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NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001

April 20, 2016

Mr. Victor M. McCree
Executive Director for Operations
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: NUREG-1927, REVISION 1, "STANDARD REVIEW PLAN FOR RENEWAL OF SPECIFIC LICENSES AND CERTIFICATES OF COMPLIANCE FOR DRY STORAGE OF SPENT NUCLEAR FUEL"

Dear Mr. McCree:

During the 633rd meeting of the Advisory Committee on Reactor Safeguards, April 7-9, 2016, we completed our review of NUREG-1927, Revision 1, "Standard Review Plan for Renewal of Specific Licenses and Certificates of Compliance for Dry Storage of Spent Nuclear Fuel." Our Metallurgy and Reactor Fuels Subcommittee reviewed this matter on April 8, 2015 and March 24, 2016. We also had the benefit of the referenced documents.

## RECOMMENDATIONS

1. NUREG-1927, Revision 1, "Standard Review Plan for Renewal of Specific Licenses and Certificates of Compliance for Dry Storage of Spent Nuclear Fuel," should be issued.

2. A future revision should be undertaken that places a priority on the development of a risk-informed approach, which includes analysis of event consequences, for aging management of dry storage systems.

## BACKGROUND

A dry storage system (DSS) is a stand-alone system used to store spent nuclear fuel. DSSs are located at Independent Spent Fuel Storage Installations[1] (ISFSIs). They are designed to comply with 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 Regulated Greater than Class C Waste." 10 CFR 72.104 limits site boundary annual dose during normal operations and anticipated occurrences to less than 0.25 mSv (25 mrem) to the whole body, 0.75 mSv (75 mrem) to the thyroid, and 0.25 mSv (25 mrem) to any other critical organ.

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1 10 CFR Part 72 defines an independent spent fuel storage installation or ISFSI as a complex designed and constructed for the interim storage of spent nuclear fuel, solid reactor-related greater than Class C waste, and other radioactive materials associated with spent fuel and reactor-related greater than Class C waste storage. An ISFSI which is located on the site of another facility licensed under 10 CFR Part 72 or a facility licensed under 10 CFR Part 50 and which shares common utilities and services with that facility or is physically connected with that other facility may still be considered independent.

NUREG-1536, Revision 1, Section 5.4.1 addresses confinement design characteristics. Construction of the primary confinement barrier has typically been in accordance with the ASME Boiler and Pressure Vessel Code, Section III, “Rules for Construction of Nuclear Facility Components,” Division 1, Subsections NB or NC. Section 5.4.1 of NUREG-1536 requires that “the design must provide a nonreactive environment to protect fuel assemblies against cladding degradation, which might otherwise lead to gross rupture.” Section 5.4.4 requires that “The analysis of potential releases must demonstrate that an inert atmosphere will be maintained within the cask during storage lifetime.”

The initial license term for a DSS was 20 years. NUREG-1927, Revision 0 was issued to provide requirements and guidance for renewal of licenses. Renewal of ISFSI specific licenses and Certificates of Compliance is for a period not to exceed 40 years. Intended functions of the system would be assured through the implementation of time-limited aging analyses (TLAAs) and aging management programs (AMPs).

Several license renewals have been submitted using NUREG-1927, Revision 0. The resulting experience and feedback from stakeholders indicated that a significant revision was warranted. NUREG-1927, Revision 1 was issued for comment on July 7, 2015.

The staff is also developing a more comprehensive guidance document on AMPs called the Managing Aging Processes in Storage Report. The document will be based on concepts similar to those in NUREG-1801.

**DISCUSSION**

The major changes in Revision 1 ensure that the design basis is maintained and the confinement boundary remains intact for the period of extended operation. The focus is on aging management reviews and the development and implementation of expanded AMPs and time-limited aging analyses. The guidance lists the following elements for an AMP:

- Scope of Program
- Preventive Actions
- Parameters Monitored or Inspected
- Detecting of Aging Effects
- Monitoring and Trending
- Acceptance Criteria
- Corrective Actions
- Confirmation Process
- Administrative Controls, and
- Operating Experience

The concept of a “learning AMP” is introduced in which AMPs will be adapted to account for operating experience as it is accumulated.

