaluation findings to be incorporated into the safety evaluation report (SER) for each area of review. The reviewer prepares the evaluation findings based on the satisfaction of the regulatory requirements. The NRC publishes the findings in the SER.

1. GENERAL INFORMATION REVIEW

1.1 Review Objective

The purpose of the general information review is to ensure that the specific-license or certificate of compliance (CoC) renewal application meets the requirements listed in Section 1.3 below.

1.2 Areas of Review

Areas of review addressed in this chapter include the following:

- general information (specific license only)
- financial information (specific license only)
- environmental report (specific license only)
- application content

Areas specifically excluded from the renewal review include the following:

- structures, systems, and components (SSCs) associated with physical protection of the independent spent fuel storage installation (ISFSI) or dry storage system (DSS), under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste," Subpart H, "Physical Protection"

- SSCs associated with the ISFSI emergency plan, under 10 CFR 72.32, "Emergency Plan"

1.3 Regulatory Requirements

Table 1-1 presents a matrix that identifies the specific regulatory requirements pertaining to application content, general information about the specific licensee or CoC holder, financial information, and the environmental report. Additional regulatory requirements for the environmental report can be found in 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions."

Table 1-1. Relationship of Regulations and General Information Review

Areas of Review			
	72.22 [a] (a), (b), (c), (d)	72.22 [a] (e)	72.30(c) [a]
Application Content	●		
General Information	●		
Financial Information		●	●
Environmental Report			

Areas of Review				
	72.34 [a]	72.42 [a]	72.48(d)	72.240 [b] (b), (c), (d)
Application Content		●	●	●
General Information				
Financial Information				
Environmental Report	●			

[a] These regulations apply only to specific license renewals per 10 CFR 72.13, "Applicability."
[b] These regulations apply only to CoC renewals per 10 CFR 72.13.

1.4 Review Guidance

This section provides review guidance for general information (Section 1.4.1), financial information (Section 1.4.2), environmental report (Section 1.4.3), and application content (Section 1.4.4). This section also provides information on timely renewal (Section 1.4.5), amendment applications submitted during the renewal review or after the renewal is issued (Section 1.4.6) and license and CoC conditions (Section 1.4.7).

1.4.1 General Information

The U.S. Nuclear Regulatory Commission (NRC) project manager (PM) should ensure that the specific licensee has provided information under 10 CFR 72.22(a)–(d), including the specific licensee's full name, address, and description of the business or occupation. If the specific licensee is a partnership, the application should identify the name, citizenship, and address of each partner, and the principal location where the partnership does business. If the specific licensee is a corporation or an unincorporated association, the application should specify the State in which it is incorporated or organized and the principal location at which it does business, along with the names, addresses, and citizenships of its directors and principal officers. If the specific licensee is acting as an agent or representative of another person in filing the application, the application should provide the above information for the principal. If the specific licensee is the U.S. Department of Energy, then the application should specify the organization responsible for the construction and operation of the ISFSI and describe any delegations of authority and assignments of responsibilities.

1.4.2 Financial Information

In general, the PM should ensure that the renewal application for a specific license contains the necessary documentation regarding financial data, under 10 CFR 72.22(e), which shows that the specific licensee can carry out the proposed activities for the requested duration. Information should state where the activity will be performed, the general plan for carrying out the activity, and the period of time for which the specific license is requested. The PM should

ensure that the renewal application is based only on the approved design bases and does not include additional construction costs beyond the design bases. The application should identify other costs related to activities associated with managing aging mechanisms and effects, and it should identify ISFSI operating and decommissioning costs that have been revised from those specified in the original specific-license application for construction, operation, and decommissioning. 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).

The scope of this standard review plan (SRP) does not include specific guidance for reviewing financial information. Financial reviews should be coordinated with financial reviewers in the Performance Assessment Branch of the Office of Nuclear Material Safety and Safeguards (NMSS) or the Office of Nuclear Reactor Regulation.

1.4.3 Environmental Report

The PM should ensure that the specific-license renewal application contains an environmental report or supplement, as required by 10 CFR 51.60, "Environmental Report—Materials Licenses" and 10 CFR 72.34, "Environmental Report." The supplemental report may be limited to incorporating by reference, updating, or supplementing the information previously submitted to reflect any significant environmental changes, including those that may result from operating experience as related to environmental conditions, or a change in operations or proposed decommissioning activities.

The environmental report should also meet the general requirements of 10 CFR 51.45, "Environmental Report," as applicable. As required by 10 CFR 51.45(c), the environmental report should contain sufficient data to aid the NRC in its development of an independent analysis.

The review of the environmental report should be coordinated with the Environmental Review Branch of NMSS.

1.4.4 Application Content

The reviewer should look for a map or guide to the renewal application to assist in its review, because the format may vary from that of a standard safety analysis report (SAR). The PM or reviewer should verify that the renewal application for both CoC and specific-license renewals contain all of the following sections:

- general Information (specific license only)
- scoping evaluation
- aging management review (AMR)
- time-limited aging analyses (TLAAs)
- aging management programs (AMPs)
- information pertaining to granted exemptions and their implication to aging management

- changes or additions to technical specifications or to the specific license or CoC

- supplement to the final safety analysis report (FSAR), including:

  – scoping results
  – table of AMR results
  – summary of TLAAs and TLAAs' conclusions
  – summary of AMPs

- annotations to show 10 CFR 72.48 ("Changes, Tests, and Experiments") changes since last biannual update as required by 10 CFR 72.48(d)(2) or any other changes from either the SAR pages included with the last approved amendment (or initial) application, or the FSAR, whichever is most recent

For CoC renewal applications that involve multiple amendments, the PM or reviewer should verify that the renewal application also includes:

- a description of the organization of the renewal application as it relates to the different amendments (i.e., for the CoC as a whole)

  – This could be in the form of a guide to the renewal application to identify the sections or appendices applicable to each CoC amendment.

- a clear description of each amendment

  – That is, what each amendment changed from (or added to) the initial certificate (i.e., "amendment 0"), or what each amendment changed from (or added to) the previous amendments, should be described.

- a clear description of the scope and content of the renewal application as it applies to each amendment

  – If there are different SSCs, materials, contents specifications, or environments described in the different CoC amendments, the application should specify any differences in the scoping evaluation, aging management review, TLAAs, and AMPs, for each individual amendment.

A CoC renewal includes the initial certificate ("amendment 0") and all subsequent amendments. The subsequent amendments have the same termination date as the initial certificate. The CoC holder has the option to request that only certain (i.e., not all) amendments under a CoC be renewed. If amendments are not renewed, upon expiration, casks loaded under that amendment would need to be removed from service when they reach the end of their storage term (see Appendix F for calculation of storage terms). As a means to extend the storage term, a general licensee (cask user) also may have the option to apply changes authorized by another amendment to the CoC that has been renewed, to a cask loaded under an amendment that has not been renewed following the requirements in 10 CFR 72.212.

Drawings provided as part of the renewal application should be clear and legible. If information in drawings is unclear or illegible, the PM should ask the applicant for additional, larger or full-size drawings. The reviewer should ensure that dimensions, materials, and other details on

the drawings are consistent with those described in both the text of the renewal application and the FSAR supplement.

The reviewer should verify that the applicant has updated the appropriate drawings to reflect any changes made to the design of the SSCs through the application of 10 CFR 72.48. Reviewers should be familiar with NUREG/CR-5502, "Engineering Drawings for 10 CFR Part 71 Package Approvals," issued May 1998. Although NUREG/CR-5502 was developed for transportation packages, the criteria for drawings are consistent for storage designs and therefore useful to the review process.

If the applicant provided drawings and descriptions as proprietary information in the application and requested them to be withheld from the public, the PM should review the request for withholding and ensure all the necessary information is available for the NRC to make a decision on the withholding request, in accordance with the requirements of 10 CFR 2.390, "Public Inspections, Exemptions, Requests for Withholding." The applicant should also submit a nonproprietary version of the document to be made available to the public.

The reviewer should ensure the specific-license or CoC renewal application does not include any changes to the design bases. Changes to the design bases must be requested through a separate amendment process. However, the renewal application may include editorial changes or corrections that do not change the design bases.

1.4.5 Timely Renewal

To renew a specific license, an applicant must submit a renewal application at least 2 years before the expiration of the license in accordance with the requirements of 10 CFR 72.42(b). To renew a CoC, an applicant must submit a renewal application at least 30 days before the expiration of the CoC in accordance with the requirements of 10 CFR 72.240(b). When the applicant has submitted a timely application for renewal, the existing specific license or CoC will not expire until a final decision concerning the application for renewal has been made by the Commission. Therefore, any DSSs loaded during the initial license or CoC period may remain in service until the review of the renewal application is complete.

1.4.6 Amendment Applications Submitted during the Renewal Review or after the Renewal Is Issued

By regulation, applicants must demonstrate that SSCs important to safety will continue to perform their intended function(s) for the requested period of extended operation as a part of the renewal request. For *concurrent amendment and renewal applications*, the amendment application should include a scoping evaluation and an AMR for that amendment to document the evaluation of the amendment's SSCs (and associated subcomponents) for extended operation, or the renewal application should be supplemented to address the proposed amendment to document the evaluation of the amendment's SSCs (and associated subcomponents) for extended operation. Any *amendment application submitted after the renewal has been issued* (*post-renewal amendment applications)* should include a scoping evaluation and an AMR for that amendment.

For post-renewal amendment applications or concurrent amendment applications that include a scoping evaluation and an AMR, the amendment application should either: (1) show that the in-scope SSCs (and associated subcomponents) described in the amendment are already encompassed in the TLAAs or AMPs included in the specific-license or CoC renewal

application, or (2) include revised or new TLAAs or AMPs to address aging effects of any new in-scope SSCs (and associated subcomponents) proposed in the amendment application. The PM and technical reviewers should verify that the following information is included in the amendment application (see also Section 1.4.4):

- a scoping evaluation that identifies any new SSCs (and associated subcomponents) included in the amendment request and discusses whether the SSCs (and associated subcomponents) are included or excluded from the scope of renewal, following the guidance in Chapter 2
- an aging management review that identifies any applicable aging mechanisms and effects for the new SSCs (and associated subcomponents) within the scope of renewal
- changes to the FSAR, which should include:
  - scoping results and identification of any new in-scope SSCs
  - revised table of AMR results
  - identification of the approved TLAAs (or the TLAAs included in the renewal application, for concurrent amendments) that address the new in-scope SSCs, or identification and a summary of any revised or new TLAAs and the TLAAs' conclusions that support the amendment
  - identification of the approved AMPs (or the AMPs included in the renewal application, for concurrent amendments) that encompass the new in-scope SSCs (and associated subcomponents), or a summary of proposed changes to approved AMPs (or the AMPs in the renewal application, for concurrent amendments) or new AMPs that will apply to the new in-scope SSCs (and associated subcomponents)

For concurrent amendment and renewal applications, if there are different PMs assigned to the renewal review and the amendment review, the PMs and technical reviewers should coordinate across the reviews to ensure that renewal aspects are covered for the amendment. Note that, before proceeding with the review of an amendment submitted *during* the renewal review, the PMs should consider how each review may affect the other, and decide, in conjunction with Branch and Division management, whether to proceed with both reviews, or to delay one review until the other is complete. For additional guidance, refer to Regulatory Issue Summary (RIS) 2004-20, "Lessons Learned from Review of 10 CFR Parts 71 and 72 Applications, (NRC 2004)."

The NRC staff may include a condition in the renewed license or CoC noting all future amendments would need to address aging management.

1.4.7 Terms, Conditions, and Specifications for Specific Licenses and CoCs in the Period of Extended Operation

In renewing a license or CoC, the staff should consider whether any terms, conditions, or specifications are needed to ensure the safe operation of the ISFSI or DSS during the period of extended operation, including but not limited to, terms, conditions, and specifications that will require implementation of any AMPs. Several conditions are likely to be included in the license or CoC.

Generally, NRC staff will renew the license or CoC with a condition requiring the specific licensee or CoC holder, respectively, to incorporate a renewal supplement into the FSAR, as submitted in the renewal application and revised through the review process (see Section 1.4.4). The specific licensee will be required to continue to update the FSAR under the requirements in 10 CFR 72.70. The CoC holder will be required to continue to update the FSAR under the requirements in 10 CFR 72.248.

NRC staff may renew a license or CoC with a condition requiring licensees to implement the activities in the AMPs (e.g., update, revise, or create programs or procedures for AMP implementation) by a specific date (see Section 3.6.3). These programs and procedures will be subject to NRC inspection to ensure they are maintained, implemented, and periodically updated to respond to operating experience, while providing reasonable assurance that the pertinent SSCs will continue to perform their intended functions in the period of extended operation.

As the entirety of the AMP may not be included in the license, CoC, or technical specifications, site procedures for AMP implementation may later be changed without prior NRC review and approval. Therefore, the staff should consider whether additional conditions or specifications are needed in the specific license or CoC to ensure elements of the AMPs, which are the basis of the staff's findings and the decision to issue the renewal, are effectively retained or implemented (e.g., timeframes for development of inspection or examination methods). These conditions should be specific to information in the AMP described in the renewal application which staff relied upon to make the requisite safety findings of reasonable assurance of adequate protection of public health and safety, and the environment.

The entire AMPs may be included as an appendix to the staff's safety evaluation report (SER), for complete documentation of the staff's safety evaluation, findings, and decision to issue the renewal. The staff should include a separate section in the SER that includes any new or modified terms, conditions, or specifications that were added to the license or CoC as a result of the renewal review. This section should include the basis for each new or revised term, condition, or specification, or it should include a reference to the other sections of the SER that discuss the staff's evaluation and findings that form the basis for the new or revised term, condition, or specification.

For CoC renewals, additional terms, conditions, or specifications may be needed to ensure the safe operation of the cask during the renewal term, including but not limited to, terms, conditions, and specifications that will require the implementation of an AMP, in accordance with 10 CFR 72.240(e). Such conditions may include requirements for a future or existing general licensee (cask user) to include in its 10 CFR 72.212(b)(5) evaluation (including the results of the review and determination per 10 CFR 72.212(b)(6) and 10 CFR 72.212(b)(8)) how it will meet the new CoC terms, conditions, or specifications for aging management (see Appendix E).

The NRC staff may also include a condition in the renewed license or CoC to ensure that all future amendments address the renewed design bases for the ISFSI or CoC, including any aging management considerations. See Section 1.4.6 for guidance on post-renewal amendments.

In addition, the applicant may also propose additional license or CoC conditions as part of its application, if these support the technical basis for the application and the proposed TLAAs or AMPs that ensure the safe operation of the ISFSI or DSS during the period of extended operation.

1.5 Evaluation Findings

The reviewer prepares a summary statement and evaluation findings based on compliance with the regulatory requirements in Section 1.3. The summary statement and evaluation findings should be similar in wording to the following example (the finding number is for convenience in cross-referencing within the SRP and SER):

The NRC staff has reviewed the general information provided in the renewal application and supplemental documentation. The NRC staff performed its review following the guidance provided in NUREG-1927, Revision 1, "Standard Review Plan for Renewal of Specific Licenses and Certificates of Compliance for Dry Storage of Spent Nuclear Fuel," and relevant interim staff guidance. Based on its review, the NRC staff finds:

F1.1 The information presented in the renewal application satisfies the requirements of 10 CFR 72.2, 72.22, 72.30, 72.34, 72.42, 72.48, and 72.240, as applicable.

F1.2 The applicant has provided a tabulation of all supporting information and docketed material incorporated by reference, in compliance with 10 CFR 72.42 or 72.240, as applicable.

2. SCOPING EVALUATION

2.1 Review Objective

The scoping evaluation should identify the structures, systems, and components (SSCs) of the independent spent fuel storage installation (ISFSI) or dry storage system (DSS) that should be reviewed for aging mechanisms and effects.

2.2 Areas of Review

The reviewer should ensure that the applicant has included information about the following areas of review:

- scoping process
- SSCs within the scope of specific-license or certificate of compliance (CoC) renewal
- SSCs not within the scope of specific-license or CoC renewal

2.3 Regulatory Requirements

The U.S. Nuclear Regulatory Commission (NRC) bases a specific-license or CoC renewal on the continuation of the approved design bases throughout the period of extended operation. The entire design bases of the specific license or CoC is considered to be renewed when NRC issues a renewed license or CoC. However, the NRC's renewal review is focused on the maintenance of the intended functions of (a) SSCs important to safety and (b) SSCs failure of which may affect a safety function, as discussed in Section 2.4.2. This guidance document refers to such SSCs as those that are within the scope of renewal, and these are the SSCs that are further reviewed for aging mechanisms and effects, as discussed in Chapter 3, "Aging Management Review."

If new safety-related deficiencies in the design bases are discovered, they must be addressed and rectified through the specific-license or CoC amendment process. The renewal process cannot be used to facilitate approval of design changes.

Table 2-1 presents a matrix of regulatory requirements for renewal related to the scoping review.

Table 2-1. Relationship of Regulations and Scoping Review

Areas of Review	10 CFR Part 72 Regulations					
	72.3	72.24 [a] (b), (c), (d)	72.24 [a] (g)	72.42 [a] (b)	Subpart F: Applicable Sections 72.120, 72.122, 72.124, 72.126, 72.128	72.236 [b] Applicable Sections
Scoping Process			●	●		●
SSCs within the Scope of Specific-License or CoC Renewal	●	●	●		●	●
SSCs not within the Scope of Specific-License or CoC Renewal		●	●		●	●

[a] These regulations apply only to specific-license renewals per Title 10 of the *Code of Federal Regulations* (10 CFR) 72.13.
[b] These regulations apply only to CoC renewals per 10 CFR 72.13.

2.4 Review Guidance

This section provides review guidance for the scoping evaluation. Section 2.4.1 explains the scoping process, Section 2.4.2 discusses SSCs within the scope of renewal, while Section 2.4.3 provides guidance for SSCs not within the scope of renewal.

2.4.1 Scoping Process

Figure 2-1 provides a flowchart of the scoping evaluation process. The reviewer should ensure that the application provides documentation of the scoping process that includes the following:

- a description of the scoping process and method for the inclusion or exclusion of SSCs (and associated subcomponents) from the renewal scope
- a list of the SSCs (and associated subcomponents) that are identified as within the scope of renewal, their intended function, and safety classification or basis for inclusion in the renewal scope
- a list of the SSCs (and associated subcomponents) that are identified as *not* within the scope of renewal and basis for exclusion
- a list of the sources of information used
- any discussion or drawings needed to clarify the process, SSC intended functions and safety classifications

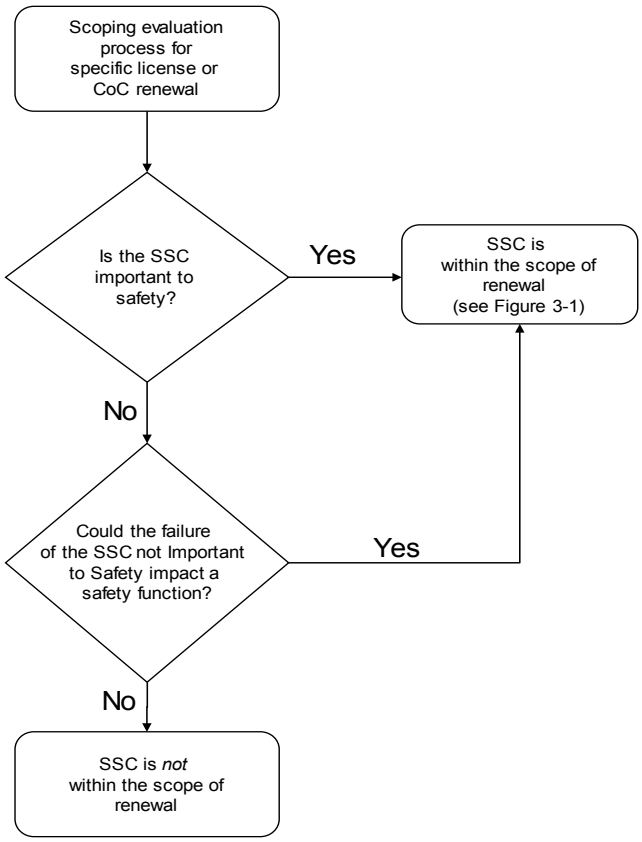

Figure 2-1. Flowchart of scoping evaluation process

The application should include a list and description of reference sources used to support the scoping evaluation. Sources may include the following:

- safety analysis reports (SARs), including final SARs (FSARs), updated FSARs, and topical SARs
- license or CoC
- technical specifications
- approved exemptions
- operating procedures
- design-bases documents (e.g., calculations, specifications, design change documents)
- drawings

- quality assurance plan or program
- docketed correspondence
- operating experience reports (site-specific or industrywide, as applicable)
- Title 10 of the *Code of Federal Regulations* (10 CFR) 72.48 ("Changes, Tests, and Experiments") evaluations and screenings
- vendor information
- applicable NRC guidance

The reviewer can refer to NUREG/CR-6407, "Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety," as a reference for classification of components as important to safety to determine the accuracy and completeness of the scoping evaluation. The reviewer should ensure that the scoping evaluation has evaluated *all* SSCs identified in the design-bases documents and properly differentiated them as either within or *not* within the scope of renewal. In addition, the identification of SSCs and SSC subcomponents in the scoping evaluation should be consistent throughout the application.

