Division of Spent Fuel Storage and Transportation
Interim Staff Guidance – 25

Issue: **Pressure and Helium Leakage Testing of the Confinement Boundary of Spent Fuel Dry Storage Systems**

Introduction:

The purpose of this interim staff guidance (ISG) is to supplement standard review plan guidance for evaluating the helium leakage testing and ASME Code[1] required pressure (hydrostatic/pneumatic) testing that is specified for the dry storage system (DSS) confinement boundary. These acceptance tests are necessary to clearly demonstrate that the DSS confinement boundary has been fabricated in accordance with the design criteria, and that its operation complies with the intended safety bases of the confinement system and regulatory requirements. Specifically, a shop helium leakage test (i.e. leakage test performed at the fabrication facility) should be performed to demonstrate that the DSS shell leak rate is within the design limits. This is important to ensure that site boundary dose limits are met and an inert helium environment is maintained for cooling of the spent nuclear fuel. Additionally, a shop helium leakage test has been accepted to demonstrate confinement integrity for inaccessible DSS shell welds that can not be visually examined during the ASME Code field pressure test (i.e. pressure test performed by a Part 72[2] licensee during loading operations). This ISG provides guidance to the staff and is not a regulatory requirement. Alternative approaches may be used to demonstrate safety and compliance, as appropriately justified by an applicant.

Discussion:

The DSS confinement boundary for welded closed canisters consists of the canister shell, bottom plate, top lid, vent and drain port cover plates, and inter-connecting welds. Some welds, such as the shell-to-bottom plate and shell seam welds are performed in the fabrication shop, while the lid-to-shell and vent port cover plate welds are performed in the field after fuel loading. The confinement boundary is relied upon to (1) confine radioactive materials to a degree sufficient to meet Part 72 dose limits, and (2) to maintain a pressurized helium environment to ensure an inert atmosphere and, in some designs, to ensure adequate cooling of the spent nuclear fuel. As discussed in ISG-5 Revision 1 “Confinement Evaluation,” [3] the applicant must specify the maximum allowed leakage rates for the total primary confinement boundary, and the allowable leakage rate must be evaluated for its radiological consequences and ability to maintain an inert atmosphere within the cask. If the entire confinement boundary is tested to be leak tight in accordance with ANSI-N14.5, "Leakage Tests on Packages for Shipment of Radioactive Materials," (i.e. 1.0×10^{-7} ref. cm^3/sec) and the canister lid-to-shell weld conforms with the criteria of ISG-18, then leakage is not considered credible and effluents are not required be considered in a confinement dose analyses.

Provisions of 10 CFR Part 72 set forth requirements to ensure DSSs maintain their confinement of radioactive material under normal, off-normal, and accident conditions. In order to maintain and to ensure the integrity of the confinement boundary, it is examined and tested by a combination of methods, including helium leakage testing, ASME pressure testing, radiographic

examination, ultrasonic examination, magnetic particle examination and /or liquid penetrant examination. These tests verify that the boundary is free of cracks, pinholes, uncontrolled voids, or other defects that could significantly reduce its structural integrity and confinement effectiveness.

Each test serves a different function. The volumetric and surface examinations of welds ensure that the welds comply geometrically with the design requirements, but can only detect flaws of a minimum size. The ASME Code pressure test provides additional assurance that the component has been properly fabricated by stressing the component to a minimum Code required loading. The helium leakage test assures there are no flaws or leak paths that could result in significant release of the helium environment and radioactive contents. Except as discussed below, the weld examinations, ASME Code pressure test, and helium leakage test are not considered equivalent substitutes for each other.

An applicant may elect not to perform a shop pressure test with visual examination of the entire confinement boundary as required by the ASME Code. Rather, the applicant may specify that the DSS user perform a field pressure test with visual examination of only accessible portions of the confinement boundary. In this case, the applicant should identify an alternative test (i.e. ANSI N14.5 helium leakage test) to demonstrate fabrication integrity of the welds that are inaccessible during the field pressure test.

The examination and testing methods employed for the DSS confinement boundary should also be consistent with the general guidance for confinement welds in ISG-15 "Materials Evaluation,"[4] and the guidance for the lid-to-shell welding specifications and helium leakage testing requirements (including exceptions) in ISG-18, "The Design and Testing of Lid Welds on Austenitic Stainless Steel Canisters as the Confinement Boundary for Spent Fuel Storage." [5]

Consistent with the guidance in ANSI 14.5, leak testing of the confinement boundary should encompass welds, joints, and surfaces of the confinement boundary including the base material. ISG-18 specifies exceptions for certain lid-to-shell welds. Although the likelihood of helium leakage through thick, forged base material for any given cask DSS confinement boundary is low, the staff does not have sufficient data to generically grant an exception of leak testing of base material that may be procured, fabricated, and operated under various conditions for multiple types of DSSs. In addition, there is not sufficient evidence to correlate the minimum flaw sizes that are detectable during other fabrication examinations (e.g. UT) with the minimum flaw sizes in any orientation that may cumulatively result in leak rates greater than 1.0×10^{-7} ref. cm^3/sec /sec.

This guidance does not apply to 10 CFR Part 71 transportation package designs, and has not been considered for such package approval applications. However, DSS designers may later request that the same confinement boundary be certified as a transportation package containment boundary under 10 CFR Part 71. In accordance with Regulatory Guide 7.4, the guidance in ANSI N14.5 constitutes a procedure acceptable to the staff for assessing the containment capability of transportation packages under 10 CFR Part 71. Therefore, the applicant should consider if the DSS design (including testing of the confinement boundary) is compatible with transportation requirements and the ANSI-N14.5 leak testing standards.