In addition, the industry has initiated a parallel effort to provide additional guidance in NEI 14-03, Revision 1. NEI 14-03 introduces the concept of “tollgates” to be included as part of an operations-based AMP. These are periodic hold points at which an evaluation of the overall process is performed. A cornerstone of this process is an aging management database developed and maintained by the Institute of Nuclear Power Operations. The purpose of the database is the sharing of operating experience relevant to DSSs. All of the current cask vendors have agreed to participate. These concepts are recognized in the operating experience guidance of NUREG-1927, Revision 1.

The NUREG contains examples of AMPs for chloride-induced stress corrosion cracking (CISCC), concrete degradation, and the storage of high burnup fuel (>45 GWD/MTU). We focus here on the CISCC AMP. The staff suspects that CISCC could be the dominant life-limiting phenomena for welded austenitic stainless steel canisters in some environments. CISCC is a known degradation phenomenon for austenitic stainless steel and has been observed in piping exposed to environmental conditions that may exist at some sites. This is especially true for coastal sites where chloride-containing salts are present and can deliquesce (form an aqueous solution) under certain conditions of humidity and temperature. Thus, the assumption is that CISCC may affect a canister. It should be noted that while there have been no known canister breaches, this does not mean that cracking is not occurring, only that penetration has not been observed.

Detection of CISCC first involves the selection of a subset of the canister population at a site deemed to be at risk based on external environmental conditions (salt-containing, moist air) and temperature (salt deliquescence can occur) in combination with regions of the canister surface thought to contain high residual stresses, primarily due to welding. This is followed by inspections every five years unless damage is detected. If damage is suspected or detected, the inspection interval is decreased and the number of canisters inspected is increased. Canisters that exceed flaw acceptance standards must either be repaired or removed from service. Successful implementation of the CISCC AMP would provide reasonable assurance that the confinement boundary of all canisters at an ISFSI would remain intact for the period of extended operation.

The guidance in NUREG-1927, Revision 1 is informed by current best practices for aging management. The continued learning process accomplished by the tollgates and operating experience allows for adjustment of the process. However, due to the multivariate nature of the stress corrosion cracking process and the physical configuration of the canister systems, it will be impossible to guarantee that the most vulnerable canisters are being inspected. For example, determining which canisters have the highest weld-induced residual stresses, as well as the highest stressed locations in such canisters, can be problematic due to one or more of the following reasons:

- Not all of the canister shell welds will be accessible.
- Weld repairs may have been performed during construction that have not been documented. The residual stresses in these regions will be extremely high.
- Determining the actual external environment at the weld region will be very difficult due to the geometry of the system.

The effect of these conditions is that the number of canisters that must be inspected, to achieve a high degree of certainty that all CISCC flaws will be detected, is likely to be very large, and a particularly susceptible canister might be overlooked.

The industry and staff are well aware of these issues, and a significant effort is now underway to develop or improve techniques for the inspection and detection of cracks or precursor conditions for cracking. Yet even with such advancements, false positive indications could occur. Also, the possibility exists that cracking could occur in a canister that was not thought to be at risk. As a result, the population of canisters requiring inspection will likely increase, leading to increased costs and worker dose.

For these reasons, although NUREG-1927, Revision 1 is expected to result in a very low probability that confinement will be compromised during the period of extended operation, the process is not foolproof.

Yet another concern is that improving access to the canisters to increase the probability of successful inspection could make the canisters more vulnerable to security concerns. Should environmental degradation produce canister leakage, the potential release of radioactivity is expected to be small. On the other hand, sabotage or terrorist attack on the cask could lead to a failure sufficiently large that a substantial release of radioactive material is possible. It is, therefore, imperative that measures taken to facilitate inspection and monitoring of casks for environmental degradation not make DSSs more vulnerable to deliberate attack.