2.4.2 Structures, Systems, and Components within the Scope of Renewal

The reviewer should verify that the SSCs (and associated subcomponents) within the scope of renewal fall into the following scoping categories:

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

i. maintain the conditions required by the regulations, specific license, or CoC to store spent fuel safely

ii. prevent damage to the spent fuel during handling and storage

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

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

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

The reviewer should verify that SSCs within the scope of renewal are screened to identify and describe the subcomponents with intended functions. The reviewer should recognize that SSC subcomponents may degrade by different modes, or have different criteria for evaluation from the overall component (i.e., different materials or environments).

The scoping evaluation should clearly (1) define the intended function of each SSC subcomponent and (2) differentiate SSC subcomponents per scoping criteria 1 and 2, as defined above. The reviewer should ensure that this information is tabulated or adequately described in the application. The reviewer should confirm that this information is comprehensive and accurate (i.e., SSC subcomponents are not missing from the scoping evaluation; SSC subcomponent naming is consistent with the design bases; intended functions are properly described) by comparing the results of the scoping evaluation to appropriate final safety analysis report (FSAR) drawings or tables.

2.4.2.1 Scoping of Fuel Assemblies

Traditional light water reactor spent nuclear fuel consists of fuel rods and assembly hardware. In turn, the fuel rods consist of uranium oxide pellets inside a cladding tube. The spent fuel cladding and assembly hardware provide structural support to ensure that the spent fuel is maintained in a known geometric configuration. The safety analyses for an ISFSI or DSS (e.g., criticality and shielding analyses) may rely on the fuel assembly having a specific configuration (e.g., geometric form, a certain number of fuel rods or solid replacement filler rods in the assembly lattice). As the renewal of a specific license or CoC is based on continuation of the approved design bases throughout the period of extended operation (as discussed in Section 2.3), for these ISFSIs or DSSs, the renewal application should demonstrate that the analyzed fuel configuration is maintained during the period of extended operation. Therefore, the condition of the fuel assembly and cladding are within the scope of renewal and should be reviewed for any aging mechanisms and effects that may lead to a change in the analyzed fuel configuration. If a licensee or CoC holder wishes to revise the safety analyses for the approved design-bases fuel configuration (i.e., analyzed fuel configuration), it should pursue such a change through an amendment or revision request, and not as part of the renewal application.

2.4.2.2 Scoping of Structures, Systems, and Components, Depending on Individual Design Bases

In some cases, transfer casks, transporter devices, reinforced concrete pads, and other engineered features (e.g., earthen berms, shield walls, or engineered fill within an underground ISFSI) may be classified as important to safety or safety-related (under 10 CFR Part 50) in the design bases of various ISFSIs or DSSs. The reviewer should review the FSAR to determine how these SSCs are used in the FSAR evaluations and described in the license or CoC, to understand whether these SSCs are considered part of the design bases, and thus whether they are considered to be within the scope of renewal.

2.4.3 Structures, Systems, and Components Not within the Scope of Renewal

For those SSCs (and associated subcomponents) excluded from the scope of renewal, the reviewer should verify that they do not meet either of the criteria described in Section 2.4.2. The reviewer should ensure that the applicant has properly justified any exclusions by referencing the design bases (i.e., FSAR description, drawings, or tables).

The following SSCs may be excluded from the scope of renewal, provided that they do not meet either of the criteria in Section 2.4.2 above:

- equipment associated with cask loading and unloading, such as (1) welding and sealing equipment, (2) lifting rigs and slings, (3) vacuum-drying equipment, (4) portable radiation

survey equipment, and (5) other tools, fittings, hoses, and gauges associated with cask loading and unloading

- Instrumentation and other active components/systems (i.e., not passive or long-lived, but subject to a change in configuration or replacement based on a qualified life or service time period)

- miscellaneous hardware that does not support or perform any function that is important to safety

2.5 Evaluation Findings

The reviewer prepares the summary statement and evaluation findings based on compliance with the regulatory requirements described in Section 2.3. The summary statement and evaluation findings should be similar in wording to the following example (the finding number is for convenience in cross-referencing within the Standard Review Plan (SRP) and safety evaluation report (SER)):

The NRC staff reviewed the scoping evaluation provided in the renewal application and supplemental documentation. The NRC staff performed its review following the guidance provided in NUREG-1927, Revision 1, "Standard Review Plan for Specific Licenses and Certificates of Compliance for Dry Storage of Spent Nuclear Fuel," and relevant ISGs. The NRC staff used the information provided in NUREG/CR-6407 ("Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety") in its review as a reference for classification of components as important to safety to determine the accuracy and completeness of the scoping evaluation. Based on its review, the NRC staff finds:

F2.1 The applicant has identified all SSCs important to safety and SSCs failure of which could prevent an SSC from fulfilling its safety function, per the requirements of 10 CFR 72.3, 10 CFR 72.24, 10 CFR 72.42, 10 CFR 72.120, 10 CFR 72.122, 10 CFR 72.124, 10 CFR 72.126, 10 CFR 72.128 and 10 CFR 72.236, as applicable.

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

3. AGING MANAGEMENT REVIEW

3.1 Review Objective

The purpose of the aging management review (AMR) is to assess the proposed aging management activities (AMAs) for structures, systems, and components (SSCs) determined to be within the scope of renewal. The AMR addresses aging mechanisms and effects [1] that could adversely affect the ability of the SSCs (and associated subcomponents) from performing their intended functions during the period of extended operation. The reviewer should verify that the renewal application includes specific information that clearly describes the AMR performed on SSCs within the scope of renewal.

3.2 Areas of Review

The reviewer should ensure that the AMR in the renewal application provides the following content with adequate technical bases:

- identification of materials and environments for those SSCs and associated subcomponents determined to be within the scope of renewal
- identification of aging mechanisms and effects requiring management
- identification of time-limited aging analyses (TLAAs), if applicable, and aging management programs (AMPs) for managing the effects of aging

Figure 3-1 contains a flowchart for the AMR process. The final safety analysis report (FSAR) and supporting documents related to the design are the primary documents that describe the safety classification, intended function, materials, and service environments for SSCs of independent spent fuel storage installations (ISFSIs), dry storage systems (DSSs), or both, identified to be within the scope of renewal (see Section 2.4.1).

The reviewer should consult applicable consensus codes and standards that provide additional guidance on the applicability of aging mechanisms and effects. The use of ambiguous terminology from any standard (e.g., “change in material properties”) should be properly defined or referenced in the application. Refer to Appendix A for assessing non-quantifiable terms.

[1] To effectively manage an aging effect, it is necessary to determine the aging mechanisms that are potentially at work for a given material and environment application. Therefore, the aging management review process identifies both the aging effects and the associated aging mechanisms that cause them.

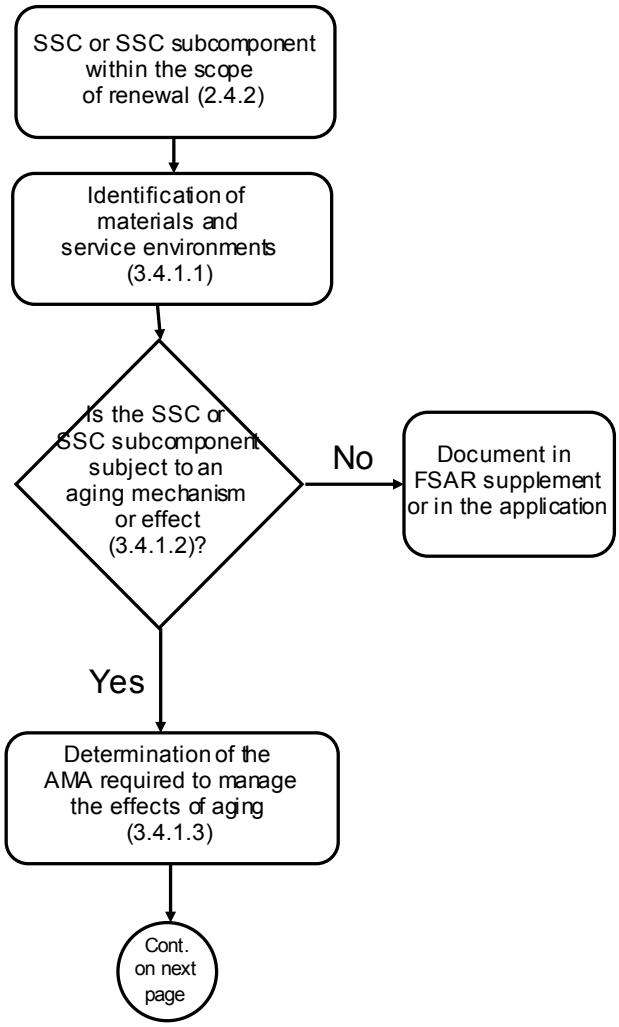

Figure 3-1. Flowchart of AMR process

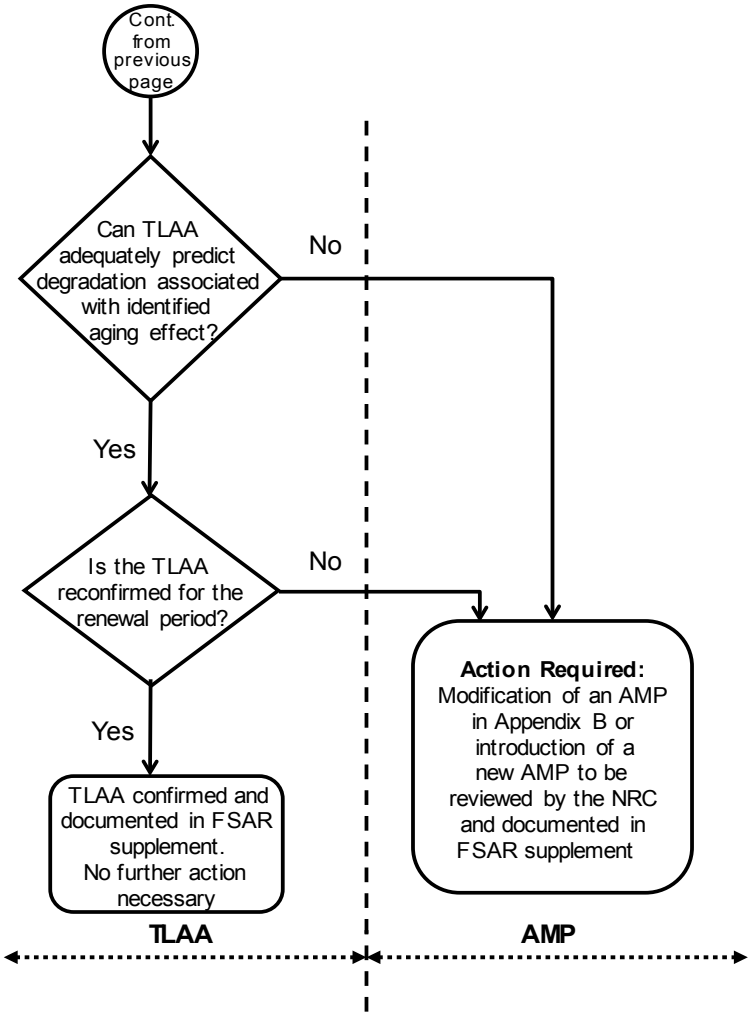

Figure 3-1. Flowchart of AMR process (continued)

3.3 Regulatory Requirements

Title 10 of the *Code of Federal Regulations* (10 CFR) 72.42 and 10 CFR 72.240 provide the overarching requirements for aging management activities for renewal of specific licenses and certificates of compliance (CoCs). Table 3-1 presents a matrix of regulatory requirements that must continue to be met to ensure that the intended functions of SSCs of ISFSIs and DSSs are maintained during the period of extended operation. Other parts of 10 CFR Part 72 may also apply.

Table 3-1. Relationship of Regulations and Aging Management Reviews

Areas of Review	10 CFR Part 72 Regulations				
	72.24 [a] (d)	72.82 [a] (d)	72.104 [a] (a)	72.106 [a] (b)	72.120 [a] (a),(d)
Aging Effects	●		●	●	●
Aging Management, Maintenance, or Surveillance Programs		●			
TLAAs	●		●	●	●

Areas of Review	10 CFR Part 72 Regulations				
	72.122 [a] (a),(b),(c),(h)(1),(h)(5),(l)	72.122 [a] (f),(h)(4),(i)	72.124	72.126[a]	72.128 [a] (a)
Aging Effects	●		●	●	
Aging Management, Maintenance, or Surveillance Programs		●		●	●
TLAAs	●	●	●	●	●

Areas of Review	10 CFR Part 72 Regulations				
	72.158	72.162	72.164	72.168 (a)	72.170
Aging Effects	●	●	●		
Aging Management, Maintenance, or Surveillance Programs	●	●	●	●	●
TLAAs					●

Table 3-1. Relationship of Regulations and Aging Management Reviews (continued)

Areas of Review	10 CFR Part 72 Regulations		
	72.172	72.236 [b] Applicable Sections	72.240(d) [b]
Aging Effects		●	●
Aging Management, Maintenance, or Surveillance Programs	●	●	●
TLAAs			

[a] These regulations apply only to specific-license renewals per 10 CFR 72.13.
[b] These regulations apply only to CoC renewals per 10 CFR 72.13.

3.4 Materials, Service Environments, Aging Mechanisms and Effects, and Aging Management Activities

3.4.1 Review Guidance

This section provides review guidance for the aging management review. Section 3.4.1.1 describes the identification of materials and their environments. Section 3.4.1.2 describes the identification of aging mechanisms and effects. Section 3.4.1.3 describes the review of aging management activities. Section 3.4.1.4 describes the aging management review for spent fuel assemblies.

3.4.1.1 Identification of Materials and Environments

The AMR process includes the identification of the materials of construction and the service environments for each SSC (or SSC subcomponent) within the scope of renewal. The identification of SSCs and SSC subcomponents in the AMR process should be consistent with the identification in the scoping evaluation. The reviewer should ensure that the renewal application has provided environmental data (and referenced the source of the data) such that the range of operating and service conditions of the SSCs can be determined. The pertinent environmental data is that which has a direct bearing on aging and the proposed aging management approach, and may include:

- temperature
- wind
- relative humidity
- relevant atmospheric pollutants and deposits
- exposure to precipitation
- marine fog, salt, or water exposure
- radiation field (gamma and neutron)
- the service environment (e.g., embedded, sheltered, or outdoor)
- gas compositions (e.g., external: air; internal: inert gas such as helium)

The reviewer should verify that the applicant considered the specific environment and material combinations in the DSS design for the evaluation of observed and potential aging mechanisms and effects that may lead to a loss of intended function. Particular attention should be paid to dissimilar metal combinations that may result in galvanic effects such as hydrogen uptake or galvanic corrosion. For sheltered environments that are in contact with the site atmosphere, the potential deposition and accumulation of atmospheric deposits should be evaluated. For example, chloride salt deposits that can promote accelerated corrosion of SSCs may be relevant in locations near salt water, adjacent to cooling towers, or in close proximity to roads that are treated with deicing salts.

3.4.1.2 Identification of Aging Mechanisms and Effects

The reviewer should ensure that the applicant has provided an analysis and documentation that identify aging mechanisms and effects pertinent to the SSCs determined to be within the scope of renewal. The AMR should include aging mechanisms and effects that could reasonably be expected to occur, as well as those that have actually occurred, based on industry and site-specific operating experience and component testing. The reviewer should ensure that the CoC renewal evaluates all potential environments where the DSS may be used and provides applicable operating experience to justify the AMR conclusions.

The reviewer should review the applicant's synopses of information used to identify applicable aging mechanisms and effects. Identification of applicable aging mechanisms and effects may be through review of:

- site maintenance, repair, and modification records
- corrective action reports, including root cause evaluations
- pre-application inspection results (see below)
- maintenance and inspection records from ISFSI sites with similar SSC materials and operating environments
- industry records
- applicable operating experience outside the nuclear industry
- applicable consensus codes and standards
- U.S. Nuclear Regulatory Commission (NRC) reports
- other applicable guidance for determining if an aging mechanism or effect should be managed for the period of extended operation

Examples of potential aging mechanisms and effects that may be identified by reviewing the sources of information cited above include: (1) cracking or loss of strength as a result of cement aggregate reactions in the concrete, (2) cracking or loss of material as a result of freeze-thaw degradation of the concrete (requires the presence of moisture combined with temperatures below freezing), (3) reinforcement corrosion and concrete cracking as a result of chloride ingress, (4) accelerated corrosion of steel structures and components and stress corrosion cracking of austenitic stainless steels as a result of atmospheric deposition of chloride salts.

The reviewer should ensure that, if the applicant relies on operating experience, it is specifically applicable to the SSC subcomponent/material/environment, and is not just a compendium of references on similar topics.

The applicant is not required to take further action if an SSC is determined to be within the scope of renewal but is found to have no potential aging effects for the period of extended operation. The reviewer should verify that the applicant's exclusion of an aging mechanism or effect is consistent with maintenance records, operating experience, and information obtained during pre-application inspection(s). The reviewer should also ensure that the FSAR supplement or other application materials document the applicant's determination of SSCs requiring no further review.

Pre-Application Inspections

Because inspections of DSSs are not typically conducted during the initial storage period, or are narrow in scope, the reviewer may have limited information regarding applicable aging mechanisms and effects for the specific design, environment, and operational parameters. Although there is no specific regulatory requirement for a pre-application inspection, it is one means by which an applicant can demonstrate that an aging effect does or does not require management. It can provide valuable operating experience and can be used to verify the condition of SSCs and SSC subcomponents is as-expected. The pre-application inspection is performed before submittal of the specific-license or CoC renewal application, and the inspection results become part of the technical bases for renewal.

Pre-application inspections should bound the site conditions, system designs, material combinations, and operating parameters that may contribute to the potential aging mechanisms and effects for SSCs and SSC subcomponents within the scope of renewal. For example, if chloride-induced stress corrosion cracking (CISCC) of a stainless steel canister is a potential aging mechanism, then the pre-application inspection should be conducted on the canister that has the greatest susceptibility to CISCC. The determination of susceptibility may involve the initial heat load of the canister, expected temperature variations on the canister surface with priority given to the coolest locations and welds, and the canister location if it is determined that some DSSs at a site may be located closest to or oriented toward a source of atmospheric chlorides. To address such variables, particularly for CoC renewal applications, pre-application inspections may involve SSCs in multiple DSSs at an ISFSI, and DSSs at multiple ISFSIs, as applicable.

Pre-application inspections may not include transfer casks or other similar SSCs that are leased or otherwise not actually on site. The latter SSCs are generally subject to maintenance requirements before use. Records from these maintenance activities may be included in the application in support of their respective aging management programs. Applicants are encouraged to discuss their considerations for selecting the system(s) to inspect with NRC staff in pre-application meetings before submitting the renewal application.

The reviewer should ensure that the scope, methods, and acceptance criteria for pre-application inspections align with the guidance for the AMP elements described in Section 3.6.1 of this document. The reviewer may use technical information in the example aging management programs in Appendix B as a reference when reviewing the adequacy of pre-application inspections. The reviewer should ensure that the application provides a description of any initiated corrective actions (including results from actions to verify extent of condition) due to conditions identified in the pre-application inspection(s).

The reviewer may accept the use of surrogate inspections (inspections conducted at other sites as a substitute for inspections conducted at the site(s) within the subject license or CoC) for identifying the relevant aging mechanisms and effects in the renewal application, but only when the technical basis is supported by substantial operating experience. Differences in materials, fabrication practices, design modifications, and environmental conditions at various sites could make comparisons between different ISFSI sites invalid.

The CoC holder is responsible for providing the technical basis for the proposed approach to aging management at multiple sites (where the CoC is and can be used). Therefore, pre-application inspections are likely only practical at a subset of sites that use the CoC. In this case, the reviewer should ensure that the chosen subset of sites is bounding with respect to the susceptibility of the various potential aging effects. Although CoC holders do not have the authority to conduct pre-application inspections at general licensee ISFSI sites, CoC holders could work within their user groups to identify bounding systems for the pre-application inspections. If pre-application inspections are not performed for each of the sites with the subject license or CoC, the reviewer should ensure that aging management programs include baseline inspections at each site upon entering the period of extended operation.

