

Managing Aging Effects on Dry Cask Storage Systems for Extended Long-Term Storage and Transportation of Used Fuel

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Abstract. The report “Managing Aging Effects on Dry Cask Storage Systems for Extended Long-Term Storage and Transportation of Used Fuel, Rev. 2” is a key reference in the U.S. Nuclear Energy Institute’s (NEI’s) “Industry Guidance for Operations-Based Aging Management.” The guidance in NEI 14-03, Rev. 0 was submitted for endorsement by the U.S. Nuclear Regulatory Commission (NRC) in September 2014, while the NRC is updating its own guidance document in the “Standard Review Plan for Renewal of Used Fuel Dry Cask Storage System License and Certificate of Compliance,” NUREG-1927. The main features of the aging management report are highlighted, along with a brief discussion of guidance documents from industry and NRC, as well as the aging management needs for a Pilot Interim Storage Facility and beyond. The latter is of interest as the used fuel may need to be stored and transported multiple times before final disposal at a mined repository or geological disposal facility.

Key Words: Aging management, spent fuel dry storage casks

1. Introduction

At present, there is no designated disposal site for used nuclear fuel in the United States, which raises the prospect of extended long-term storage (i.e., >60 years) and deferred transportation of used fuel at operating and decommissioned nuclear power plant sites. Under U.S. federal regulations contained in Title 10 of the Code of Federal Regulations 72.42, the initial license term for an independent spent fuel storage installation (ISFSI) must not exceed 40 years from the date of issuance. Licenses may be renewed by the U.S. Nuclear Regulatory Commission (NRC) at the expiration of the license term upon application by the licensee, for a period not to exceed 40 years. Applications for ISFSI license renewals must include (1) time-limited aging analyses (TLAAs) that demonstrate that structures, systems, and components (SSCs) important to safety will continue to perform their intended function for the requested period of extended operation and (2) a description of the aging management program (AMP) for management of issues associated with aging that could adversely affect SSCs important to safety. In addition, the application must include design basis information as documented in the most recently updated final safety analysis report, as required by 10 CFR 72.70. Information contained in previous applications, statements, or reports filed with the Commission under the license may be incorporated by reference, provided that these references are clear and specific. The NRC has issued the “Standard Review Plan for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance,” NUREG-1927 [1], under which NRC may renew a specific license or a Certificate of Compliance (CoC) for a term not to exceed 40 years. Both the license and the CoC renewal applications

must contain revised technical requirements and operating conditions (fuel storage, surveillance and maintenance, and other requirements) for the ISFSI and dry cask storage system (DCSS) that address aging effects that could affect the safe storage of the used fuel. The information contained in the license and CoC renewal applications will require NRC review to verify that the aging effects on the SSCs in DCSSs/ISFSIs are adequately managed for the requested period of extended operation. Over 2,000 dry casks in the United States were loaded with used fuel; four ISFSIs (Surry, H.B. Robinson, Oconee, and Calvert Cliffs) have received their renewed licenses for 40 years, and an application for license renewal for 40 years for another, Prairie Island, is pending approval by NRC. In addition, renewal of the CoCs for the VSC-24 cask and Standardized NUHOMS are pending NRC approval. The NRC expects to receive fifteen (15) renewal applications between 2015 and 2025.

2. The ANL/DOE Aging Management Report

2.1. Description of the Aging Management Report

As part of the U.S. Department of Energy's (DOE's) Used Fuel Disposition Campaign Research and Development program, Argonne National Laboratory (Argonne) has prepared a report titled "Managing Aging Effects on Dry Cask Storage Systems for Extended Long-Term Storage and Transportation of Used Fuel," Rev. 2, FCRD-UFD-2013-000294, ANL-13/15 [2]. This report, herein referred to as the aging management report, examines issues related to managing the aging effects on the SSCs in DCSSs and ISFSIs for extended long-term storage and subsequent transportation of used fuels, following an approach similar to that of the Generic Aging Lessons Learned (GALL) report, NUREG-1801 [3], for the aging management and license renewal of nuclear power plants. The aging management report contains five chapters and two appendices, A and B, respectively, on Quality assurance for AMPs for used-fuel dry cask storage systems and a comparison of TLAAs and AMPs in the aging management report with those in NUREG-1801, Chapters X and XI.