Given the above, we suggest that an alternative, risk-informed path be pursued. Our bases for this suggestion are:

1. The potential source term from canister failure is very small.
2. The probability of confinement failure has been estimated by two independent pilot probabilistic risk assessments which suggest that the latent cancer fatality rate would be on the order $10^{-12}$-$10^{-13}$/year.
3. While the pilot probabilistic risk assessments did not consider CISSC, the consequences of a leak due to such cracks are likely to also be very small. Stress corrosion cracks are very “tight” which would limit release given the differential pressure once the canister is depressurized. Even assuming a significant amount of failed fuel, the release of radioactivity would be very small and would occur at a very slow rate.
4. Simple, external monitoring systems and procedures that could be put in place would likely detect a breach long before the 10 CFR Part 72 boundary dose limits would be challenged. Site boundary radiation levels are monitored continuously and routine visual inspections are required. Additionally, sites plan to have local external monitoring systems in place.

Consideration of a risk-informed approach, which includes analysis of event consequences, could yield a simpler and more cost-effective process that would achieve the same level of protection for the public at a lower worker dose. Recent discussions with the staff and industry indicate that this path is now being seriously explored. We encourage the staff to continue efforts to pursue such an approach and to engage with the industry in this effort.

**SUMMARY**

NUREG-1927, Revision 1 is a significant improvement over the original version and provides more thorough guidance to the staff to ensure that the DSSs perform as designed.

A future revision should be undertaken that places a priority on the development of a risk-informed approach to the aging management of DSSs.

Dr. Joy Rempe did not participate in the Committee's deliberations regarding this matter.

Sincerely,

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Dr. Dennis Bley
Chairman

**REFERENCES**


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2. U.S. Nuclear Regulatory Commission, NUREG-1536, Revision 1, “Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility,” July 30, 2010 (ML101040620).

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4. U.S. Nuclear Regulatory Commission, NUREG-1801, “Generic Aging Lessons Learned (GALL) Report, December 2010 (ML103490041).

5. NEI 14-03, “Format, Content and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management,” Revision 1, September 2015 (ML15272A329).

6. U.S. Nuclear Regulatory Commission, NUREG-1864, “A Pilot Probabilistic Risk Assessment of a Dry Cask Storage System at a Nuclear Power Plant,” March 2007 (ML071340012).

7. Electric Power Research Institute, Technical Report 1009691, “Probabilistic Risk Assessment (PRA) of Bolted Storage Casks: Updated Quantification and Analysis Report,” December 2004.

8. U.S. Nuclear Regulatory Commission, Draft Regulatory Issue Summary 2015-XX, “Considerations in Licensing High Burnup Spent Fuel in Dry Storage and Transportation,” February 20, 2015 (ML14175A203).

9. U.S. Nuclear Regulatory Commission, Interim Staff Guidance-24, Revision 0, "The Use of a Demonstration Program as a Surveillance Tool for Confirmation of Integrity for Continued Storage of High Burnup Fuel Beyond 20 Years," June 11, 2014 (ML14058B166).

10. U.S. Nuclear Regulatory Commission, "Identification and Prioritization of the Technical Information Needs Affecting Potential Regulation of Extended Storage and Transportation of Spent Nuclear Fuel," May 2014 (ML14043A402).

11. U.S. Nuclear Regulatory Commission, 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 (ML12319A440).

12. U.S. Nuclear Regulatory Commission, Interim Staff Guidance-11, Revision 3, "Cladding Considerations for the Transportation and Storage of Spent Fuel," November 17, 2003 (ML033230335).

13. U.S. Nuclear Regulatory Commission, NUREG-1567, "Standard Review Plan for Spent Fuel Dry Storage Facilities," March 2000 (ML003686776).

9. U.S. Nuclear Regulatory Commission, Interim Staff Guidance-24, Revision 0, "The Use of a Demonstration Program as a Surveillance Tool for Confirmation of Integrity for Continued Storage of High Burnup Fuel Beyond 20 Years," June 11, 2014 (ML14058B166).

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13. U.S. Nuclear Regulatory Commission, NUREG-1567, "Standard Review Plan for Spent Fuel Dry Storage Facilities," March 2000 (ML003686776).

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