During baseline inspections, or the first inspections conducted per the AMPs, each licensee should assess the condition of SSCs: (1) to confirm the results of pre-application inspections that were conducted at other sites are bounding, or (2) to verify the adequacy of the AMPs and the conclusions of the TLAAs, when pre-application inspections were not performed. Also, the reviewer should consider whether uncertainties in SSC degradation due to the lack of a pre-application inspection warrant conditions in the license or CoC to require baseline inspections immediately upon entering the period of extended operation (see Section 1.4.7).

3.4.1.3 Aging Management Activities

The reviewer should ensure that the applicant has identified those aging mechanisms and effects requiring either an AMP or TLAA. Figure 3-1 illustrates the process for handling those SSCs that are determined to be within the scope of renewal and subject to a potential aging effect. The AMR defines two methods for addressing potential aging mechanisms and effects: TLAA (Section 3.5) and AMP (Section 3.6).

The NRC may condition the approval of a renewal on the requirements of a given AMP being met during the period of extended operation (see Section 1.4.7). The CoC user (general licensee) would ordinarily carry out the activities described in this AMP. Under 10 CFR 72.212(b)(11) and 10 CFR 72.240(e), the NRC may add the appropriate condition(s) or technical specification(s) to the renewed CoC for general licensee implementation of the AMP. Specific licenses may also be similarly conditioned (see Section 1.4.7).

3.4.1.4 Aging Management Review for Fuel Assemblies

Because the DSS interior and cladding cannot be reasonably inspected, the reviewer should rely on lessons learned from NUREG/CR-6745, “Dry Cask Storage Characterization Project—Phase 1; CASTOR V/21 Cask Opening and Examination,” (Bare et al., 2001), and NUREG/CR-6831, “Examination of Spent PWR Fuel Rods after 15 Years in Dry Storage,” (Einziger et al., 2003). This research demonstrated that low burnup fuel cladding and other cask internals had no deleterious effects after 15 years of storage. This research confirmed the basis for the guidance on creep deformation in Interim Staff Guidance (ISG) 11, “Cladding Considerations for the Transportation and Storage of Spent Fuel,” Revision 3, (NRC 2003). The

NRC staff has indicated in ISG 11, Revision 3 that the spent fuel configuration is expected to be maintained as analyzed in the safety analyses for the ISFSI or DSS, provided certain acceptance criteria (regarding maximum fuel clad temperature and thermal cycling) are met, and the fuel is stored in a dry inert atmosphere. These research results suggest that degradation of low burnup fuel cladding and assembly hardware should not occur during the first renewal period, provided that the cask or canister internal environment is maintained.

The reviewer should assess whether the applicant has considered the most recent revision of ISG-11 and research results in this area, especially with respect to high burnup (HBU) fuel. Research into fuel performance in storage is an ongoing effort.[2] The reviewer should ensure that the applicant has monitored new research developments to ensure it has identified any new potential aging mechanisms and effects and provided new supporting data demonstrating HBU fuel performance during the period of extended operation. Although NRC has confidence based on short-term testing (i.e., laboratory scale testing up to a few months) that there is no degradation of HBU fuel that would result in spent fuel being in an unanalyzed configuration in the period of extended operation, there is no operational data to demonstrate this as was done in the aforementioned demonstration on low burnup fuel.

Guidance for one acceptable approach to demonstrate the HBU fuel performance during the period of extended operation is provided in the "Example of a High Burnup Fuel Monitoring and Assessment Program" in Appendix B. This is a licensee program that monitors and assesses data and other information regarding HBU fuel performance, to confirm that the analyzed HBU fuel configuration is maintained during the period of extended operation. Guidance for determining if a surrogate demonstration program can provide the data to support a licensee's HBU Fuel Monitoring and Assessment Program is given in Appendix D. Alternative approaches to that presented in Appendix B may be used, as appropriately justified by an applicant.

3.4.2 Evaluation Findings

The reviewer prepares the summary statement and evaluation findings based on compliance with the regulatory requirements in Section 3.3. The summary statement and evaluation findings should be similar in wording to the following example (the finding number is for convenience in cross-referencing within the Standard Review Plan (SRP) and safety evaluation report (SER)):

The NRC staff reviewed the aging management review provided in the renewal application and supplemental documentation. The NRC staff performed its review following the guidance provided in NUREG-1927, Revision 1, "Standard Review Plan for Renewal of Specific Licenses and Certificates of Compliance of Dry Storage of Spent Nuclear Fuel," and relevant ISGs. Based on its review, the NRC staff finds:

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

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[2] For example, research programs at Argonne National Laboratory (for NRC and the U.S. Department of Energy (DOE)), and other programs performed for the Nuclear Regulation Authority (formerly Japan Nuclear Energy Safety Organization) have studied hydride reorientation effects; Oak Ridge National Laboratory has also studied bending responses of the fuel.

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

3.5 Time-Limited Aging Analyses

TLAAs are calculations or analyses used to demonstrate that in-scope SSCs will maintain their intended function throughout an explicitly stated period of extended operation (e.g., 40 years). These calculations or analyses may be used to assess fatigue life (number of cycles to predicted failure), or time-limited life (operating timeframe until expected loss of intended function). TLAAs should account for environmental effects. Under 10 CFR 72.3, "Definitions," TLAAs are those calculations and analyses meeting all six of the following criteria:

(1) Involve SSCs important to safety within the scope of the specific-license renewal, as delineated in Subpart F of 10 CFR Part 72, or within the scope of the spent fuel storage CoC renewal, as delineated in Subpart L of 10 CFR Part 72, respectively.

(2) Consider the effects of aging.

(3) Involve time-limited assumptions defined by the current operating term.

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

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

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

Under 10 CFR 72.42(a)(1) or 72.240(c)(2), the reviewer should ensure that the application includes a list of TLAAs. The NRC staff uses the FSAR and other documents where the design bases are detailed to perform the review and confirm that the applicant did not omit any TLAAs submitted as part of the approved design bases. The number and type of TLAAs vary depending on the design bases of the ISFSI or DSS. The reviewer should ensure that all six criteria set forth in 10 CFR 72.3 (and repeated in this section) are satisfied to conclude that a calculation or analysis is a TLAA.

The following examples illustrate analyses that are not TLAAs and need not be addressed under 10 CFR 72.42(a)(1) or 72.240(c)(2):

- Analyses with time-limited assumptions defined short of the initial license or CoC term, for example, an analysis for a component based on a service life that would not reach the end of the initial license or CoC term.

- Analyses *not* contained or incorporated by reference in the design bases. Although not TLAAs by definition, the reviewer should note that these analyses may be included in the renewal application to justify the proposed attributes of an AMP (e.g., inspection frequency, sample size) for a particular SSC within the scope of renewal. These analyses may further be used in the AMR to justify the exclusion of an aging mechanism/effect or SSC subcomponent from the scope of an AMP (i.e., not requiring

any aging management activities), if the analysis is approved by the staff and included or summarized in the application.

3.5.1 Review Guidance

The reviewer should ensure that the applicant has appropriately identified TLAAs by applying the six criteria described below for SSCs within the scope of renewal:

(1) *Involve SSCs important to safety within the scope of the specific-license or CoC renewal*. Chapter 2 of this SRP provides the reviewer guidance on the scoping methodology.

(2) *Consider the effects of aging*. The effects of aging include but are not limited to loss of material, change in dimension, change in material properties, loss of strength, settlement, and cracking. The reviewer should ensure that any calculations or analyses relying on environmental susceptibility criteria are adequately supported by a valid technical basis, such as NRC endorsed criteria or operating experience. An AMP might be more applicable in these cases.

(3) *Involve time-limited assumptions defined by the current operating term*. The defined operating term should be explicit in the analysis. Simply asserting that the SSC is designed for a DSS or ISFSI service life is not sufficient. Calculations, analyses, or testing that explicitly include a time limit should support the assertions.

(4) *Were determined to be relevant by the licensee or certificate holder in making a safety determination*. Relevancy is a determination that the applicant makes based on a review of the information available. A calculation or analysis is relevant if it can be shown to have a direct bearing on the action taken as a result of the analysis performed. Analyses are also relevant if they provide the basis for a safety determination, and, in the absence of analyses, the applicant might have reached a different conclusion.

(5) *Involve conclusions or provide the basis of conclusions related to the capability of SSCs to perform their intended safety functions*. The TLAA should provide conclusions or a basis for conclusions regarding the capability of the SSC to perform its intended function through the end of the period of extended operation. If the TLAA does not provide a conclusion supporting the capability of the SSC to perform its intended function through the end of the period of extended operation, then the TLAA is not confirmed, and the applicant should propose an AMP to address/manage the aging mechanism or effect on the SSC. Analyses that do not affect the intended functions of SSCs are not TLAAs.

(6) *Are contained or incorporated by reference in the design bases*. TLAAs should already be contained or incorporated by reference in the design-bases documents. Such documentation includes the (1) FSAR, (2) technical specifications, (3) correspondence to and from the NRC, (4) quality assurance plan, and (5) topical reports included as references in the FSAR. The reviewer should ensure that the applicant has provided any references cited in design-bases documents that may be needed to clarify the assumptions, methods, or values used in TLAAs.

The reviewer should ensure that the applicant has appropriately dispositioned an identified TLAA by one of the following methods:

- Demonstrate the existing analysis remains valid for the period of extended operation, has already considered the requested period of extended operation, and concludes that the SSC will continue to perform its intended function through the end of the requested period of extended operation.

- Revise or update the existing analysis to demonstrate that it has been projected to the end of the requested period of extended operation and concludes that the SSC will continue to perform its intended function through the end of the requested period of extended operation.

- Manage the effects of aging on the SSC for the requested period of extended operation through an AMP.

3.5.2 Evaluation Findings

The reviewer prepares the summary statement and evaluation finding based on compliance with the regulatory requirements in Section 3.3. The summary statement and evaluation finding should be similar in wording to the following example (the finding number is for convenience in cross-referencing within the SRP and SER):

The NRC staff reviewed the TLAAs provided in the renewal application and supplemental documentation. The NRC staff performed its review following the guidance provided in NUREG-1927, Revision 1, "Standard Review Plan for Renewal of Specific Licenses and Certificates of Compliance for Dry Storage of Spent Nuclear Fuel," and relevant ISGs. The NRC staff verified that the TLAA assumptions, calculations, and analyses are adequate and bound the environment, and aging mechanism or aging effect for the pertinent SSCs. Based on its review, the NRC staff finds:

F3.3 The applicant identified all aging mechanisms and effects pertinent to SSCs within the scope of renewal that involve TLAAs. The methods and values of the input parameters for the applicant's TLAAs are adequate. Therefore, the applicant's TLAAs provide reasonable assurance that the SSCs will maintain their intended function(s) for the period of extended operation, require no further aging management activities, and meet the requirements in 10 CFR 72.42(a)(1) or 10 CFR 72.240(c)(2), as applicable.

3.6 Aging Management Programs

AMPs monitor and control the degradation of SSCs within the scope of renewal so that aging effects will not result in a loss of intended functions during the period of extended operation. An AMP includes all activities that are credited for managing aging mechanisms or effects for specific SSCs, including activities conducted during the initial storage period. An effective AMP prevents, mitigates, or detects the aging effects and provides for the prediction of the extent of the effects of aging and timely implementation of corrective actions before there is a loss of intended function.

AMPs should be informed, and enhanced when necessary, based on the ongoing review of both site-specific and industrywide operating experience, including relevant international and non-nuclear operating experience. Operating experience provides direct confirmation of the effectiveness of an AMP and critical feedback for the need for improvement. As new knowledge and data become available from new analyses, experiments, and operating experience,

licensees and CoC holders should revise existing AMPs (or pertinent procedures for AMP implementation) to address program improvements or aging issues.

3.6.1 Review Guidance

An AMP should contain the following 10 elements:

(1) scope of program
(2) preventive actions
(3) parameters monitored or inspected
(4) detection of aging effects
(5) monitoring and trending
(6) acceptance criteria
(7) corrective actions
(8) confirmation process
(9) administrative controls
(10) operating experience

Review of the AMPs should include an assessment of the 10 program elements to verify their technical adequacy. In general, the reviewer should examine the details of these 10 elements for managing the aging mechanisms and effects identified by the aging management review (AMR) process. The reviewer should recognize that an applicant may develop AMPs following a different format or style. For such reviews, the NRC staff should ensure that sufficient detail (i.e., supporting technical bases) is provided in the alternate format in comparison with the 10 AMP elements of this guidance.

The reviewer should determine if the proposed AMP is adequate for managing the aging mechanisms and effects of the SSCs identified by the AMR. The following sections provide specific guidance for the review of each element of an AMP.

3.6.1.1 Scope of Program

The scope of the program should list the specific SSCs and subcomponents covered by the AMP and the intended functions to be maintained. In addition, the element should state the specific materials, environments, and aging mechanisms and effects to be managed. The reviewer should verify that the scope defined for the AMP is clear and specific.

3.6.1.2 Preventive Actions

Preventive actions are used to prevent aging or mitigate the rates of aging for SSCs through the activities in the AMP. The reviewer should verify that these activities, if applicable, are described. For example, an applicant may cite a ground dewatering system to ensure control of long-term settlement of structures or the continuance of inspections to ensure that air inlet/outlet vents are not blocked. Some condition or performance monitoring programs do not rely on preventive actions and thus this information need not be provided.

The reviewer should ensure that any proposed preventive action will not result in an unintended consequence to the ability of an SSC to fulfill its intended function(s). For example, if the applicant has proposed to change a coating system to prevent loss of material due to corrosion, the reviewer should ensure that the applicant has verified coating compatibility to confirm that the proposed action will not compromise the intended function(s) of the SSC.

3.6.1.3 Parameters Monitored or Inspected

This program element should identify the specific parameters that will be monitored or inspected and describe how those parameters will be capable of identifying degradation or potential degradation before a loss of intended function. The use of the parameters should be demonstrated to be capable of:

- monitoring the effectiveness of activities that prevent or mitigate aging (e.g., environmental controls)

- monitoring the performance of SSCs as an indirect indicator of degradation (e.g., radiation rate monitoring at the external surface of a cask)

- detecting, through direct inspection, the presence and severity of conditions or discontinuities that may have an effect on the function of SSCs (e.g., nondestructive examination of a component surface)

The reviewer should ensure that this program element provides a clear link between the aging effects identified in the scope of the program and the parameters monitored or inspected.

3.6.1.4 Detection of Aging Effects

Detection of aging effects should occur before there is a loss of intended function for any SSC identified within the scope of the program. This element should include inspection and monitoring details, including method or technique (i.e., visual, volumetric, surface inspection), frequency, sample size, data collection, and timing of inspections to ensure timely detection of aging effects. In general, the information in this element describes the "when," "where," and "how" of the AMP (i.e., the specific aspects of the activities to collect data as part of the inspection or monitoring activities).

The reviewer should ensure that the applicant has provided sufficient details on the following aspects of the inspection or monitoring activities:

- Method or technique: Consistent with quality assurance requirements, the method should be demonstrated to be capable of evaluating the condition of the SSC against the acceptance criteria for the specific aging mechanism or effect being monitored or inspected (as defined in AMP Element 6). For example, the applicant should provide a valid technical basis that a particular visual inspection method or instrument has sufficient resolution to identify a specific crack or defect dimension. Inspections should utilize consensus codes and standards, as applicable.

- Frequency: The reviewer should ensure that the proposed intervals for inspection or monitoring are consistent with applicable site-specific, design-specific, or industrywide operating experience. Inspections should have sufficient frequency to ensure that intended functions will be maintained until the next scheduled inspection.

- Sample size and selection of SSCs for inspection: For a limited sample size, the applicant should identify and justify the number of SSCs to be evaluated per inspection, including the extent of the inspection for each SSC (e.g., all accessible areas of five concrete overpacks in service), and criteria for selection of the specific SSCs for inspection based on parameters that may contribute to the operable aging mechanisms

and effects. Consideration should also be given to event-driven fabrication or operational issues that may contribute to degradation when selecting SSCs for inspection (e.g., welding repairs, occurrence of natural or man-induced events, exposure to potentially corrosive environments before the storage term, duration of time between fabrication of an SSC and the start of the storage term). The reviewer should ensure the applicant has justified using a limited sample size (e.g., one cask per pad) with a technical basis, which should include applicable site-specific, design-specific and industrywide operating experience. The application should also define the areas that have been determined to be inaccessible or below-grade and propose how the condition of the inaccessible SSCs will be assessed. The reviewer should ensure that the scope of each inspection is properly defined for both accessible and inaccessible (including below-grade) areas.

- Data collection: The application should reference any specific methods to be used for data acquisition and documentation, including any applicable consensus codes and standards. For example, the application may reference field evaluation guides for evaluating and documenting cracks in concrete (e.g., ACI 224.1R, ACI 201.1R).

- Timing of inspections: If pre-application inspections were not performed for each of the sites covered by or using the subject license or CoC, the reviewer should ensure that AMPs include baseline inspections at each site upon entering the period of extended operation. Baseline inspections, or the first inspections conducted within the AMPs, should assess the condition of SSCs to confirm the results of the pre-application inspections that were conducted at other sites or to verify the technical justification provided in the application when pre-application inspections were not performed. The reviewer should also consider any specific information on the proposed inspection schedule (e.g., time of the year) to support the effective detection of aging effects before a loss of intended function.

3.6.1.5 Monitoring and Trending

Monitoring and trending should provide for an evaluation of the extent of the effects of aging and the need for timely corrective or mitigative actions. This element describes how the data collected will be evaluated. This includes an evaluation of the results against the acceptance criteria and an evaluation regarding the rate of degradation to ensure that the timing of the next scheduled inspection will occur before a loss of intended function. For most cases, this element should have a baseline established before or at the beginning of the period of extended operation. The reviewer should determine if a baseline inspection is necessary to establish the parameters to be monitored and the trending analysis and, if so, whether the proposed baseline inspection is adequate.

Although the licensee may have the flexibility to inspect different SSCs or SSC subcomponents during subsequent inspections, the selection of different components for the inspections defined in the AMP relative to the components inspected in the baseline inspection may present issues for purposes of monitoring and trending. If subcomponents from different systems will be inspected over the period of extended operation, the monitoring and trending element should address how a given operable degradation mode will be adequately trended.

3.6.1.6 Acceptance Criteria

The acceptance criteria, against which the need for corrective action will be evaluated, should ensure that the SSC intended functions and the approved design bases are maintained during the period of extended operation. The proposed acceptance criteria should be appropriately justified.

The acceptance criteria could be specific numerical values or could consist of a discussion of the process for calculating specific numerical values of conditional acceptance criteria to ensure that the design bases are maintained. The reviewer should ensure that the acceptance criteria:

- Include a quantitative basis (justifiable by operating experience, engineering analysis, consensus codes/standards).
- Avoid use of non-quantifiable phrases (e.g., significant, moderate, minor, little, slight, few; see Appendix A).
- Are achievable and actionable.

The acceptance criteria may be taken directly from the design bases information included in either the final safety analysis report (FSAR) or technical specifications. The acceptance criteria also may be established by methods provided in NRC-approved topical reports or appropriate codes and standards.

3.6.1.7 Corrective Actions

Corrective actions are the measures to be taken when the acceptance criteria are not met. Timely corrective actions, including root cause determination and prevention of recurrence for significant conditions adverse to quality, are critical for maintaining the intended functions of the SSCs during the initial storage period as well as the period of extended operation.

Corrective actions should be described in adequate detail or referenced to source documents. An applicant may reference the use of a Corrective Action Program (CAP) approved under 10 CFR Part 50, Appendix B, “Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants,” or 10 CFR Part 72, Subpart G, “Quality Assurance,” to capture and address aging effects identified in the period of extended operation. At a minimum, all conditions that do not meet the AMP acceptance criteria should be entered into the CAP. The QA Program ensures that corrective actions are completed within the specific or general licensee’s CAP and includes provisions (as applicable) to:

- Perform functionality assessments.
- Perform apparent cause evaluations and root cause evaluations.
- Address the extent of condition.
- Determine actions to prevent recurrence for significant conditions adverse to quality.
- Justify non-repairs.

- Ensure corrective actions are adequately and effectively performed and do not have an adverse effect (aging-related or otherwise) on the subject component or other SSCs.

- Trend conditions.

The CAP should be able to respond to and adequately address any ISFSI or DSS aging issues. Also, the CAP's response to addressing any ISFSI or DSS aging issues should include any specific corrective actions specified in the license or CoC renewal application.

In some cases, the reviewer may determine the need for specific corrective actions, rather than referring only to the use of the CAP. For example, when very limited information exists on the condition of an SSC or the applicability of an aging effect at the time of the application, the application should include specific follow-up activities when AMP acceptance criteria are not met. Thus, the reviewer should review the corrective actions element with consideration of the safety-significance of the SSC and the ISFSI site-specific, DSS design-specific, and industrywide operating experience to ensure that the proposed corrective actions are adequate and effective.