Among the five chapters in the report, Chapter I provides an overview of the ISFSI license renewal process based on 10 CFR 72 and the guidance provided in NUREG-1927 [1]. Chapter II contains definitions and terms for structures and components in DCSSs, materials, environments, aging effects, and aging mechanisms. Chapter III and Chapter IV contain the TLAAs and AMPs, respectively, that have been developed for managing aging effects on the SSCs important to safety in the DCSS designs described in Chapter V, which contains summary descriptions and tabulations of evaluations of AMPs and TLAAs for the SSCs that are important to safety in the DCSS designs (i.e., NUHOMS, HI-STORM/HI-STAR 100, TN metal cask, NAC International S/T storage cask, Ventilated Storage Cask [VSC-24], Westinghouse MC-10 metal dry storage cask, CASTOR V/21 and X/33 dry storage casks, and W150 FuelSolutions storage system) that have been and continue to be used by utilities across the United States for the dry storage of used fuel.

The goal of the aging management report is to help establish the technical basis for extended long-term storage and subsequent transportation of used fuel, which may occur multiple times before final disposal at a mined repository or geological disposal facility. It has been suggested that future efforts should include (1) development of additional TLAAs and AMPs that may be deemed necessary and (2) further evaluation of the adequacy of the generic TLAAs and AMPs that may need augmentation. Industry and site-specific operating experience from the various DCSSs/ISFSIs located across the United States should be

periodically examined to (a) ascertain the potential aging effects on the SSCs in the DCSSs, thereby enabling a compilation of existing aging management activities, and (b) assess adequacy of these activities for extended long-term storage and subsequent transportation of used fuel.

2.2. Resolution of Stakeholder Comments

An earlier version of the aging management report, Rev. 1, was released by DOE in November 2013 for stakeholder comments worldwide, via the United States Electric Power Research Institute's (EPRI's) Extended Storage Collaboration Program (ESCP), with the comment period ending March 31, 2014. Over 200 written comments were received from stakeholders representing industry, utilities, NRC, U.S. national laboratories, and Germany. The various comments focused on:

1. Interpretations of 10 CFR 72 and related NRC regulatory requirements;
2. Definitions of environments, aging mechanisms, and aging effects;
3. Specific content in recommended AMPs and TLAAs with respect to aging management activities and analyses;
4. Difficulties in performing inspections, condition monitoring, and other aging management activities in terms of accessibility and hostile environments; and
5. Descriptions and evaluations of the various dry cask storage systems.

At the request of industry and NRC, separate meetings were held at Argonne in May 2014 to discuss the comments and their proposed resolutions. These meetings were highly productive in that the technical issues in aging management were discussed in depth, as were the approaches reflecting the unique perspectives of the NRC and industry. Over 100 additional comments were also received in June from NRC, as well as from dry cask vendors — these comments are particularly important for verifying the accuracy of the descriptions of the DCSS designs in Chapter V of the aging management report. Highlights of the significant changes resulting from the stakeholder comments can be found in the Executive Summary of the report [2].

3. The U.S. Industry and NRC Guidance on Aging Management

The industry has incorporated the aging management report into the Nuclear Energy Institute's (NEI's) "14-03: Guidance for Operations-based Aging Management for Dry Cask Storage" [4] to augment the 10 CFR 72 license and Certificate of Compliance (CoC) renewal review guidance in NUREG-1927, Section 3.0, "Aging Management Review." Revision 0 of NEI 14-03 was submitted for the NRC's endorsement in September 2014. Note that NEI 14-03 introduced "tollgates" into the Part 72 license and CoC renewal process. "Tollgate" is a new term created by the industry to address the fact that the applicability of potential dry cask storage aging mechanisms may not be able to be verified at the time license and CoC renewal applications are submitted. This information would enhance the current understanding of the future state of dry spent fuel and the canisters that contain it. Tollgates are part of a learning, operations-based aging management program implemented by licensees via requirements in the renewed license or CoC and associated final safety analysis report. These requirements obligate the licensees to perform periodic assessments of the aggregate state of knowledge of aging-related operational experience, research, monitoring, and inspections to ascertain the ability of in-scope DCSS design SSCs to continue performing their intended safety functions throughout the requested period of extended operation.