3.6.1.8 Confirmation Process

This element of the program is intended to verify that preventive actions are adequate and that appropriate corrective actions have been completed and are effective. The confirmation process is commensurate with the specific or general licensee QA Program approved under 10 CFR Part 72, Subpart G, or 10 CFR Part 50, Appendix B. The QA Program ensures that the confirmation process includes provisions to preclude repetition of significant conditions adverse to quality. The reviewer should ensure the confirmation process describes or references procedures to:

- determine follow-up actions to verify effective implementation of corrective actions
- monitor for adverse trends due to recurring or repetitive findings or observations

The reviewer should be aware that the effectiveness of prevention and mitigation programs should be verified periodically. For example, in managing corrosion of carbon steel components, a mitigation program (coating) may be used to minimize susceptibility to corrosion. However, it also may be necessary to have a condition monitoring program (visual or other types of inspections) to verify that corrosion is being prevented or controlled to prevent a loss of intended function.

3.6.1.9 Administrative Controls

Administrative controls provide a formal review and approval process. Thus, any aging management programs must be administratively controlled and included in the FSAR supplement. The administrative controls are in accordance with the specific or general licensee QA Program approved under 10 CFR Part 72, Subpart G or 10 CFR Part 50, Appendix B, respectively. The QA Program ensures that the administrative controls include provisions, such as those that define:

- instrument calibration and maintenance
- inspector requirements
- record retention requirements
- document control

3.6.1.10 Operating Experience

The reviewer should verify that the operating experience element of the program supports a determination that the effects of aging will be adequately managed so that the SSC intended functions will be maintained during the period of extended operation. Operating experience is useful in providing justification for the effectiveness of each AMP program element and critical feedback for enhancement. The reviewer should verify that any degradation in the referenced operating experience has been clearly identified as either age-related or event-driven, with proper justification for that assessment.

The reviewer should verify that the AMP references and evaluates applicable operating experience, including, but not necessarily limited to:

- internal and industrywide condition reports
- relevant international and non-nuclear operating experience
- pre-application inspection results (see below)
- licensee event reports
- vendor-issued safety bulletins
- NRC Generic Communications
- updated consensus codes, standards, or guides
- applicable industry-initiatives (e.g., Department of Energy or Electric Power Research Institute sponsored inspections)

The reviewer should consider operating experience of existing programs, including past corrective actions resulting in program enhancements or additional programs. A past failure would provide feedback from operating experience and should have resulted in appropriate program enhancements or new programs. This information can demonstrate where an existing program has been implemented correctly and where it has shortcomings in detecting degradation in a timely manner. This information should provide objective evidence to support or refute the conclusion that the effects of aging will be managed adequately so that the SSC intended functions will be maintained during the period of extended operation.

<u>Pre-Application Inspections</u>

Because inspections of DSSs and ISFSI SSCs are not typically conducted during the initial storage period, or are narrow in scope, the reviewer may have limited information regarding the extent and rate of operable degradation mechanisms for the specific design, environment, and operational parameters. In this case, the reviewer should ensure that the scope, methods, frequencies and acceptance criteria for monitoring and inspection activities in the aging management programs are sufficiently conservative, such that a loss of SSC-intended functions does not occur during the period of extended operation. Pre-application inspections are one means by which an applicant can provide operating experience to justify the specific information in the 10 elements of the proposed aging management programs. In addition, pre-application inspections may provide data to support a TLAA or other analysis that justifies that an aging

effect will not challenge a SSC's ability to perform its function(s) (see Section 3.5). The staff considers the results of a pre-application inspection, in conjunction with other relevant operating experience in its review of the renewal application.

Section 3.4.1.2 discusses the acceptable characteristics of a pre-application inspection, including the selection of bounding systems, the use of surrogate inspections, and ensuring that the inspection scope, methods, and acceptance criteria align with the guidance for the AMP elements described in Section 3.6.1 of this document. Section 3.4.1.2 also discusses the use of baseline inspections in an AMP upon entering the period of extended operation to assess the condition of SSCs at sites that were not the subject of a pre-application inspection. Furthermore, when pre-application inspections are not performed, the reviewer should consider whether uncertainties in the degradation of SSCs warrant the addition of conditions to the license or CoC to require the baseline and other specific inspections to ensure the AMPs are adequate, including for all potential user sites in the case of a renewed CoC (see Section 1.4.7).

Learning AMPs

The reviewer should ensure that the application includes provisions to conduct future reviews of site-specific, design-specific, and industrywide operating experience, including relevant international and non-nuclear operating experience, to confirm the effectiveness of the AMPs or identify a need to enhance or modify an AMP. The reviewer should verify that the applicant: (1) references a specific system to be used to obtain, aggregate, and enter site-specific, design-specific, and industrywide operating experience (e.g., Institute of Nuclear Power Operations database), and (2) has discussed how it intends to provide timely reporting of operating experience to this system.

The commitment to future reviews should ensure that, as knowledge and data become available from new analyses, experiments, and operating experience, the licensees and CoC holders will revise the existing AMPs (or pertinent procedures for AMP implementation) as necessary to address any lessons learned identified during the review of operating experience.

If an applicant follows this approach, the reviewer should ensure that the description of the periodic assessments includes specific performance criteria (e.g., program-specific performance indicators for each of the 10 AMP elements) and proposed actions based on the assessment findings. The reviewer should also ensure that the timing of the assessments appropriately considers the rate of aging degradation and the anticipated availability of data from industry initiatives. The reviewer should consider the frequency, acceptance criteria, and proposed corrective actions for these assessments for the requisite finding of reasonable assurance.

Nuclear Energy Institute (NEI) 14-03, "Format, Content, and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management," Revision 1, provides a proposed framework for learning AMPs through the use of "tollgates." NEI 14-03 defines "tollgates" as periodic points within the period of extended operation when licensees would be required to evaluate aggregate feedback and perform and document a safety assessment that confirms the safe storage of spent fuel. Tollgates are described as an additional set of in-service assessments beyond the normal continual assessment of operating experience, research, monitoring, and inspections on DSS component and ISFSI SSC performance that is part of normal ISFSI operations for licensees during the initial storage period as well as the period of extended operation. The reviewer should be aware that an applicant may reference the use of "tollgates" in the renewal application. The reviewer should (1) assess the applicant's proposed periodic assessments of operating experience and other relevant data, and (2) make a

determination regarding the ability of these assessments to ensure the continued effectiveness of AMPs. The reviewer should ensure that tollgates determined to be necessary to demonstrate the continued effectiveness of the AMPs are included in the application.

NEI 14-03, Revision 1, also describes a framework for the aggregation and dissemination of operating experience across the industry through the use of an aging-related operating experience "clearinghouse," titled the ISFSI Aging Management Institute of Nuclear Power Operations Database (ISFSI AMID). Whether the applicant references the ISFSI AMID described in NEI 14-03 or proposes an alternative means to seek out operating experience, the reviewer should ensure that the application describes how industrywide operating experience and results of industry initiatives will be accessed, utilized, and assessed to ensure that AMPs are modified as appropriate.

At the time of publication, the staff was continuing its review of NEI 14-03, Revision 1, for proposed NRC endorsement, as discussed in the Introduction.

The NRC will inspect licensees' implementation of AMPs in the period of extended operation, including any licensee actions taken as part of the "learning" aspect of AMPs. The NRC will inspect licensees' periodic assessments of AMP effectiveness and any adjustments licensees have made to AMPs to respond to operating experience and ensure AMPs are effective for addressing aging effects in the period of extended operation.

3.6.2 Commencement of AMP(s) for CoC Renewals

An AMP for a renewed CoC commences at the end of the initial storage period for each loaded DSS (see Appendix F for discussion of storage terms, including an explanation of when storage begins). Activities in an AMP may start at different timeframes (e.g., an AMP can be implemented before the period of extended operation to capture baseline data and AMPs may have different frequencies of implementation). Additional considerations for CoC renewals and general licensee implementation of AMPs are provided in Appendix E.

3.6.3 Implementation of AMP(s)

Generally, licensees should develop the infrastructure for AMP implementation (e.g., procure equipment or contracts, train personnel, or update, revise, or develop procedures for implementing AMP activities) before entering the period of extended operation. However, this may not be possible when the initial storage term ends shortly after the license or CoC is renewed or if a license or CoC is in the period of timely renewal (Section 1.4.5). In such cases, the development of the infrastructure for AMP implementation generally should be no later than one year from the date the NRC issues a renewed specific license or CoC. The reviewer should ensure that the timing of implementation for each AMP is addressed in the application in a clear manner and is appropriately justified if it exceeds the above guidance. Additional considerations for CoC renewals and general licensee implementation of AMPs are provided in Appendix E.

3.6.4 Evaluation Findings

The reviewer prepares the summary statement and evaluation finding based on compliance with the regulatory requirements in Section 3.3. The summary statement and evaluation finding should be similar in wording to the following example (the finding number is for convenience in cross-referencing within the SRP and SER):

The NRC staff reviewed the aging management programs provided in the renewal application and supplemental documentation. The NRC staff performed its review following the guidance provided in NUREG-1927, Revision 1, “Standard Review Plan for Renewal of Specific Licenses and Certificates of Compliance for Dry Storage of Spent Nuclear Fuel” and relevant ISGs. Based on its review, the NRC staff finds:

F3.4 The applicant has identified programs that provide reasonable assurance that aging effects will be managed effectively during the period of extended operation, in accordance with 10 CFR 72.42(a)(2) or 10 CFR 72.240(c)(3), as applicable.

4. CONSOLIDATED REFERENCES

Title 10 of the *Code of Federal Regulations* (10 CFR) Part 2, “Agency Rules of Practice and Procedure,” Washington, DC.

10 CFR Part 20, “Standards for Protection against Radiation,” Washington, DC.

10 CFR Part 50, “Domestic Licensing of Production and Utilization Facilities,” Washington, DC.

10 CFR Part 51, “Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions,” Washington, DC.

10 CFR Part 52, “Licenses, Certifications, and Approvals for Nuclear Power Plants,” Washington, DC.

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,” Washington, DC.

American Concrete Institute (ACI) 349.3R-02, “Evaluation of Existing Nuclear Safety-Related Concrete Structures” (Reapp 2010).

ACI 318-05, “Building Code Requirements for Structural Concrete and Commentary,” 2005.

ACI 349-06, “Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary,” 2007.

ACI 201.1R-8, “Guide for Conducting a Visual Inspection of Concrete in Service,” 2008.

ACI 224.1R-07, “Causes, Evaluation, and Repair of Cracks in Concrete Structures,” 2007.

ACI 562-13, “Code Requirements for Evaluation, Repair, and Rehabilitation of Concrete Buildings and Commentary,” 2013.

ACI 364.1R-07, “Guide for Evaluation of Concrete Structures before Rehabilitation,” 2007.

ACI 207.3R-94, “Practices for Evaluation of Concrete in Existing Massive Structures for Service Conditions,” 2008.

ACI 506R-05, “Guide to Shotcrete,” 2005.

ACI CT-13, “ACI Concrete Terminology,” 2013.

American Society of Civil Engineers (ASCE)/Structural Engineering Institute (SEI) 11-99 (2000), “Guideline for Structural Condition Assessment of Existing Buildings.”

American Society of Mechanical Engineers (ASME), “Boiler and Pressure Vessel Code Section XI—Rules for Inservice Inspection of Nuclear Power Plant Components,” New York, NY, 2007.

ASME Code Section XI, Subsection IWL, “Requirements for Class CC Concrete Components of Light-Water-Cooled Plants,” 2013.

Bare, W.C, L.D. Torgerson, “Dry Cask Storage Characterization Project—Phase 1: CASTOR V/21 Cask Opening and Examination,” NUREG/CR-6745, Idaho National Engineering and Environmental Lab, Idaho Falls, ID, 2001, Agencywide Documents Access and Management System (ADAMS) Accession No. ML013020363.

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

Cumblidge, S.E., M.T. Anderson, S.R. Doctor, “An Assessment of Visual Testing,” NUREG/CR-6860, Pacific Northwest National Laboratory, Richland, WA, 2004, ADAMS Accession No. ML043630040.

Cumblidge, S.E, et al., “A Study of Remote Visual Methods to Detect Cracking in Reactor Components,” NUREG/CR-6943, Pacific Northwest National Laboratory, Richland, WA, 2007, ADAMS Accession No. ML073110060.

Daum, R.S., et al., “Radial-Hydride Embrittlement of High-Burnup Zircaloy-4 Fuel Cladding”, Journal of Nuclear Science and Technology, Vol. 43, No. 9, 2006, p. 1054.

Dominion Resources, Inc., “North Anna ISFSI TN-32 High Burnup Dry Storage Research Project,” May 13, 2015, ADAMS Accession No. ML15133A082.

Einziger, R.E., et al., “Examination of Spent PWR Fuel Rods after 15 Years in Dry Storage,” NUREG/CR-6831, Argonne National Laboratory, Argonne, IL., 2003, ADAMS Accession No. ML032731021.

Electric Power Research Institute (EPRI)/U.S. Department of Energy (DOE), HBU Dry Storage Cask Research and Development Project Final Test Plan, February 27, 2014, DOE Contract No. DE-NE-0000593. Accessible at http://www.energy.gov/sites/prod/files/2014/03/f8/HBUDry%20StrgeCaskRDfinalDemoTestPlanRev9.pdf.

Gorman, J., K. Fuhr, J. Broussard, “Literature Review of Environmental Conditions and Chloride-Induced Degradation Relevant to Stainless Steel Canisters in Dry Cask Storage Systems,” EPRI-3002002528, Palo Alto, CA, 2014.

Hayashibara, H., et al., “Effect of Temperature and Humidity on Atmospheric Stress Corrosion Cracking of 304 Stainless Steel,” NACE International, Corrosion 2008, paper 08492, Houston, TX, 2008.

He, X., et al., “Assessment of Stress Corrosion Cracking Susceptibility for Austenitic Stainless Steels Exposed to Atmospheric Chloride and Non-Chloride Salts,” NUREG/CR-7170, U.S. Nuclear Regulatory Commission (NRC), 2014, ADAMS Accession No. ML14051A417.

Kamimura, K., “Integrity Criteria of Spent Fuel for Dry Storage in Japan,” Proceedings of International Seminar on Interim Storage of Spent Fuel, ISSF 2010, Tokyo Nov 2010, page VI3-1.

Kosaki, A., “Evaluation Method of Corrosion Lifetime of Conventional Stainless Steel Canister under Oceanic Air Environment,” Nuclear Engineering and Design, Vol. 238, 2008, pp. 1233-1240.

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, 1996. Accessible at http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr6407/cr6407.pdf.

Nuclear Energy Institute (NEI), "Guidance for Operations-Based Aging Management for Dry Cask Storage," NEI 14-03, Rev. 0, 2014, ADAMS Accession No. ML14266A225.

NEI, "Format, Content and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management for Dry Cask Storage," NEI 14-03, Rev. 1, 2015, ADAMS Accession No. ML15272A329.

NRC,[3] "Standard Review Plan for Spent Fuel Dry Storage Facilities," NUREG-1567, Rev. 0, Washington, DC, 2000, ADAMS Accession No. ML003686776.

NRC, "10 CFR Part 72, License and Certificate of Compliance Terms, Final Rule," *Federal Register*, Vol. 76, No. 32, February 16, 2011, pp. 8872–8892 (76 FR 8872).

NRC, "Cladding Considerations for the Transportation and Storage of Spent Fuel," ISG-11, Rev. 3, Washington, DC, 2003, ADAMS Accession No. ML033230335.

NRC, Regulatory Issue Summary (RIS) 2004-20, "Lessons Learned from Review of 10 CFR Parts 71 and 72 Applications," December 16, 2004, ADAMS Accession No. ML043510074.

NRC, "Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility," NUREG-1536, Rev. 1, Washington, DC, 2010a, ADAMS Accession No. ML101040620.

NRC, "Fuel Retrievability," ISG-2, Rev. 1, Washington, DC, 2010b, ADAMS Accession No. ML100550861.

NRC, "Generic Aging Lessons Learned (GALL) Report," NUREG-1801, Rev. 2, Washington, DC, 2010c, ADAMS Accession No. ML103490041.

NRC, "Standard Review Plan for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance," NUREG-1927, Rev. 0, Washington, DC, 2011, ADAMS Accession No. ML111020115.

NRC, "Clarifying the Relationship Between 10 CFR 72.212 and 10 CFR 72.48 Evaluations," RIS 2012-05, 2012a, ADAMS Accession No. ML113050537.

NRC, "Potential Chloride-Induced Stress Corrosion Cracking of Austenitic Stainless Steel and Maintenance of Dry Cask Storage System Canisters," Information Notice 2012-20, 2012b, ADAMS Accession No. ML12319A440.

NRC, "The Use of a Demonstration Program as a Surveillance Tool for Confirmation of Integrity for Continued Storage of High Burnup Fuel Beyond 20 Years," ISG-24, Rev. 0, Washington, DC, 2014, ADAMS Accession No. ML14058B166.

[3] Note that references to NRC NUREG reports may be superseded by later versions. References to ISGs may be superseded by incorporation into NUREG reports.

NRC, Letter from M. Lombard (NRC) to R. McCullum (NEI), Response to September 23, 2014, Nuclear Energy Institute Submittal: NEI 14-03, “Guidance for Operations-Based Aging Management for Dry Cask Storage,” Rev. 0, dated January 21, 2015, ADAMS Accession No. ML15013A201.

NRC, Request for public comments on draft NUREG, “Standard Review Plan for Renewal of Specific Licenses and Certificates of Compliance for Dry Storage of Spent Nuclear Fuel,” *Federal Register*, Vol. 80, No. 129, July 7, 2015, pp. 38780–38782 (80 FR 38780).

Selby, G. “BWR Vessel and Internals Project, Reactor Pressure Vessel and Internals Examination Guidelines,” EPRI 1011689, TR-105696-R8 (BWRVIP-03) Rev. 8, Palo Alto, CA, 2005.

Sheaffer, M.K., et al., “Engineering Drawings for 10 CFR Part 71 Package Approvals,” NUREG/CR-5502, Washington, DC, 1998. Accessible at https://www.orau.org/ptp/pdf/5502.pdf.

Tokiwai, M., H. Kimura, H. Kusanagi, “The Amount of Chlorine Contamination for Prevention of Stress Corrosion Cracking in Sensitized Type 304 Stainless Steel,” Corrosion Science, Vol. 25, Issue 8–9, 1985, pp. 837–844.

Waldrop, K., et al., “Calvert Cliffs Stainless Steel Dry Storage Canister Inspection,” EPRI-1025209, EPRI, Palo Alto, CA, 2014.

5. GLOSSARY

Accident condition: The extreme level of an event or condition, which has a specified resistance, limit of response, and requirement for a given level of continuing capability, which exceeds off-normal events or conditions. Accident conditions include both design-basis accidents and conditions caused by natural and manmade phenomena.

Aging effect: The manifestation of an aging mechanism (e.g., cracking, loss of fracture toughness, loss of material).

Aging management activity (AMA): An application of either the aging management program (AMP) or time-limited aging analyses (TLAAs) to provide reasonable assurance that the intended functions of structures, systems, and components (SSCs) of independent spent fuel storage installations (ISFSIs) and dry storage systems (DSSs) are maintained during the period of extended operation.

Aging management program (AMP): A program for addressing aging effects that may include prevention, mitigation, condition monitoring, and performance monitoring. See Title 10 of the *Code of Federal Regulations* (10 CFR) 72.3, "Definitions."

Aging management review (AMR): An assessment conducted by the licensee or certificate of compliance (CoC) holder that addresses aging mechanisms and effects that could adversely affect the ability of SSCs from performing their intended functions during the period of extended operation.

Aging mechanism: The degradation process for a given material and environment which results in an aging effect (e.g., freeze-thaw degradation, neutron irradiation, erosion).

Amendment of a license or CoC: An application for amendment of a license or a CoC must be submitted whenever a holder of a specific license or CoC desires to amend the license or CoC (including a change to the license or CoC conditions). The application must fully describe the changes desired and the reasons for such changes, and following as far as applicable the form prescribed for original applications. See 10 CFR 72.56, "Application for Amendment of License," and 10 CFR 72.244, "Application for Amendment of a Certificate of Compliance".

Baseline inspection: The first inspection of an AMP to assess the condition of SSCs to either: (1) confirm that the results of pre-application inspections conducted at other sites are bounding of the subject site, or (2) verify the adequacy of the AMPs and the conclusions of the TLAAs when pre-application inspections were not performed.

Burnup: The measure of thermal power produced in a specific amount of nuclear fuel through fission, usually expressed in GWd/MTU (gigawatt days per metric ton uranium).

Can for damaged fuel: A metal enclosure that is sized to confine one damaged spent fuel assembly. A fuel can for damaged spent fuel with damaged spent-fuel assembly contents must satisfy fuel-specific and system-related functions for undamaged spent nuclear fuel (SNF) required by the applicable regulations.

Canister (in a dry storage system for SNF): A metal cylinder that is sealed at both ends and may be used to perform the function of confinement. Typically, a separate overpack performs the radiological shielding and physical protection function. See NUREG-1536, "Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility."

Certificate of compliance (CoC) (for a dry storage system for SNF): The certificate issued by the NRC that approves the design of a spent fuel storage cask in accordance with the provisions of 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," Subpart L, "Approval of Spent Fuel Storage Casks." See 10 CFR 72.3.

Certificate of compliance holder (CoC holder): A person who has been issued a CoC by the U.S. Nuclear Regulatory Commission (NRC) for a spent fuel storage cask design under 10 CFR Part 72. See 10 CFR 72.3.

Certificate of compliance user (CoC user): The general licensee that has loaded, or plans to load, a dry storage system (DSS) in accordance with a CoC issued under 10 CFR Part 72.

Confinement (in a dry storage system for spent nuclear fuel): The ability to limit or prevent the release of radioactive substances into the environment.

Confinement systems: Those systems, including ventilation, that act as barriers between areas containing radioactive substances and the environment. See 10 CFR 72.3.

Controlled area: The area immediately surrounding an ISFSI for which the licensee exercises authority over its use and within which it performs ISFSI operations. See 10 CFR 72.3.

Criticality: The condition wherein a system or medium is capable of sustaining a nuclear chain reaction.

Degradation: Any change in the properties of a material that adversely affects the performance of that material; adverse alteration. See NUREG-1536.

Design bases:[4] Information that identifies the specific function(s) to be performed by SSCs (both important-to-safety and not important-to-safety) of a facility or of a spent fuel storage cask and the specific values or ranges of values chosen for controlling parameters as reference bounds for design. These values may be (1) restraints, derived from generally accepted "state-of-the-art" practices for achieving functional goals, or (2) requirements, derived from analysis (based on calculation, experiments, or both) of the effects of a postulated event under which SSCs must meet their functional goals. See 10 CFR 72.3.

Dry storage: The storage of spent nuclear fuel in a DSS, which typically involves drying the DSS cavity and backfilling with an inert gas.

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[4] The NRC has removed references to either "current licensing basis" (CLB) or "licensing basis", and replaced them with "design bases" in this guidance revision. Neither "current licensing basis" nor "licensing basis" is defined in 10 CFR Part 72. In addition, in the Statement of Considerations for the 2011 Part 72 rulemaking change (NRC, 2011), the NRC stated "The NRC does not believe that it is appropriate for the CLB to be applied to cask CoC renewals, which are generic."

Dry storage system (DSS): A system that typically uses a cask or canister in an overpack as a component in which to store spent nuclear fuel in a dry environment. A DSS provides confinement, radiological shielding, sub-criticality control, structural support, and passive cooling of its spent nuclear fuel during normal, off-normal, and accident conditions.

General license: Authorizes the storage of spent fuel in an ISFSI at power reactor sites to persons (i.e., general licensee) authorized to possess or operate nuclear power reactors under 10 CFR Part 50 ("Domestic Licensing of Production and Utilization Facilities") or Part 52 ("Licenses, Certifications, and Approvals for Nuclear Power Plants"). The general license is limited to (1) that spent fuel which the general licensee is authorized to possess at the site under the specific Part 50 or Part 52 license for the site, and (2) storage of spent fuel in casks approved under the provisions of 10 CFR Part 72, Subpart L. See 10 CFR 72.210 ("General License Issued") and 72.212(a)(1)–(2).

High burnup (HBU) fuel: Spent nuclear fuel with burnups generally exceeding 45 GWd/MTU.

Horizontal storage module: A reinforced, heavy-walled concrete structure designed to store dry spent fuel canisters in a horizontal position at an independent spent fuel storage installation. The horizontal storage module provides physical protection of canisters and radiological shielding, while allowing passive cooling.

Important to safety (ITS): See structures, systems, and components (SSCs) important to safety.

Independent spent fuel storage installation (ISFSI): A complex designed and constructed for the interim storage of spent nuclear fuel, solid reactor-related greater-than-Class-C (GTCC) waste, and other radioactive materials associated with spent fuel and reactor-related GTCC waste storage. See 10 CFR 72.3.

Inspection: The examination of an SSC, using a nondestructive testing technique, to determine its current condition and if there is any damage, defect, or degradation that could have an adverse effect on the function of that SSC.

Intended function: A design-bases function defined as either (1) important to safety or (2) failure of which could impact a safety function.

Interim staff guidance (ISG): Supplemental information that clarifies important aspects of regulatory requirements. An ISG provides review guidance to NRC staff in a timely manner until standard review plans are revised accordingly. See NUREG-1536.

Monitored retrievable storage installation (MRS): A complex designed, constructed, and operated by the U.S. Department of Energy for the receipt, transfer, handling, packaging, possession, safeguarding, and storage of spent nuclear fuel aged for at least 1 year, solidified high-level radioactive waste resulting from civilian nuclear activities, and solid reactor-related GTCC waste, pending shipment to a HLW repository or other disposal. See 10 CFR 72.3.

Monitoring: Data collection (from activities performed in either the initial storage period or the period of extended operation) to determine the status of a DSS, ISFSI, or both, and to verify the continued efficacy of the system, on the basis of measurements of specified parameters, including temperature, direct radiation, radioactive effluents, functionality, and characteristics of components of the system. Monitoring could thus be described as those activities that periodically or continuously monitor performance as an indirect indicator of degradation (e.g., monitoring groundwater chemistry) or monitor the effectiveness of preventive measures. With respect to direct radiation and radioactive effluents, according to 10 CFR 20.1003, "Definitions," monitoring means the measurement of radiation levels, concentrations, surface area concentrations or quantities of radioactive material, and the use of the results of these measurements to evaluate potential exposures and doses. See NUREG-1536.

Normal events or conditions: The maximum level of an event or condition expected to routinely occur. Events and conditions that exceed the levels associated with "normal" are considered to be, and to have the response allowed for, "off-normal" or "accident-level" events and conditions. See NUREG-1567, "Standard Review Plan for Spent Fuel Dry Storage Facilities."

Off-normal events or conditions: The maximum level of an event or condition that, although not occurring regularly, can be expected to occur with moderate frequency (once per calendar year) and for which there is a corresponding maximum specified resistance, specified limit of response, or requirement for a specified level of continuing capability. Off-normal is considered to include "anticipated occurrences" as used in 10 CFR Part 72. See NUREG-1536.

Overpack: A heavy-walled concrete, metal, or combined concrete and metal structure designed to store spent fuel canisters at an ISFSI. The overpack provides physical protection of canisters and radiological shielding, while allowing passive cooling.

Pre-application inspection: An inspection performed at the discretion of the licensee or CoC holder before submittal of the renewal application to provide operating experience to support the aging management review, proposed AMP activities, or evaluation of TLAAs.

Radiation shielding: ISFSI and DSS SSCs that are designed so that dry storage operations at an ISFSI meet the requirements of 10 CFR 72.126(a)(6) and 10 CFR 72.128(a)(2) and the requirements of 10 CFR 72.104(a) and 10 CFR 72.106(b), when both direct radiation and radioactive effluents are considered.

Renewal of a license or CoC: A certificate holder may apply for renewal of the design of a spent fuel storage cask for a term not to exceed 40 years. In the event that the certificate holder does not apply for a cask design renewal, any licensee using a spent fuel storage cask, a representative of the licensee, or another certificate holder may apply for a renewal of that cask design for a term not to exceed 40 years. See 10 CFR 72.240, "Conditions for Spent Fuel Storage Cask Renewal." Specific licenses may be renewed by the Commission at the expiration of the license term upon application by the licensee for a period not to exceed 40 years. See 10 CFR 72.42, "Duration of License; Renewal."

Retrievability: Storage systems must be designed to allow ready retrieval of spent fuel, high-level radioactive waste, and reactor-related GTCC waste for further processing or disposal. See 10 CFR 72.122(l). ISG-2 provides guidance on the fuel retrievability, including ready retrieval.

Safety analysis report (SAR): The document that a CoC holder, specific licensee, an applicant for a CoC, or an applicant for a specific license supplies to the NRC for evaluation. For specific-license renewals, the SAR must contain information required in 10 CFR 72.24, "Contents of Application; Technical Information." For CoC renewals, the SAR must meet the requirements of 10 CFR 72.240(b). The SAR provides references and drawings of the DSS, ISFSI, or both; details of construction; materials; and standards to which the SSC has been designed or fabricated. For clarification, SAR is a general term; while FSAR indicates the document that is submitted within 90 days after the issuance of the license or CoC that is based on the SAR in the license or CoC application and reflects any changes or applicant commitments developed during the license or CoC approval and/or hearing process. Both FSAR and updated final safety analysis report (UFSAR) are terms that are used to indicate the FSAR update that is required every 2 years. A specific licensee or CoC holder shall update the FSAR in accordance with 10 CFR 72.70 ("Safety Analysis Report Updating") or 10 CFR 72.248, ("Safety Analysis Report Updating") respectively.

Safety evaluation report (SER): The document that the NRC publishes at the completion of a licensing or certification review. The SER contains all of the NRC staff findings and conclusions from the licensing or certification review.

Safety function: A function defined as ITS. The ITS functions that structures, systems, and components are designed to maintain include:

- structural integrity
- content temperature control (i.e., heat-removal capability)
- radiation shielding
- confinement
- sub-criticality control
- retrievability

See NUREG-1536.

Service conditions: Conditions (e.g., time of service, temperatures, environmental conditions, radiation, and loading) that a component experiences during storage.

Specific license: A license for the receipt, handling, storage, and transfer of spent fuel, high-level radioactive waste, or reactor-related GTCC waste that is issued to a named person (i.e., specific licensee) on an application filed under regulations in 10 CFR Part 72, Subpart B, "License Application, Form, and Contents."

Spent fuel storage cask or cask: All the components and systems associated with the container in which spent fuel, or other radioactive materials associated with spent fuel, is stored at an ISFSI. See 10 CFR 72.3.

Spent nuclear fuel or spent fuel: Nuclear fuel that has been withdrawn from a nuclear reactor after irradiation, has undergone at least a 1-year decay process since being used as a source of energy in a power reactor, and has not been chemically separated into its constituent elements by reprocessing. Spent fuel includes the special nuclear material, byproduct material, source material, and other radioactive materials associated with fuel assemblies. See 10 CFR 72.3.

Structures, systems, and components (SSCs) important to safety: See 10 CFR 72.3. Those features of the ISFSI and spent fuel storage cask whose functions are at least one of the following:

- to maintain the conditions required to safely store spent fuel, high-level radioactive waste, or reactor-related GTCC waste
- to prevent damage to the spent fuel, the high-level radioactive waste, or reactor-related GTCC waste container during handling and storage
- to provide reasonable assurance that spent fuel, high-level radioactive waste, or reactor-related GTCC waste can be received, handled, packaged, stored, and retrieved without undue risk to the health and safety of the public

Time-limited aging analysis (TLAA): See 10 CFR 72.3. A licensee or CoC holder calculation or analysis that has all of the following attributes:

- involves SSCs important to safety within the scope of license or CoC renewal
- considers the effects of aging
- involves time-limited assumptions defined by the current operating term, for example, 40 years
- was determined to be relevant by the licensee or CoC holder in making a safety determination
- involves conclusions or provides the basis for conclusions related to the capability of the SSCs to perform their intended safety functions
- is contained or incorporated by reference in the design bases

Transfer cask: A shielded SSC used to transfer the fuel canister between the spent fuel handling area and the overpack or storage module.

APPENDIX A

NON-QUANTIFIABLE TERMS

Appendix A

Non-Quantifiable Terms

It is preferred that renewal applications use quantifiable terms and quantitative information, where it exists. However, the following non-quantifiable terms, as well as others, may appear in the renewal application, safety analysis report (SAR), and updates to final SARs:

- large
- small
- slight
- slightly
- significant
- significance
- moderate
- moderately
- low
- minor
- many
- few
- little
- routine
- some
- major
- undetectable
- visible
- measurable
- unchanged
- changed
- no loss of

Table A-1 may be used as guidance for the terms listed above, for additional consideration, or to provide quantitative measures or information.

Table A-1. Screening Criteria for Non-Quantifiable Terms

	Terms	Actions
Screened In	**The term requires additional consideration if it is used for one of the following:** • characterizing an aging effect (e.g., degradation, cracking, fatigue, corrosion, loss of material, change in material properties) • providing important information about the operations, functions, or other characteristics of an in-scope SSC • describing dose, environmental impact, or other hazard, such as combustible material or dust	**If the term screens in, one of the following must be provided:** • quantitative information, if it is available • additional descriptions • definition of the meaning of the term (e.g., "insignificant" means the function of the SSC is not impaired)
Screened Out	**The term is considered immaterial to the SAR and ISFSI/DSS UFSAR for one of the following reasons:** • The term is included in the title of reference document. • The term is included in a quote. • The term is explained by adjacent quantitative information (e.g., small: less than 20 percent). • Use of the term is NOT related to any of the following: – in-scope SSCs per AMR results – aging effect – dose, environment impact, or other hazard (e.g., combustible material) • Use of the term does not provide important information. It is merely descriptive and the meaning of the statement is not changed if the term is deleted (e.g., the word "small" could be deleted from the following statement without altering the meaning: "Water in the grapple ring is drained through a small hole").	No action

APPENDIX B

EXAMPLES OF AGING MANAGEMENT PROGRAMS

Appendix B

Examples of Aging Management Programs

Appendix B contains example aging management programs (AMPs) for:

- localized corrosion and stress corrosion cracking of welded stainless steel dry storage canisters (Table B-1)
- reinforced concrete structures (Table B-2)
- high burnup (HBU) fuel monitoring and assessment program (Table B-3)

This appendix provides examples of acceptable AMPs for staff reference during review of renewal applications.

Example AMP for Localized Corrosion and Stress Corrosion Cracking of Welded Stainless Steel Dry Storage Canisters

Welded stainless steel canisters are used in the majority of the dry storage systems in the United States for spent nuclear fuel from commercial power reactors at both specific-licensed and general-licensed independent spent fuel storage installations (ISFSIs). The welded stainless steel canisters are the primary confinement boundary during storage. Although there are no known operational occurrences of aging or localized corrosion of welded stainless steel canisters, operating experience with nuclear reactors that were located close to an open ocean or bay has shown that pitting corrosion, crevice corrosion, and chloride-induced stress corrosion cracking (CISCC) can occur in welded stainless steel components as a result of atmospheric deposition and deliquescence of chloride-containing salts. Laboratory and natural exposure tests suggest that CISCC can occur with sufficient surface chloride concentrations and that, with those concentrations of chloride, crack propagation rates can be of engineering significance for welded stainless steel canisters during the period of extended operation.

Based on reactor operating experience as well as laboratory and field testing, localized corrosion and CISCC are potential aging mechanisms for welded stainless steel canisters. Environments where chloride-containing salts may be deposited on welded stainless steel canisters include coastal locations near salt water and locations that are close to cooling towers or roads that are salted. ASME Section XI has formed a Task Group to develop a code case to establish the requirements for inservice inspection and acceptance criteria for dry storage system canisters. However, the development of a consensus based code case for inservice inspection of dry storage system canisters may take several years to complete. To address potential aging effects as a result of localized corrosion cracking and stress corrosion cracking in the absence of an acceptable code case, the U.S. Nuclear Regulatory Commission (NRC) has provided an example AMP for welded stainless steel canisters used in dry storage systems that relies on guidance from consensus codes and standards for inservice inspection of nuclear power plant components. Elements of an NRC staff developed example AMP are provided in Table B-1.

Table B-1. Example AMP for Localized Corrosion and Stress Corrosion Cracking of Welded Stainless Steel Dry Storage Canisters

Element	Description
1. Scope of Program	Inspection of welded stainless steel dry storage canister confinement boundary external surfaces for atmospheric deposits, localized corrosion, and stress corrosion cracking. Examinations should be focused on areas with the following attributes: • canister fabrication welds and weld heat affected zones • closure welds and weld heat affected zones • areas of the canister to which temporary supports or attachments were attached by welding and subsequently removed • locations where a crevice is formed on the canister surface • horizontal (±30°) surfaces where deposit accumulation may accumulate at a faster rate compared to vertical surfaces • canister surfaces that are cold relative to the average surface temperature • canister surfaces with higher amounts of atmospheric deposits Effort should be made to identify and prioritize examinations of areas on canisters that have two or more of the above attributes (e.g., canister surface that is cold relative to average surface temperature and also has a weld/weld heat affected zone).
2. Preventive Actions	None, AMP is for condition monitoring. However, dry storage system canister designs may include preventative actions, such as fabrication procedures and surface modification methods to impart compressive residual stresses on the canister welds and weld heat affected zones to reduce the potential for stress corrosion cracking. Preventative actions may also include the use of dry storage system canister confinement boundary materials that are resistant to localized corrosion and stress corrosion cracking. For such cases the preventative actions described should be supported with an analysis and data demonstrating the preventative actions are effective.
3. Parameters Monitored or Inspected	Parameters monitored/inspected should include: • visual evidence of discontinuities and imperfections, such as localized corrosion, including pitting corrosion, crevice corrosion and stress corrosion cracking of the canister welds and weld heat affected zones • size and location of localized corrosion and stress corrosion cracks • appearance and location of deposits on the canister surfaces

Element	Description
4. Detection of Aging Effects	Visual examination of deposits on the canister surfaces and to identify corrosion products that may be indicators of localized corrosion and stress corrosion cracking in the welds and weld heat affected zones. Visual examination instrumentation with demonstrated sizing and depth measurement capability may be useful in the determination of the size and depth of pits open to the surface. Visual examination may also detect the presence of cracks originating from pits. However, the ability to detect cracks on clean metal surfaces using visual examination methods is dependent on several factors and can be difficult for tight crack opening displacements (Cumblidge et al., 2004; 2007). The presence of significant corrosion product accumulation may also interfere with the identification of stress corrosion cracks using visual examination methods. Volumetric examination is necessary to characterize stress corrosion cracking. Volumetric examination of pits and areas immediately adjacent to pits is necessary when pits are within 25 mm (1 inch) of a through thickness weld or within 25 mm (1 inch) of an area where an temporary attachment was known to be located. <u>Visual Examination</u> Pitting and crevice corrosion that is open to the surface can potentially be detected by visual testing (ASME Section V, Table A-110). Because of the high neutron and gamma radiation fields near the surface of the stainless steel dry storage canisters, direct visual examination is not possible. Procedures for remote visual examination should be performance demonstrated; procedure attributes including equipment resolution, lighting requirements, etc., should reference applicable standards, such as ASME Section XI, Article IWA-2200 for VT-1 and VT-3 examinations (ASME, 2007) and BWRVIP-03 (Selby 2005) for EVT-1 examinations. <u>Volumetric Examination</u> Additional assessment is necessary for suspected areas of localized corrosion or stress corrosion cracking. In these cases, the severity of degradation must be assessed including the dimensions of the affected area and the depth of penetration with respect to the thickness of the canister. For accessible areas where adequate cleaning can be performed, remote visual examination meeting the requirements for VT-1 Examination (ASME Section XI, IWA-2211) may be used to determine the type of degradation present (e.g., pitting corrosion or stress corrosion cracking) and the location of degradation. Examinations to characterize the extent and severity of localized corrosion or stress corrosion cracking should be conducted using surface or volumetric examination methods consistent with the requirements of ASME Section XI, IWB-2500 for category B-J components (ASME, 2007).