In March 2015, the NRC released a draft of NUREG-1927, Rev. 1 [5], which was developed in parallel with the NEI effort to develop guidance in NEI 14-03, Rev. 0 for the industry in the preparation of applications for renewal of licenses and CoC. The draft NUREG-1927, Rev. 1 includes guidance on the continued evaluation of operating experience (see Section 3.6.1.10 of NUREG-1927, Rev. 1 [5]) and mentioned the use of “tollgates” in NEI 14-03, Rev. 0 as a structured approach for assessing operating experience and data from applicable research and industry initiatives. The NRC staff has provided comments on NEI 14-03, Rev. 0 in January 2015 (ADAMS Accession No. ML15013A201). The NRC is continuing to work with NEI as it develops its guidance for proposed NRC endorsement. In the meantime and according to NRC, Section 3.6.1.10 of the NUREG-1927, Rev. 1 draft reflects the current thinking and guidance regarding information in NEI 14-03 that may be used or referenced by applicants for license or CoC renewals. As mentioned earlier, the aging management report recommends periodic assessment of industry and site-specific operating experience of the various DCSSs/ISFSIs, which share the same basic philosophy as that of the tollgates in NEI 14-03 and NUREG-1927.

4. Aging Management Needs for a Pilot Interim Storage Facility (ISF) and Beyond

The DOE established the Nuclear Fuels Storage and Transportation (NFST) Planning Project in October 2012. The mission of the NFST is to lay the groundwork for implementing interim storage, including associated transportation, and to develop a foundation for a new nuclear waste management organization [6]. The NFST activities are divided into four major areas: (1) consent-based siting, (2) storage, (3) transportation, and (4) strategic crosscuts. Descriptions of these activities can be found in reference [6]. The objective for the storage design activity is to lay the groundwork for implementation of interim storage as a planned part of the waste management system, with an initial focus on a pilot ISF accepting SNF in dual-purpose canisters from reactor sites that have been shut down. The primary focus is on developing and evaluating interim storage design options, including design concepts to support development of a Topical Safety Analysis Report (TSAR) for eventual submittal to the NRC. This is a key activity that can be performed now to help reduce uncertainties and mitigate schedule risks associated with full implementation in the future.

Assessing aging management needs for a pilot ISF and beyond is an ongoing activity that supports the storage design. Under this activity, regulatory, programmatic, and technical needs for aging management of a pilot ISF and beyond are being assessed by:

1. Performing a comparison of the TLAAs and AMPs in the DOE/ANL aging management report with those in the recent and ongoing ISFSI license/CoC renewal applications to identify gaps;
2. Updating the DOE/ANL aging management report, as appropriate, to ensure consistency of the generic AMPs and TLAAs for the DCSS designs with the operations-based AMPs in the NRC/industry guidance documents; and
3. Compiling “lessons learned” in the present aging management activities for potential application to address aging management needs for the pilot ISF and beyond.

A database of operations-based AMPs and supporting technologies, including aging management R&D and domestic/international guidance documents, is also being established by continuing collaboration with the EPRI’s ESCP partners, such as the Federal Institute for Materials Research and Testing (Bundesanstalt für Materialforschung und-prüfung [BAM]) in Germany [7] and other countries.

5. Summary and Conclusions

An aging management report has been prepared to address issues related to managing the aging effects on SSCs in DCSSs/ISFSIs for extended long-term storage and subsequent transportation of used nuclear fuel. Managing aging effects on DCSSs/ISFSIs for extended long-term storage and transportation of used fuel requires knowledge and understanding of the various aging degradation mechanisms for the materials of the SSCs and their environmental exposure conditions during the extended period of operation. The operating experience involving the AMPs, including the past corrective actions resulting in program enhancements or additional programs, provides objective evidence to support a determination that the effects of aging will be adequately managed so that the intended safety functions of the SSCs will be maintained during the period of extended operation. Operations-based or operations-focused AMPs and periodic assessment of their efficacy and effectiveness are a theme consistent in the aging management report and the guidance documents being developed by industry and the NRC. The fundamental principles and approach in aging management discussed herein are applicable to addressing the aging management needs for a pilot Interim Storage Facility and beyond.

Managing aging effects on DCSSs for extended long-term storage and subsequent transportation of used fuel depends on AMPs for the prevention, mitigation, and early detection of aging effects on the SSCs through condition and/or performance monitoring. Detection of aging effects should occur before there is a loss of any structure's or component's intended functions that are important to safety. Among the important aspects of detection are the method or technique employed (i.e., visual, volumetric, or surface inspection), frequency, sample size, data collection, and timing of new/one-time inspections to ensure timely detection of aging effects. The challenges in the detection of aging effects include (1) detection of aging in regions that are inaccessible for inspection and monitoring and (2) determination of the frequency of inspection and monitoring (i.e., periodic versus continuous). DOE, the NRC, and industry personnel worldwide are actively engaged in various R&D and demonstration activities and meet regularly to exchange information through EPRI's Extended Storage Collaboration Program and other venues, such as the International Atomic Energy Agency Coordinated Research Programs and international conferences.

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