Element	Description
4. Detection of Aging Effects (cont'd)	<u>Sample Size</u> For sites where inspections are necessary, a minimum of one canister at each site. Preference should be given to the canisters with the greatest susceptibility for localized corrosion or SCC. Factors to be considered include older and colder canisters with the greatest potential for the accumulation and deliquescence of deposited salts that may promote localized corrosion and stress corrosion cracking, types of systems used at site, canister location with respect to potential sources of atmospheric deposits, system design, and operating experience. Industry guidance on evaluating susceptibility has been published by EPRI (Fuhr et al., 2015). Justification for not conducting inspections for localized corrosion or stress corrosion cracking should be provided on a case-by-case basis for each ISFSI site where welded stainless steel canisters are in use. Acceptable justification may be based on a comparison of susceptibility for the ISFSI location versus at least two other ISFSI sites determined to have greater susceptibility but showed no evidence of localized corrosion or stress corrosion cracking in inspections completed within 5 years of the time of the assessment. The justification must consider the full range of available ISFSI susceptibility assessments and welded stainless steel canister examination results. <u>Data Collection</u> Canister Examination: Documentation of the examination of the canister, location, and appearance of deposits. Assessment of the suspect areas where corrosion products were observed as described in corrective actions. Bounding Analysis: A complete listing of other sites considered, susceptibility assessments for those sites and results of examinations conducted at those sites. Justification for not including other sites where examinations showed evidence of localized corrosion and/or stress corrosion cracking. <u>Frequency</u> Once every 5 years

Element	Description
4. Detection of Aging Effects (cont'd)	<u>Timing of Inspections</u> The timing of the inspections includes the pre-application inspection or general-licensee baseline inspection, performed per Sections 3.4.1.2 and 3.6.1.10 of this NUREG, and at the frequency specified by the AMP. Alternative detection methods or techniques may be provided. For these cases: • The method or technique should be adequate and proven to be capable of evaluating the condition of the external surface of the canister against the acceptance criteria for the detection of localized corrosion and stress corrosion cracking. • The proposed intervals for inspection or monitoring are consistent with applicable site-specific, design-specific, or industrywide operating experience and should have sufficient frequency to ensure that the confinement function will be maintained until the next scheduled inspection. • The data collection methods should be sufficient for evaluating localized corrosion and stress corrosion cracking and should reference specific methods to be used for data acquisition including any applicable consensus codes and standards.
5. Monitoring and Trending	Monitoring and trending methods are in accordance with ASME Section XI evaluation criteria. Monitoring and trending methods reference plans/procedures used to: • Establish a baseline before or at the beginning of the period of extended operation. • Track trending of parameters or effects not corrected following a previous inspection, including: – the locations and size of any areas of localized corrosion or the stress corrosion cracking – the disposition of canisters with identified aging effects and the results of supplemental canister inspections Monitoring and trending should also include: • documentation of the appearance of the canister, particularly at welds and in crevice locations, with images and video that will allow comparison in subsequent examinations • changes to the size and number of any rust colored stains as a result of iron contamination of the surface in subsequent inspections

6. Acceptance Criteria	No indications of localized corrosion pits, etching, crevice corrosion, stress corrosion cracking, red-orange colored corrosion products emanating from crevice locations, or red-orange colored corrosion products in the vicinity of canister fabrication welds, closure welds, and welds associated with temporary attachments during canister fabrication. Confirmed or suspected areas of crevice corrosion, pitting corrosion and stress corrosion cracking must be assessed in accordance with acceptance standards identified in ASME Section XI, IWB-3514. Flaws exceeding the acceptance standards in IWB-3514.1 must be evaluated using the acceptance criteria identified in IWB-3640. <u>Indications Requiring Additional Evaluation</u> Although shop and handling procedures include controls to prevent iron contamination of the stainless steel surfaces, contamination does occur and is usually identified by rust-colored surface deposits. Iron contamination can exacerbate CISCC in stainless steels. In accessible locations, removal of the deposits and rust stains that reveal undamaged welds (i.e., absence of pits, crack, localized attack, or etching) and the original machining/grinding marks on the stainless steel base metal, including weld heat affected zones, may be used to confirm that localized corrosion or stress corrosion cracking have not been initiated. Indications of interest that are subject to additional examination and disposition include: • localized corrosion pits, crevice corrosion, stress corrosion cracking, and etching (note that these indications may be covered by obstructions (i.e., crevices)); deposits; or corrosion products • discrete red-orange colored corrosion products that are 1 mm in diameter or larger especially those adjacent to fabrication welds, closure welds, locations where temporary attachments may have been welded to and subsequently removed from the stainless steel dry storage canister, and the weld heat affected zones of these areas • linear appearance of any color of corrosion products of any size parallel to or traversing fabrication welds, closure welds, locations where temporary attachments may have been welded to and subsequently removed from the stainless steel dry storage canister, and the weld heat affected zones of these areas • red-orange colored corrosion products greater than 1 mm in diameter combined with deposit accumulations in any location of the stainless steel canister • red-orange colored corrosion tubercles of any size • red-orange corrosion products present at the mouth of a crevice that includes a portion of the canister surface Alternative acceptance criteria may be provided. For such cases, the acceptance criteria should: • Include a quantitative basis (justifiable by operating experience, engineering analysis, consensus codes/standards). • Avoid use of non-quantifiable phrases (e.g., significant, moderate, minor, little, slight, few). • Be achievable and clearly actionable.

Element	Description
7. Corrective Actions	The corrective actions are in accordance with the specific or general licensee Quality Assurance (QA) Program approved under 10 CFR Part 72, Subpart G, or 10 CFR Part 50, Appendix B. The QA Program ensures that corrective actions are completed within the specific or general licensee's Corrective Action Program (CAP), and include provisions to: • Perform functionality assessments. • Perform apparent cause evaluations, and root cause evaluations. • Address the extent of condition. • Determine actions to prevent recurrence for significant conditions adverse to quality; ensure justifications for non-repairs. • Trend conditions. • Identify operating experience actions, including modification to the existing AMP (e.g., increased frequency). • Determine if the condition is reportable per 10 CFR 72.75. Example provisions are provided below, for assessment of extent of condition and evaluation criteria for canisters with aging effects, following from the example acceptance criteria. Alternative corrective actions to those provided below may be appropriate, per the licensees CAP evaluation to determine appropriate corrective actions to be taken if AMP acceptance criteria are not met. <u>Extent of Condition</u> Confirmation of localized corrosion or stress corrosion cracking may warrant inspection of additional canisters at the same ISFSI location to determine the extent of condition. Priority for additional inspections should be to canisters with similar time in service and initial loading. Canisters with confirmed localized corrosion or stress corrosion cracking must be evaluated for continued service. Canisters with localized corrosion or stress corrosion cracking that do not meet the prescribed evaluation criteria must be repaired or replaced.

Element	Description
7. Corrective Actions (cont'd)	<u>Evaluation Criteria for Canisters with Aging Effects</u> For austenitic stainless steel canisters covered by an AMP that utilizes the inspection and acceptance criteria in ASME B&PV code Section XI for Class 1 piping system, the disposition of canisters should be commensurate with in-service inspection results: • Canisters with no evidence of corrosion are permitted to remain in service and will continue to be evaluated at 5-year intervals. • Canisters with rust deposits that are determined to be a result of iron contamination but do not have evidence of localized corrosion or stress corrosion cracking are permitted to remain in service and will continue to be evaluated at 5-year intervals. • Canisters that show evidence of localized corrosion or stress corrosion cracking that does not exceed the acceptance standards in IWB-3514.1 are permitted to remain in service and will be evaluated at 5-year intervals. Sample size should be increased to assess canisters with similar susceptibility assessments. • Canisters that show evidence of localized corrosion or stress corrosion cracking that exceeds the acceptance standards in IWB-3514.1 but meet the acceptance criteria identified in IWB-3640 including the required evaluation per IWB-3641(a) using the prescribed evaluation procedures, are permitted to remain in service and should be evaluated at 3-year intervals. Sample size should be increased to assess canisters with similar susceptibility assessments. • Canisters that show evidence of localized corrosion or stress corrosion cracking that exceeds acceptance criteria identified in IWB-3640 are not permitted to remain in service without an engineering analysis and/or mitigation actions. Sample size should be increased to assess canisters with similar susceptibility assessments.
8. Confirmation Process	The confirmation process will be commensurate with the specific or general licensee Quality Assurance (QA) Program approved under 10 CFR Part 72, Subpart G or 10 CFR Part 50, Appendix B. The QA Program ensures that the confirmation process includes provisions to preclude repetition of significant conditions adverse to quality. The confirmation process describes or references procedures to: • Determine follow-up actions to verify effective implementation of corrective actions. • Monitor for adverse trends due to recurring or repetitive findings or observations.

Element	Description
9. Administrative Controls	The administrative controls are in accordance with the specific- or general-licensee QA Program approved under 10 CFR Part 72, Subpart G, or 10 CFR Part 50, Appendix B, respectively. The QA Program ensures that administrative controls include provisions that define: • instrument calibration and maintenance • inspector requirements • record retention requirements • document control The administrative controls describe or reference: • methods for reporting results to the NRC per 10 CFR 72.75 • frequency for updating AMP based on site-specific, design-specific, and industrywide operating experience

Element	Description
10. Operating Experience	The AMP references and evaluates applicable operating experience, both before renewal and will continue to do so as new operating experience is developed and made available after renewal, including: • internal and industrywide condition reports • internal and industrywide corrective action reports • vendor-issued safety bulletins • NRC Generic Communications • applicable DOE or industry initiatives (e.g., EPRI- or DOE-sponsored inspections) The AMP clearly identifies any degradation in the referenced operating experience as either age-related or event-driven, with proper justification for that assessment. Past operating experience supports the adequacy of the proposed AMP, including the method/technique, acceptance criteria, and frequency of inspection. The AMP references the methods for capturing operating experience from other ISFSIs with similar in-scope SSCs. CISCC of austenitic stainless steels is a known degradation mechanism for aqueous environments; however, operating experience in aqueous environments is not directly applicable in assessing the potential for atmospheric CISCC for austenitic stainless steel dry storage canisters. Atmospheric CISCC of austenitic stainless steels has been reported in a range of industries including welded stainless steel components and piping in operating nuclear power plants. <u>Spent Fuel Storage</u> Inspections of dry storage canisters after 20 years in service have been conducted at a few independent spent fuel installation (ISFSI) sites. Details of the inspection conducted at the Calvert Cliffs nuclear power plant ISFSI are documented in a recent EPRI report (Waldrop et al., 2014; Bryan and Enos, 2015). No evidence of localized corrosion was identified but some amount of chloride-containing salts were determined to be present and corrosion products believed to be related to iron contamination were identified. <u>Operating Power Reactors</u> NRC Information Notice 2012-20 (NRC, 2012) documents previous cases of atmospheric CISCC of welded stainless steel piping systems and tanks at operating reactor locations. Atmospheric CISCC growth rates determined from operating experience at both domestic and foreign nuclear power plants including events at San Onofre, Turkey Point, St. Lucie, and Koeberg (South Africa) range from 3.6×10^{-12} m/s to 2.9×10^{-11} m/s for components at ambient temperatures.

Element	Description
10. Operating Experience (cont'd)	<u>Relevant Literature and Testing</u> Electric Power Research Institute (EPRI) has recently conducted a literature review of CISCC which summarizes the results of many previous laboratory investigations (Gorman et al., 2014). The NRC has recently published the results of a completed investigation of CISCC testing of type 304, 304L and 316L stainless steel and welds (He, et al., 2014). This study indicates that SCC was initiated at stresses just above the yield strength in tests conducted using 304 stainless steel C-ring specimens. Testing with U-bend specimens showed that CISCC was observed with the lowest simulated sea salt concentrations tested (100 mg salt/m^2 or ~55 mg chloride/m^2) at temperatures of 52°C (125.6°F) using a maximum absolute humidity of 30 g/m^3, which is generally accepted as being near the maximum absolute humidity in a natural environment. Both laboratory and field investigations have been conducted by Central Research Institute of Electric Power Industry (CRIEPI) and Tokyo Electric Power Company (TEPCO). This includes the early work by Tokiwai et al. (1985) who reported the critical surface chloride concentrations of 8 mg/m^2 for CISCC on sensitized Type 304 stainless steel. Kosaka (2008) reported crack growth rates of 9.6×10^{-12} m/s obtained in natural exposure tests on Miyakojima Island with Type 304 base metals and welds, Type 304L welds and Type 316LN welds. Hayashibara, et al. (2008) reported activation energy for crack growth in Type 304 stainless steel of 5.6 to 9.4 kcal/mol (23 to 39 kJ/mol) based on testing conducted at temperatures of 50 to 80°C (122 to 176°F).

Element	Description
References	American Society of Mechanical Engineers, “Boiler and Pressure Vessel Code Section XI—Rules for Inservice Inspection of Nuclear Power Plant Components,” New York, NY: ASME, 2007. Bryan, C.R., D.G. Enos, “Analysis of Dust Samples Collected from Spent Nuclear Fuel Interim Storage Containers at Hope Creek, Delaware, and Diablo Canyon, California,” SAND2014-16383, Albuquerque, NM: Sandia National Laboratories, July 2014. Cumblidge, S.E., M.T. Anderson, S.R. Doctor, “An Assessment of Visual Testing,” NUREG/CR 6860, Pacific Northwest National Laboratory, Richland, WA, 2004, ADAMS Accession No. ML043630040. Cumblidge, S.E., et al., “A Study of Remote Visual Methods to Detect Cracking in Reactor Components,” NUREG/CR-6943, Pacific Northwest National Laboratory, Richland, WA, 2007, ADAMS Accession No. ML073110060. Fuhr, K., J. Broussard, G. White, “Susceptibility Assessment Criteria for Chloride-Induced Stress Corrosion Cracking (CISCC) of Welded Stainless Steel Canisters for Dry Cask Storage Systems,” Electric Power Research Institute (EPRI), EPRI-3002005371, Palo Alto, CA, 2015. Gorman, J., K. Fuhr, J. Broussard, “Literature Review of Environmental Conditions and Chloride-Induced Degradation Relevant to Stainless Steel Canisters in Dry Cask Storage Systems,” EPRI-3002002528, Palo Alto, CA, 2014. Hayashibara, H., et al. “Effect of Temperature and Humidity on Atmospheric Stress Corrosion Cracking of 304 Stainless Steel,” NACE International, Corrosion 2008, paper 08492, Houston, TX, 2008. He, X., et al., “Assessment of Stress Corrosion Cracking Susceptibility for Austenitic Stainless Steels Exposed to Atmospheric Chloride and Non-Chloride Salts,” NUREG/CR-7170, U.S. Nuclear Regulatory Commission, February 2014, ADAMS Accession No. ML14051A417. Kosaki, A., “Evaluation Method of Corrosion Lifetime of Conventional Stainless Steel Canister under Oceanic Air Environment,” Nuclear Engineering and Design, Vol. 238, 2008, pp.1233–1240. Selby, G., “BWR Vessel and Internals Project, Reactor Pressure Vessel and Internals Examination Guidelines,” EPRI 1011689, TR-105696-R8 (BWRVIP-03) Rev. 8, Palo Alto, CA, 2005. Tokiwai, M., H. Kimura, H. Kusanagi, “The Amount of Chlorine Contamination for Prevention of Stress Corrosion Cracking in Sensitized Type 304 Stainless Steel,” Corrosion Science, Vol. 25 Issue 8–9, 1985, pp. 837–844.

Element	Description
References (cont'd)	U.S. Nuclear Regulatory Commission (NRC), Information Notice 2012-20: "Potential Chloride-Induced Stress Corrosion Cracking of Austenitic Stainless Steel and Maintenance of Dry Cask Storage System Canisters," November 14, 2012, ADAMS Accession No. ML12319A440. Waldrop, K. et al., "Calvert Cliffs Stainless Steel Dry Storage Canister Inspection," EPRI-1025209, EPRI, Palo Alto, CA, 2014.

Example AMP for Reinforced Concrete Structures

An example aging management program (AMP) for reinforced concrete structures is provided below. The AMP consists of condition monitoring, performance monitoring, mitigation and prevention activities. The program includes periodic visual inspections by personnel qualified to monitor reinforced concrete for applicable aging effects, such as those described in the American Concrete Institute (ACI) guides 349.3R-02, ACI 201.1R-08, and American National Standards Institute/American Society of Civil Engineers guidelines (ANSI/ASCE) 11-99. Identified aging effects are evaluated against acceptance criteria derived from the design bases or industry guides and standards, including ACI 349, ACI 318, ACI 349.3R-02 and the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, Subsection IWL.

The program also includes periodic sampling and testing of groundwater and the need to assess the impact of any changes in its chemistry on below-grade concrete structures. Additional activities include radiation surveys to ensure the shielding functions of the concrete structure are maintained and daily inspections to ensure the air convection vents are not blocked, if applicable (per the requirements of the approved design bases). The program also includes provisions where modifications may be appropriate for specific license renewals.

Table B-2. Example AMP for Reinforced Concrete Structures

Element	Description
1. Scope of Program	The scope of the program includes the following aging management activities: 1. visual inspection of above-grade (accessible, inaccessible) and below-grade (underground) concrete areas (See Element 4 for sample size and justification of areas to be inspected) 2. groundwater chemistry monitoring program to identify conditions conducive to below-grade (underground) aging mechanisms: • corrosion of embedded steel • chemical attack (chloride and sulfate induced degradation 3. radiation surveys to: • Ensure compliance with 10 CFR 72.104 (i.e., dose equivalent requirements beyond the controlled area during normal and off-normal conditions of storage). • Monitor performance of the concrete as a neutron/gamma shield at near system locations as an indicator of concrete degradation. The program provides means to address the following aging effects and mechanisms, as described in ACI 349.3R-02 and ASCE/SEI 11-99: • cracking or loss of material (spalling, scaling) due to freeze-thaw degradation • cracking or loss of material (spalling, scaling) due to chemical attack (chloride, sulfate induced) • cracking and loss of strength due to cement aggregate reactions • cracking, loss of material, and loss of bond due to corrosion of embedded steel • increase in porosity/permeability and loss of strength due to leaching of calcium hydroxide ($Ca(OH)_2$) • cracking and distortion due to long-term settlement • cracking and reduction in strength due to gamma and neutron irradiation Calculations or analyses (time-limited aging analyses, when appropriate) may be used to demonstrate that aging effects due to irradiation do not require an AMP. More specifically, the renewal application may demonstrate that no part of the concrete exceeds critical cumulative fluences of 10^{17} neutrons/m^2 or 10^{10} rad (gamma dose), per ACI 349.3R-02.[a] Additional site-specific AMPs may be required for the following scenarios: • A dewatering system is used to prevent long-term settlement. • The design bases includes embedded aluminum subcomponents without a protective insulating coating. • Protective coatings are relied upon to manage the effects of aging for a subcomponent.

Element	Description
2. Preventive Actions	Preventive actions include (1) continuance of inspections to ensure that air inlet and outlet vents are not blocked, or (2) temperature monitoring, if applicable, to ensure design temperature limits are not exceeded. These inspections would be part of the approved design bases and be continued for the sample size and inspection frequency identified in the respective technical specification. Additional preventive actions are not required for structures designed and fabricated in accordance to ACI 318 or ACI 349, as specified in the design bases. Otherwise, a site-specific AMP may be required.
3. Parameters Monitored or Inspected	For visual inspections, the parameters monitored/inspected quantify the following aging effects: • cracking • material loss (spalling, scaling) • loss of bond • increased porosity/permeability The AMP references the following parameters for characterizing the above aging effects, as appropriate:[b] • affected surface area • geometry/depth of defect • cracking, crazing, delaminations, drummy areas • curling, settlements or deflections • honeycombing, bug holes • popouts and voids • exposure of embedded steel • staining/ evidence of corrosion • dusting, efflorescence of any color The parameters evaluated consider any surface geometries that may support water ponding and potentially increase the rate of degradation. For the groundwater chemistry program, the parameters monitored/inspected include: • water pH • concentration of chlorides and sulfates in the water For radiation surveys, the parameters monitored/inspected include gamma dose rate and/or neutron fluence rate.

Element	Description
4. Detection of Aging Effects	<u>Method/Technique</u> The method/technique achieves the acceptance criteria, as defined in AMP Element 6. An engineering justification or technical bases is provided, which references applicable consensus guides, codes and standards, or calibration procedures that ensure the method or technique will provide reliable data. For visual inspections, the method/technique is defined as: • visual method for normally accessible areas (e.g., feeler gauges, crack comparators) • visual method for normally inaccessible areas (site-qualified remote inspection system) Procedures for remote visual inspections should be demonstrated to ensure the acceptance criteria in ACI 349.3R is achievable; procedure attributes should include equipment resolution, lighting requirements, etc. and reference applicable standards when possible. For the groundwater chemistry program, the method/technique is defined as a chemical analysis method with a valid measurement range relative to the acceptance criteria. For radiation surveys, the method/technique is defined as calibrated neutron and gamma detectors with valid energy ranges. <u>Frequency of Inspection</u> The proposed inspection schedule is commensurate with ACI 349.3R-02. Alternative inspection frequencies provide a valid technical basis (engineering justification, operating experience data) for any deviation from ACI 349.3R-02. For visual inspections, the frequency of inspection is defined as: • for above-grade (accessible and inaccessible) areas: ≤ 5 years • for below-grade (underground) areas: ≤ 10 years, and when excavated for any reason • the use of opportunistic inspections in lieu of planned inspections per the above schedule provides a valid technical basis (engineering justification, operating experience data). For the groundwater chemistry program, the frequency of monitoring is justified (e.g., quarterly, semiannual). For radiation surveys, the frequency of monitoring is justified (e.g., quarterly).

Element	Description
4. Detection of Aging Effects (cont'd)	<u>Sample Size</u> Visual inspections cover 100 percent of readily accessible surfaces of all reinforced concrete structures in operation (e.g., all normally accessible exterior surfaces of all loaded overpacks), and 100 percent of normally inaccessible surfaces for a justified subset of the reinforced concrete structures in operation (e.g., interior surfaces of two overpacks, including the overpack earliest loaded and the overpack loaded with the highest heat-load canister). The extent of inspection coverage should be specified and demonstrated to sufficiently characterize the condition of the structure. For the groundwater chemistry program and radiation surveys, the sample size clearly identifies and justifies specific locations where inspection/monitoring will be conducted to sufficiently characterize the condition of the structure (e.g., periodic dose rate measurements will be performed at same locations specified in the technical specifications for dose rate measurements at loading). <u>Data Collection:</u> Data collection for visual inspections is commensurate with applicable consensus codes/standards/guides: • for example, ACI 224.1R for quantitative analysis (crack width, extent), ACI 562, ACI 364.1R. The AMP references a clearinghouse for documenting inspection/monitoring operating experience. <u>Timing</u> The timing of the inspections includes the pre-application inspection or general-licensee baseline inspection, performed per Sections 3.4.1.2 and 3.6.1.10 of this NUREG, and at the frequency justified by the AMP.

5. Monitoring and Trending	Monitoring and trending methods are commensurate with defect evaluation guides and standards (e.g., ACI 201.1R, ACI 207.3R, ACI 364.1R, ACI 562, or ACI 224.1R for crack evaluation).
	
	Monitoring and trending methods reference plans/procedures used to:
	• Establish a baseline before or at the beginning of the period of extended operation.
	• Track trending of parameters or effects not corrected in a previous inspection, for example:
	  • crack growth/extent
	  • pore/void density and affected areas
	  • dose rates

Element	Description
6. Acceptance Criteria	For visual inspections, the acceptance criteria are commensurate with the three-tier quantitative criteria in ACI 349.3R-02: • acceptance without further evaluation • acceptance after review • acceptance requiring further evaluation The acceptance criteria clearly identify when a condition is to be entered in the Corrective Action Program (e.g., when Tier 2 acceptance per ACI 349.3R-02 is exceeded). For the groundwater chemistry program, the acceptance criteria are commensurate with ASME Code Section XI, Subsection IWL, which states that an aggressive below-grade environment is defined as: • pH < 5.5, chlorides > 500 ppm, or sulfates > 1500 ppm For radiation surveys, the acceptance criteria are justified and sufficient to ensure compliance with 10 CFR 72.104 and identify dose rates that statistically exceed calculated/expected dose rates at pre-determined measurement locations. The adequacy of the acceptance criteria considers measured dose rates versus calculated/expected dose rates for a dry storage system (DSS) given the DSS contents and accounting for the decay of the source term since the DSS loading. Measurement locations should be consistent with those specified in the license/CoC conditions/technical specification (if any) and/or locations where dose rates were calculated in the FSAR and likely measured at the time of loading. Alternative acceptance criteria may be provided. For such cases, the acceptance criteria should: • Include a quantitative basis (justifiable by operating experience, engineering analysis, consensus codes/standards). • Avoid use of non-quantifiable phrases (e.g., significant, moderate, minor, little, slight, few). • Be achievable and clearly actionable.
7. Corrective Actions	The corrective actions are in accordance with the specific- or general-licensee QA Program approved under 10 CFR Part 72, Subpart G, or 10 CFR Part 50, Appendix B, respectively. The QA Program ensures that corrective actions are completed within the specific or general licensee's CAP, and include provisions to: • Perform functionality assessments. • Perform apparent cause evaluations, and root cause evaluations. • Address the extent of condition. • Determine actions to prevent recurrence for significant conditions adverse to quality; ensure justifications for non-repairs. • Trend conditions. • Identify operating experience actions, including modification to the existing AMP (e.g., increased frequency). • Determine if the condition is reportable to the NRC per 10 CFR 72.75. The AMP references applicable concrete rehabilitation guides or standards, for example: • cracking: ACI 224.1R, ACI 562, ACI 364.1R, and ACI RAP Bulletins • spalling/scaling: ACI 562, ACI 364.1R, ACI 506R, and ACI RAP Bulletins

Element	Description
8. Confirmation Process	The confirmation process is commensurate with the specific- or general-licensee QA Program approved under 10 CFR Part 72, Subpart G, or 10 CFR Part 50, Appendix B, respectively. The QA Program ensures that the confirmation process includes provisions to preclude repetition of significant conditions adverse to quality. The confirmation process describes or references procedures to: • determine follow-up actions to verify effective implementation of corrective actions • monitor for adverse trends due to recurring or repetitive findings or observations
9. Administrative Controls	The administrative controls are in accordance with the specific- or general-licensee QA Program approved under 10 CFR Part 72, Subpart G, or 10 CFR Part 50, Appendix B, respectively. The QA Program ensures that the administrative controls include provisions that define: • instrument calibration and maintenance • inspector requirements (commensurate with ACI 349.3R-02) • record retention requirements • document control The administrative controls describe or reference: • methods for reporting results to the NRC per 10 CFR 72.75 • frequency for updating the AMP based on industrywide operating experience
10. Operating Experience	The AMP references and evaluates applicable operating experience, both before renewal and will continue to do so as new operating experience is developed and made available after renewal, including: • internal and industrywide condition reports • internal and industrywide corrective action reports • vendor-issued safety bulletins • NRC Generic Communications • applicable DOE or industry initiatives (e.g., EPRI- or DOE-sponsored inspections) The AMP clearly identifies any degradation in the referenced operating experience as either age-related or event-driven, with proper justification for that assessment. Past operating experience supports the adequacy of the proposed AMP, including the method/technique, acceptance criteria, and frequency of inspection. The AMP references the methods for capturing operating experience from other ISFSIs with similar in-scope SSCs.

Element	Description
References	ACI 201.1R-08, “Guide for Conducting a Visual Inspection of Concrete in Service,” 2008. ACI 207.3R-94, “Practices for Evaluation of Concrete in Existing Massive Structures for Service Conditions,” 2008. ACI 224.1R-07, “Causes, Evaluation, and Repair of Cracks in Concrete Structures,” 2007. ACI 318-05, “Building Code Requirements for Structural Concrete and Commentary,” 2005. ACI 349.3R-02, “Evaluation of Existing Nuclear Safety-Related Concrete Structures,” 2010. ACI 349-06, “Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary,” 2007. ACI 364.1R-07, “Guide for Evaluation of Concrete Structures before Rehabilitation,” 2007. ACI 506R-05, “Guide to Shotcrete,” 2005. ACI 562-13, “Code Requirements for Evaluation, Repair, and Rehabilitation of Concrete Buildings,” 2013. ACI CT-13, “ACI Concrete Terminology,” 2013. ASCE/SEI 11-99, “Guideline for Structural Condition Assessment of Existing Buildings,” 2000. ASME Boiler and Pressure Vessel Code, Section XI, Subsection IWL, “Requirements for Class CC Concrete Components of Light-Water-Cooled Plants,” 2013. NRC, “Standard Review Plan for Spent Fuel Dry Storage Facilities,” NUREG-1567, Rev. 0. Washington, DC, 2000. ADAMS Accession No. ML003686776. NRC, “Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility,” NUREG-1536, Rev. 1, Washington, DC, 2010a. ADAMS Accession No. ML101040620. NRC, “Generic Aging Lessons Learned (GALL) Report,” NUREG-1801, Rev. 2, Washington, DC, 2010c. ADAMS Accession No. ML103490041.

[a] The staff recognizes the critical cumulative fluence in ACI 349.3R-02 as adequately conservative. The applicant may choose to justify a higher critical cumulative fluence if a technical bases is provided.
[b] Terminology consistent with ACI standard CT-13.

Example of a High Burnup Fuel Monitoring and Assessment Program

An example of a High Burnup (HBU) Fuel [1] Monitoring and Assessment Program is provided below. This is a licensee program that monitors and assesses data and other information regarding HBU fuel performance, to confirm that the design-bases HBU fuel configuration is maintained during the period of extended operation. This example HBU Monitoring and Assessment Program relies on a surrogate demonstration program to provide data on HBU fuel performance. Guidance for determining if a surrogate demonstration program can provide the data to support a licensee's HBU Fuel Monitoring and Assessment Program is given in Appendix D. Although this example focuses on the use of a surrogate demonstration program, a licensee may use alternative approaches that are appropriately justified.

The aging management review is not expected to identify any aging effects that could lead to fuel reconfiguration, as long as the HBU fuel is stored in a dry inert environment, temperature limits are maintained, and thermal cycling is limited (see Sections 2.4.2.1 and 3.4.1.4). Short-term testing (i.e., laboratory scale testing up to a few months) and scientific analyses examining the performance of HBU fuel have provided a foundation for the technical basis that storage of HBU fuel in the period of extended operation may be performed safely and in compliance with regulations. However, there has been relatively little operating experience, to date, with dry storage of HBU fuel.

Therefore, the purpose of a HBU Fuel Monitoring and Assessment Program is to monitor and assess data and other information regarding HBU fuel performance to confirm there is no degradation of HBU fuel that would result in an unanalyzed configuration during the period of extended operation. The following description of an example HBU Fuel Monitoring and Assessment Program presents the applicable information in a format using each element of an effective aging management program, to provide a framework for such a monitoring and assessment program.

[1] Fuel assemblies with discharge burnup greater than 45 gigawatt-days per metric ton of uranium (GWd/MTU)

Table B-3. Example of a High Burnup Fuel Monitoring and Assessment Program

Element	Description
1. Scope of the Program	The scope of the program provides a description of: (1) the design-bases characteristics of the HBU fuel, (2) the surrogate demonstration program that will be used to provide data on the applicable design-bases HBU fuel performance, and (3) how the parameters of the surrogate demonstration program are applicable to the design-bases HBU fuel. Aging effects will be determined for material/environment combinations through an alternative surrogate demonstration program meeting the guidance in Appendix D. Example language to address this "scope of the program" element follows: Fuel stored in a *[define cask/canister model]* is limited to an assembly average burnup of *[define design-bases limit]* GWd/MTU. The cladding materials for the HBU fuel are *[define types of cladding],* and the fuel is stored in a dry helium environment. HBU fuel was first placed into dry storage in a *[define cask/canister model]* on *[start date of storage term of first storage of HBU fuel].* The program relies on the joint Electric Power Research Institute (EPRI) and Department of Energy (DOE) "HBU Dry Storage Cask Research and Development Project" (HDRP) (EPRI 2014), conducted in accordance with the guidance in Appendix D, as a surrogate demonstration program that monitors the performance of HBU fuel in dry storage. The HDRP is a program designed to collect data from a spent nuclear fuel storage system containing HBU fuel in a dry helium environment. The program entails loading and storing a AREVA TN-32 bolted lid cask (the "Research Project Cask") at Dominion Virginia Power's North Anna Power Station with intact HBU fuel (of average assembly burnups ranging between 53 GWd/MTU and 55.5 GWd/MTU). The fuel to be used in the program include four kinds of cladding (Zircaloy-4, low-tin Zircaloy-4, Zirlo™, and M5™). The Research Project Cask is to be licensed to the temperature limits contained in Interim Staff Guidance (ISG) 11, Rev. 3 (NRC 2003), and loaded such that the fuel cladding temperature is as close to the limit as practicable. *[If an alternative surrogate demonstration program is used, provide a description of the program.]*

Element	Description
1. Scope of the Program (cont'd)	The parameters of the surrogate demonstration program are applicable to the design-bases HBU fuel, as the: (1) maximum assembly-average burnup of the design-bases HBU fuel *[define value]* is less than the assembly-average burnup of the fuel in the surrogate demonstration program *[define value]*; (2) the cladding type of the design-bases HBU fuel *[define type]* is the same as the surrogate demonstration program *[define type]*; and (3) the peak temperatures in the surrogate demonstration program *[define values]* bound the peak temperatures of the loaded systems (or design bases) *[define values]*.[a]
2. Preventive Actions	There are no specific preventive actions associated with this HBU Fuel Monitoring and Assessment Program. However, the applicant should discuss the design-bases characteristics of the licensed/certified dry storage system, in terms of initial cask loading operations, to show the HBU fuel is stored in a dry inert environment. Example language follows: During the initial loading operations of the cask/canister, the design and ISFSI Technical specifications (TS) require that the fuel be stored in a dry inert environment. TS *[name and number]* demonstrates that the cask/canister cavity is dry by maintaining a cavity absolute pressure less than or equal to *[value]* for a *[time period]* with the cask/canister isolated from the vacuum pump. TS *[name and number],* requires that the cask/canister then be backfilled with helium. These two TS requirements ensure that the HBU fuel is stored in an inert environment thus preventing cladding degradation due to oxidation mechanisms. TS *[name and number]* also requires that the helium environment be established within *[time]* hours of commencing cask/canister draining. The cask/canister is loaded in accordance with the criteria of ISG-11.
3. Parameters Monitored or Inspected	The applicant identifies the parameters monitored and inspected in a surrogate demonstration program that are applicable to its particular design-bases HBU fuel and describes how this meets the guidance of Appendix D.
4. Detection of Aging Effects	The applicant identifies the detection of aging effects in a surrogate demonstration program that are applicable to its particular design-bases HBU fuel and describes how this meets the guidance of Appendix D.

Element	Description
5. Monitoring and Trending	As information/data from a surrogate demonstration program or from other sources (such as testing or research results and scientific analyses) becomes available, the licensee will monitor, evaluate, and trend the information via its operating experience program and/or the Corrective Action Program (CAP) to determine what actions should be taken. The licensee will evaluate the information/data from a surrogate demonstration program or from other sources to determine whether the acceptance criteria in Element 6 are met. • If all of the acceptance criteria are met, no further assessment is needed. • If any of the acceptance criteria are not met, the licensee must conduct additional assessments and implement appropriate corrective actions (see Element 7). Formal evaluations of the aggregate information from a surrogate demonstration program and other available domestic or international operating experience (including data from monitoring and inspection programs, NRC generic communications, and other information) will be performed at specific points in time during the period of extended operation, as delineated in Table B-4.
6. Acceptance Criteria	The High Burnup Fuel Monitoring and Assessment Program acceptance criteria are: • Hydrogen content—maximum hydrogen content of the cover gas over the approved storage period should be extrapolated from the gas measurements to be less than the design-bases limit for hydrogen content. • Moisture content—the moisture content in the cask/canister, accounting for measurement uncertainty, should be less than the expected upper bound moisture content per the design-bases drying process.[b] • Fuel condition/performance—nondestructive examination (e.g., fission gas analysis) and destructive examination (e.g., to obtain data on creep, fission gas release, hydride reorientation, cladding oxidation, and cladding mechanical properties) should confirm the design-bases fuel condition (i.e., no changes to the analyzed fuel configuration considered in the safety analyses of the approved design bases). The applicant should provide information on the design-bases characteristics of the dry storage system or ISFSI, with regard to these criteria. The applicant should reference the source of specific values, or explain any assumptions made, for defining design-bases characteristics of the fuel condition/performance.

Element	Description
7. Corrective Actions	The corrective actions are in accordance with the specific- or general-licensee QA Program approved under 10 CFR Part 72, Subpart G, or 10 CFR Part 50, Appendix B, respectively. Corrective actions should be implemented if data from a surrogate demonstration program or other sources of information indicate that any of the High Burnup Fuel Monitoring and Assessment Program acceptance criteria (in Element 6) are not met. If any of the acceptance criteria are not met, the licensee will: (1) Assess fuel performance (effects on fuel and changes to fuel configuration). (2) Assess the design-bases safety analyses, considering degraded fuel performance (and any changes to fuel configuration), to determine the ability of the dry storage system/ISFSI to continue to perform its intended functions under normal, off-normal, and accident conditions. The licensee will determine what corrective actions should be taken to: (1) Manage fuel performance, if any. (2) Manage impacts related to degraded fuel performance to ensure that all intended functions for the dry storage system/ISFSI are met. In addition, the licensee will obtain the necessary NRC approval in the appropriate licensing/certification process for modification of the design bases to address any conditions outside of the approved design bases.
8. Confirmation Process	The confirmation process is commensurate with the specific- or general-licensee QA Program approved under 10 CFR Part 72, Subpart G, or 10 CFR Part 50, Appendix B, respectively. The QA Program ensures that the confirmation process includes provisions to ensure corrective actions are adequate and appropriate, have been completed, and are effective. The focus of the confirmation process is on the follow-up actions that must be taken to verify effective implementation of corrective actions. The measure of effectiveness is in terms of correcting the adverse condition and precluding repetition of significant conditions adverse to quality. Procedures include provisions for timely evaluation of adverse conditions and implementation of any corrective actions required, including root cause evaluations and prevention of recurrence where appropriate. These procedures provide for tracking, coordinating, monitoring, reviewing, verifying, validating, and approving corrective actions, to ensure effective corrective actions are taken.
9. Administrative Controls	The administrative controls are in accordance with the specific- or general-licensee QA Program approved under 10 CFR Part 72, Subpart G, or 10 CFR Part 50, Appendix B, respectively. The QA Program ensures that the administrative controls include provisions that define: • formal review and approval processes • record retention requirements • document control

Element	Description
10. Operating Experience	The program references and evaluates applicable operating experience, both before renewal and will continue to do so as new operating experience is developed and made available after renewal, including: • internal and industrywide condition reports • internal and industrywide corrective action reports • vendor-issued safety bulletins • NRC Generic Communications • applicable DOE or industry initiatives (e.g., HDRP) • applicable research (e.g., Oak Ridge National Laboratory studies on bending responses of the fuel, Argonne National Laboratory and Central Research Institute of Electric Power Industry studies on hydride reorientation effects) The review of operating experience clearly identifies any HBU fuel degradation as either age-related or event-driven, with proper justification for that assessment. Past operating experience supports the adequacy of the HBU Fuel Monitoring and Assessment Program. Surrogate demonstration programs with storage conditions and fuel types similar to those in the licensed ISFSI/certified dry storage system that meet the guidance in Appendix D are a viable method to obtain operating experience. New data/research on fuel performance from both domestic and international sources that are relevant to the licensed/certified HBU fuel in the dry storage system/ISFSI should be evaluated on a periodic basis and the AMP updated and revised as needed.

Element	Description
References	Center for Nuclear Waste Regulatory Analyses, "Extended Storage and Transportation: Evaluation of Drying Adequacy," June 2013, NRC Contract No. NRC-02-07-006, 2013. ADAMS Accession No. ML13169A039. Dominion Resources, Inc., "North Anna ISFSI, TN-32 High Burnup Dry Storage Research Project," May 13, 2015. ADAMS Accession No. ML15133A082. EPRI, "HBU Dry Storage Cask Research and Development Project, Final Test Plan," February 27, 2014, DOE Contract No. DE-NE-0000593. NRC, "Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility," NUREG-1536, Rev. 1, Washington, DC, 2010. ADAMS Accession No. ML101040620. NRC, Interim Staff Guidance 11, "Cladding Considerations for the Transportation and Storage of Spent Fuel," Revision 3, November 17, 2003. ADAMS Accession No. ML033230335.

[a] The AMP should provide a technical basis that supports the conclusion that the demonstration fuel is reasonably characteristic of the licensee's stored fuel, in the event of differences in burnup, cladding composition (alloy types) and peak cladding temperatures observed during loading (See Appendix D).

[b] The applicant will need to provide the expected upper bound moisture content based on its design-bases drying process. For example, if the design-bases drying process involves a vacuum drying method of evacuating a cask/canister to less than or equal to 3 torr and maintaining a constant pressure for 30 minutes after the cask/canister is isolated from the vacuum pump, the expected water content is about 0.43 gram-mole. (See NUREG-1536, Rev. 1.)

Table B-4. Formal Evaluations of Aggregate Information on HBU Fuel Performance

	Year	Assessment
1	Date—before HBU fuel exceeds the initial storage term [a]	Evaluate information obtained from a surrogate demonstration program for loading and initial period of storage along with other available sources of information. If surrogate demonstration program nondestructive examination (NDE) (i.e., cask/canister gas sampling, temperature data) data has not been obtained at this point, then the licensee has to provide evidence that the acceptance criteria in Element 6 are met or initiate a corrective action.
2	Date—10 years after Assessment 1 above	Evaluate, if available, information obtained from the destructive examination and NDE of the fuel placed into storage in a surrogate demonstration program along with other available sources of information. If the destructive examination data from a surrogate demonstration program has not been obtained at this point, then the licensee has to provide evidence to the NRC, by opening a cask/canister or separate effects surrogate experiments, that the acceptance criteria in Element 6 are met or initiate a corrective action.
3	Date—10 years after Assessment 2 above	Evaluate any new information.

[a] See Appendix F for a discussion of storage terms.

APPENDIX C

[RESERVED]

Upon consideration of public comments received on Draft NUREG-1927, Revision 1, the concepts regarding lead system inspections originally presented in Appendix C of the Draft NUREG-1927, Revision 1, have been incorporated into Chapter 3, “Aging Management Review,” of this Final NUREG-1927, Revision 1. Therefore, the content in Appendix C has been deleted, and Appendix C is reserved for future use.

APPENDIX D

SUPPLEMENTAL GUIDANCE FOR THE USE OF A DEMONSTRATION PROGRAM AS A SURVEILLANCE TOOL FOR CONFIRMATION OF INTEGRITY OF HIGH BURNUP FUEL DURING THE PERIOD OF EXTENDED OPERATION

Appendix D

Supplemental Guidance for the Use of a Demonstration Program as a Surveillance Tool for Confirmation of Integrity of High Burnup Fuel During the Period of Extended Operation

This guidance provides the U.S. Nuclear Regulatory Commission (NRC) staff a basis for reviewing if a demonstration of high burnup (HBU) fuel has the necessary properties to qualify as one method that an applicant might use in license and certificate of compliance renewal applications to confirm the integrity of HBU fuel during continued storage.

D.1 Discussion

The experimental confirmatory basis that low burnup fuel (≤45 GWd/MTU) will maintain its integrity in dry cask storage over extended time periods was provided in a demonstration test (NRC, 2003; Bare, et al., 2001; Einziger, et al., 2003). A similar confirmation test, which includes information over a similar length of the time available for low burnup fuel, does not exist for other light water reactor (LWR) fuels, HBU fuel [1] and mixed oxide fuels. Certification and licensing HBU fuel for storage was permitted for an initial 20-year-term using the guidance contained in Interim Staff Guidance (ISG) 11 (NRC 2003), which was based on short-term laboratory tests and analysis that may not be applicable to the storage of HBU fuel beyond 20 years, particularly with the current state of knowledge regarding HBU fuel cladding properties.

One concern stated in ISG-11 was the potential detrimental effects, such as reduced ductility, of hydride reorientation on cladding behavior (NRC, 2003). Research performed in Japan and the United States indicated that: (1) hydrides could reorient at a significantly lower stress than previously believed (Billone, et al., 2013; Kamimura, 2010; Daum, et al, 2006), and (2) the radial hydrides could raise the cladding ductile-to-brittle transition temperature enough to compromise the ability of the cladding to withstand stress without undergoing brittle failure (Billone, et al., 2013). This phenomenon could influence the retrievability of HBU fuel assemblies and result in operational safety concerns in the handling of individual assemblies as HBU fuel cooled. Circumferential zirconium hydrides in the fuel cladding regions would dissolve into the fuel cladding during drying and reprecipitate (reorient) as radial hydrides as the fuel cladding cooled. Thus, fuel cladding with radial hydrides that is below a ductile-to-brittle transition temperature could be too brittle to retrieve (remove from the DSS) on an assembly basis. The maximum temperatures and internal rod pressures in ISG-11 were recommended to mitigate hydride reorientation and are applicable to HBU fuel during the initial 20-year storage, as the decay heat of HBU fuel is expected to maintain cladding temperatures above a ductile-to-brittle transition temperature (about 200 degrees Celsius, or about 392 degrees Fahrenheit).

There is no evidence to suggest that HBU fuel cannot similarly be stored safely and then retrieved for time periods beyond 20 years, but the supporting experimental data is not extensive. Therefore, confirmatory data or a commitment to obtain data on HBU fuel and taking appropriate steps in an aging management plan (AMP) will provide further information that will be useful in evaluating the safe handling of individual assemblies of HBU fuel for extended durations.

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[1] High burnup fuel is fuel with burnup ≥ 45 GWd/MTU.

A demonstration program could provide an acceptable method for an applicant to demonstrate compliance with the cited regulations for storage of light water reactor fuels (LWR) for periods of greater than 20 years by:

- confirming the expected fuel conditions, based on technical arguments made in ISG-11 (NRC, 2003), after a substantial storage period that is sufficiently long (about 10 years) to extrapolate the findings to the storage duration of interest (The behavior of the cladding for the period of extended operation will depend on its physical condition at the end of the initial 20-year storage period.)

- providing data for benchmarking, confirming predictive models, and updating aging management plans

- confirming the time-limited aging analysis (TLAA) cladding creep predictions that are the basis for the guidance recommendation for the maximum temperature in ISG-11 (NRC, 2003) are not exceeded and that sufficient creep margin exists for the extended storage period

- determining the system is sufficiently dry to eliminate moisture-driven degradation from consideration

- providing operating experience on the fuel behavior and drying procedure as input to an AMP on the behavior of the fuel

- identifying any aging effects that may be missed through short-term accelerated studies and analyses

Monitoring of the fuel temperatures, gas composition, and other conditions in the canister or cask combined with physical examination of the fuel at periodic intervals should be able to provide confirmation if:

- The models of the phenomena used for the first 20-year predictions can be used for the TLAA beyond 20 years.

- The condition of the fuel, after an appropriately long period of storage, does not degrade.

- New degradation mechanisms are not being exhibited.

Extrapolation outside the recorded data carries risk, but that risk can be minimized if the length of the extrapolation is reduced and those extrapolations are updated as the demonstration continues to monitor and measure fuel properties.

D.2 Technical Review Guidance

The applicant may use the results of a completed demonstration or an ongoing demonstration if the conditions of the demonstration meet the requirements stated below for the fuels and conditions of storage for which the term is to be renewed. The approach in this guidance can be applied to a generic demonstration program or a site/system-specific program as long as the demonstration's parameters are reasonably applicable to the applicant's fuel type and characteristics.

The technical reviewers should establish that the following conditions are met if the demonstration is to be used by the applicant to support fuel assembly conditions for storage of HBU fuel beyond 20 years and to be applicable to support a license or certificate application:

(1) That the maximum burnup of the fuel in the application is less than the burnup of the fuel in the demonstration. If the burnup is higher than that in the demonstration, the applicant should provide evidence, based on characteristics of the fuel, derived either from reactor rod qualification testing or other separate effects tests, that the demonstration fuel is reasonably characteristic of the stored fuel and the added burnup will not change the results determined by the demonstration. Similarly, if there is a different cladding type used, arguments based on comparison of composition and fabrication technique (e.g., stress-relieved and annealed, recrystallized) should justify the use of the demonstration results.

(2) If the applicant uses direct observations of the rod behavior to imply the condition of the rods in its system, either (1) the temperatures in the demonstration must bound the temperatures in the application, or (2) if the applicant uses predictive tools that have been confirmed by the demonstration, then the temperatures of the rods in the application do not have to be bounded by the temperature of the rods in the demonstration. The temperature models used in the application should either be benchmarked (1) against the demonstration temperature data, or (2) against actual measured rod temperature data in the same temperature range.

(3) If the applicant is using gas analysis or another gas detection method to establish the condition of the fuel, then the interior of a demonstration canister or cask should be quantitatively monitored for, at a minimum, moisture, oxygen, and fission gas. The duration and frequency of the gas monitoring should be determined by analysis of the potential degradation. Gases should always be quantitatively monitored before opening of the canister. If the applicant claims that no galvanic degradation is feasible, then, if after drying, moisture is detected in the canister, moisture and hydrogen should be monitored at a reasonable frequency to be determined by the applicant until the moisture disappears. Gas monitoring is not expected during movement of the canister. If the applicant is using the gas analysis to show no breaches would occur during transport, gas quantitative monitoring must be conducted before and after transport.

(4) Temperature monitoring should be conducted at a frequency that is suitable for determining the profile over the duration of the demonstration.

(5) If possible, some population of stored rods should be examined whenever the system is opened. These rods should be extracted from the fuel assembly to determine properties of the rods that affect degradation such as cladding creep, fission gas release, hydride reorientation, cladding oxidation, and mechanical properties.

(6) The demonstration program fuel shall include at least two full fuel assemblies. The assemblies may be reconstituted.

(7) Data from the demonstration program must be indicative of a storage duration long enough to justify extrapolation to the total storage time requested but no less than

10 years if the data is to be used to support license extension from the initial 20 years to an additional 40 years.[2]

D.3 References

Bare, W.C, L.D. Torgerson, "Dry Cask Storage Characterization Project—Phase 1: CASTOR V/21 Cask Opening and Examination," NUREG/CR-6745, Idaho National Engineering and Environmental Laboratory, Idaho Falls, ID, 2001. Agencywide Documents Access and Management System (ADAMS) Accession No. ML013020363.

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

Daum, R.S., et al., 2006. "Radial-Hydride Embrittlement of High-burnup Zircaloy-4 Cladding", Journal of Nuclear Science and Technology, Vol. 43, No. 9, p.1054, 2006.

Einziger, R.E., et al., "Examination of Spent PWR Fuel Rods after 15 Years in Dry Storage," NUREG/CR-6831, Argonne National Laboratory, Argonne, IL, 2003. ADAMS Accession No. ML032731021.

Kamimura, K. "Integrity Criteria of Spent Fuel for Dry Storage in Japan," Proceedings of the International Seminar on Interim Storage of Spent Fuel, ISSF 2010, page VI3-1, Tokyo November 2010.

U.S. Nuclear Regulatory Commission (NRC), Interim Staff Guidance 11, "Cladding Considerations for the Transportation and Storage of Spent Fuel," Rev. 3, November 17, 2003.

NRC, "The Use of a Demonstration Program as a Surveillance Tool for Confirmation of Integrity for Continued Storage of HBU Fuel Beyond 20 Years," ISG-24, Revision 0. Washington, DC, 2014. ADAMS Accession No. ML14058B166.

[2] A demonstration is to provide that there was satisfactory performance during the first 20 years and that the results could be extrapolated to support an additional 40 years. The NRC staff agreed that a demonstration of ≤ 10 years storage duration is insufficient to support these goals.

APPENDIX E

CONSIDERATIONS FOR RENEWALS OF CERTIFICATES OF COMPLIANCE

Appendix E

Considerations for Renewals of Certificates of Compliance

E.1 Development of Time-Limited Aging Analyses and Aging Management Programs

From Title 10 of the *Code of Federal Regulations* (10 CFR) 72.240, "Conditions for Spent Fuel Storage Cask Renewal," the certificate of compliance (CoC) renewal application must include time-limited aging analyses (TLAAs), if applicable, and aging management programs (AMPs). The CoC holder, as the applicant for the CoC renewal and the owner of the storage cask or dry storage system (DSS) design, will develop the TLAAs and AMPs. The renewal application should address age-related degradation of the DSS design in a bounding manner (i.e., fully address pertinent aging mechanisms and effects in all possible service environments where the DSS is being used and can be used). If there is an AMP that may not be applicable to certain general licensees, because of the service environment in which the DSS is located, the AMP should specify this. In addition, the CoC holder and the staff should consider the need for a CoC condition to specify this potential limited use of the AMP, so it is clear for general licensee implementation.

For a CoC renewal that encompasses CoC amendments with different design bases, the CoC holder will need to address in the renewal application how the TLAAs or AMPs apply to each amendment covered by the CoC. For example, if different materials are used or different SSCs are part of the DSS design in different CoC amendments, or if different environments (e.g., underground vs. aboveground system) are reflected in different CoC amendments, then there may be different TLAAs or AMPs specified for the individual amendments.

E.2 Implementation of AMPs

In approving the renewal of the DSS design, the U.S. Nuclear Regulatory Commission (NRC) may revise the CoC to include terms, conditions, and specifications that will ensure the safe operation of the DSS during the period of extended operation, including but not limited to, terms, conditions, and specifications that will require the implementation of an AMP by a general licensee, in accordance with 10 CFR 72.240(e). General licensees' implementation of AMPs is subject to NRC inspection.

Regulations in 10 CFR 72.212, "Conditions of General License Issued under § 72.210," provide requirements for general licensees using approved CoCs. Regulations in 10 CFR 72.212(b)(11) require general licensees to comply with the terms, conditions, and specifications of the CoC, including but not limited to, the requirements of any AMP put into effect as a condition of the NRC approval of a CoC renewal application in accordance with 10 CFR 72.240.

General licensees (CoC users) are responsible for implementing the AMPs. To document the licensee's compliance with the renewed CoC, a future or existing general licensee should include in its 10 CFR 72.212(b)(5) evaluation (including the results of the review and determination per 72.212(b)(6) and 72.212(b)(8)) how it will meet the new CoC terms, conditions, or specifications for aging management. Note that the renewed CoC may include a condition for the general licensee to do so. As part of this evaluation, general licensees should consider any granted exemptions or 10 CFR 72.48 changes that could affect aging management.

The general licensee should update the 10 CFR 72.212(b)(5) evaluation before entering the period of extended operation. Considering timely renewal provisions (See Section 1.4.5), update of the 10 CFR 72.212(b)(5) evaluation before the loaded systems enter the period of extended operation may not be possible. In such cases, the reviewer should ensure that timing for update of the 10 CFR 72.212(b)(5) evaluation is addressed in the application in a clear manner. Also, any CoC condition related to the update of the 10 CFR 72.212(b)(5) evaluation may include timing provisions.

The AMP-related information in the DSS FSAR will be implemented by general licensees as-written. If a general licensee wishes to deviate from the DSS FSAR, it must evaluate any such deviation under the provisions of 10 CFR 72.48. If AMP details in the FSAR specify that the AMP is not applicable for certain users (e.g., if it is not applicable in certain climates or environments), the general licensee can include the technical justification in its 10 CFR 72.212 report for not implementing such an AMP. The general licensee would need to evaluate any changes to the 10 CFR 72.212 report or any deviations from the DSS FSAR, using the requirements of 10 CFR 72.48 (See NRC Regulatory Issue Summary 2012-05, "Clarifying the Relationship Between 10 CFR 72.212 and 10 CFR 72.48 Evaluations").

E.3 Corrective Actions

As discussed in Section 3.6.1.7, corrective actions are measures to be taken when the AMP acceptance criteria are not met. Corrective actions are critical for maintaining the intended functions of the structures, systems, and components during the initial storage term as well as the period of extended operation. The CoC holder should discuss in its renewal application any applicable and appropriate corrective actions to be taken if the AMP acceptance criteria are not met.

A general licensee will use its Corrective Action Program (CAP) (that is consistent with the criteria in 10 CFR Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants") to capture and address aging effects identified in the period of extended operation. At a minimum, all conditions that do not meet the AMP acceptance criteria should be entered into the CAP. The general licensee's CAP should be able to respond to and adequately address and rectify any ISFSI or DSS aging issues. Also, the CAP's response to address any DSS aging issues should include any specific corrective actions specified in the CoC renewal application.

APPENDIX F

STORAGE TERMS

Appendix F

Storage Terms

F.1 Introduction

This appendix provides a flow chart for calculating storage terms of a dry storage system (DSS) or a DSS structure, system, and component (SSC) loaded during either the initial storage period or renewal period(s) of a certificate of compliance (CoC).

F.2 Storage Term Defined

The storage term (length of time a DSS can remain loaded) is determined by the period specified in the applicable CoC in effect at the time the DSS is placed into service (from Title 10 of the *Code of Federal Regulations* (10 CFR) 72.212(a)(3) and Ref. 1). The storage period begins when the DSS is first used by the general licensee to store spent fuel (10 CFR 72.212(a)(3)).[1] The clock starts when the loaded cask has been deployed in the independent spent fuel storage installation (76 FR 8872). If a CoC is not renewed, upon expiration, casks loaded under that CoC would need to be removed from service when they reach the end of their storage term. An AMP for a renewed CoC commences at the end of the initial storage period for each loaded DSS (see Section 3.6.2).

- If the DSS is loaded during the initial CoC term (e.g., 20 years) and the CoC is not renewed, the storage term is the entirety of the initial CoC term (e.g., 20 years).
- If the DSS is loaded during the initial CoC term and the CoC is renewed once, the storage term is the remaining time in the initial CoC term added to the entirety of the first renewal period.
- If the DSS is loaded during the first renewal period (e.g., 40 years), and the CoC is not subsequently renewed, the storage term is the entirety of the first renewal period (e.g., 40 years).
- If the DSS is loaded during the first renewal period, and the CoC is subsequently renewed, the storage term is the remaining time in the first renewal period added to the entirety of the subsequent renewal period (cumulative).

F.3 Flowchart for Calculating Storage Terms

A flowchart is provided below to assist the user in calculating the storage term for a DSS loaded under a CoC.

[1] The storage period for a particular DSS SSC begins when it is first used to store spent fuel, regardless if the SSC is later stored at a different location.

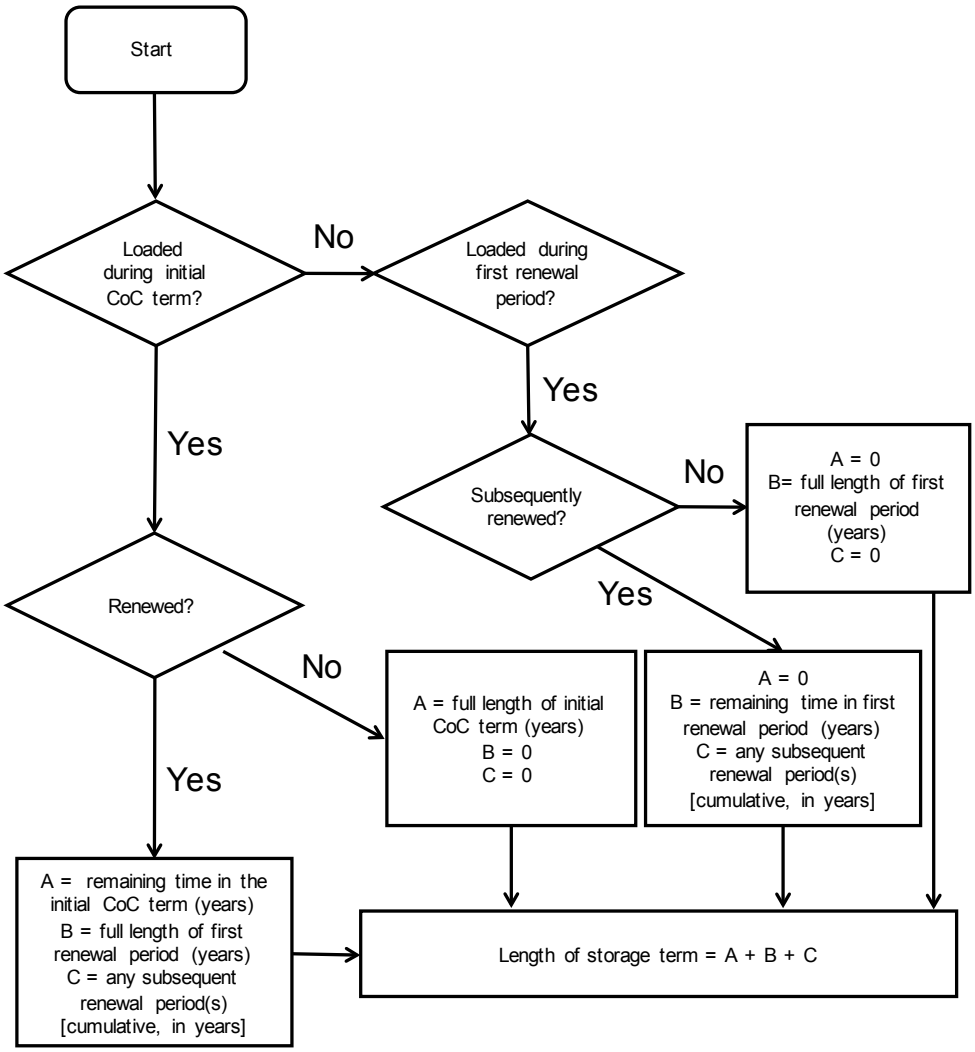

Figure F-1. Flowchart for calculating storage terms

F.4 References

U.S. Nuclear Regulatory Commission, "10 CFR Part 72, License and Certificate of Compliance Terms, Final Rule," *Federal Register*, Vol. 76, No. 32, February 16, 2011, pp. 8872–8892 (76 FR 8872).

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11. ABSTRACT (200 words or less)

This Standard Review Plan is intended for use by U.S. Nuclear Regulatory Commission (NRC) reviewers. It provides guidance for the safety review of renewal applications for specific licenses of independent spent fuel storage installations and certificates of compliance (CoCs) of dry storage systems, as codified in Title 10 of the Code of Federal Regulations (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."

To renew a specific license, an applicant (i.e., licensee) must submit a license renewal application at least 2 years before the expiration of the license in accordance with the requirements of 10 CFR 72.42(b). To renew a CoC, an applicant (i.e., CoC holder, user, or user's representative) must submit a renewal application at least 30 days before the expiration of the associated CoC in accordance with the requirements of 10 CFR 72.240(b). The NRC may renew a specific license or a CoC for a term not to exceed 40 years, in accordance with 10 CFR 72.42(a), or 10 CFR 72.240(a), respectively.

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