Regulatory Basis:

- 10 CFR 72.122(l): Storage systems must be designed to allow retrieval of spent fuel, high-level waste, and reactor- related GTTC waste for further processing or disposal.

- 10 CFR 72. 232(b): The certificate holder and applicant for a CoC shall make available to the NRC for inspection, upon reasonable notice, records kept by them pertaining to the design, fabrication and testing of spent fuel storage casks.

- 10 CFR 72.236(d): Radiation shielding and confinement features must be provided sufficient to meet the requirements in § § 72.104 and 72.106.

- 10 CFR 72.236(j): The spent fuel storage cask must be inspected to ascertain that there are no cracks, pinholes, uncontrolled voids, or other defects that could significantly reduce its confinement effectiveness.

- 10 CFR 72.236(l): The spent fuel storage cask and its systems important to safety must be evaluated, by appropriate tests or by other means acceptable to the NRC, to demonstrate that they will reasonably maintain confinement of radioactive material under normal, off-normal, and credible accident conditions.

- 10 CFR 72.236(m): To the extent practicable in the design of spent fuel storage casks, consideration should be given to the compatibility with removal of the stored spent fuel from a reactor site, transportation, and ultimate disposition by the Department of Energy.

Acceptable Codes and Standards:

- "2007 ASME Boiler and Pressure Vessel Code, Section III, Division 1, Subsection NB, Class 1 Components, Rules for Construction of Nuclear Facility Components", as applied to confinement boundary.

- "2007 ASME Boiler and Pressure Vessel Code, Section III, Division 1, Subsection NC, Class 1 Components, Rules for Construction of Nuclear Facility Components", as applied to confinement boundary.

- ANSI N 14.5 – 1997, "American National Standard for Radioactive Materials – Leakage Tests on Package for Shipment," ANSI, Inc., February 1998.[6]

Applicability:

This guidance applies to reviews of dry storage systems in accordance with NUREG-1536, "Standard Review Plan for Dry Cask Storage Systems," (January 1997)[7]; NUREG-1567, "Standard Review Plan for Spent Fuel Dry Storage Facilities," (March 2000)[8]; Interim Staff Guidance 5 Rev. 1 (ISG-5), "Confinement Evaluation," (May 1999); Interim Staff Guidance 15 (ISG-15), "Materials Evaluation," (January 2001); and Interim Staff Guidance 18 Rev. 1 (ISG-18), "The Design and Testing of Lid Welds on Austenitic Stainless Steel Canisters as the Confinement Boundary for Spent Fuel Storage," (October 2008).

Technical Review Guidance:

The staff should verify that welding examination and pressure testing of the confinement boundary are specified in accordance with Section III, Division 1, Subsection NB or NC of the ASME Code. The staff should also verify that helium leakage testing of the entire confinement boundary (i.e. base material, welds, seals, and closures) are performed in accordance with the leak testing standards of ANSI N14.5, with the exception of lid-to-shell welds defined in ISG-18. Some components and inaccessible welds may be tested during the fabrication process. Other leakage testing methods may be acceptable if they are consistent with ANSI N14.5 leakage test methods and procedures. The staff should verify the following acceptance examinations and tests are specified and appropriately described in the Safety Analysis Report (SAR):

(1) The examination of confinement welds should be performed in accordance with the guidance of ISG-15 and other acceptable practices, as appropriate.

(2) The entire confinement boundary should be pressure tested hydrostatically or pneumatically to 125 or 110 percent of the design pressure, respectively. The test pressure should be maintained for a minimum of 10 minutes prior to initiation of a visual examination for leakage, per the ASME Code.

Following the application of the test pressure for the required time, all joints, connections, and regions of high stress, such as regions around openings and thickness transition sections, should be visually examined for leakage. This visual examination shall be performed in accordance with ASME Code requirements and shall be performed at a pressure equal to or greater than the design pressure or three-fourths of the test pressure. This pressure test and visual examination applies to both the canister body constructed at a fabrication facility and the lid-to-shell welds fabricated and closed in the field by a Part 72 licensee.

If pressure testing is performed only in the field, the visual examination of the portions of the canister shell may be impractical due to its inaccessibility inside the transfer cask. The application should discuss the proposed operations and reasons for inaccessibility for visual examination. Due to the inability to perform the visual examination of inaccessible portions of the canister welds during the field ASME Code hydrostatic test, staff has accepted the results from the shop helium leakage test applied under ANSI-N14.5 standards. The exception and basis should be listed in the table of ASME code exceptions in the Certificate of Compliance (CoC).

(3) A shop helium leakage test, using ANSI N14.5 testing standards, must be performed to demonstrate that the entire DSS confinement body is free of defects that could lead to a leakage rate greater than the allowable design basis leakage rate specified in the confinement analyses. The requirements for the helium leakage test should be specified in the CoC to meet the requirements of 10 CFR 72.236(j) and (l).

(4) The lid-to-shell welds and vent ports should be fabricated and helium leakage tested in accordance with the guidance of ISG-18, as applicable. The staff should note that only lid-to-shell welds are within the scope of leak testing exceptions specified in ISG-18.

(5) For bolted closure casks the entire confinement boundary should be similarly helium leak tested and pressure tested. The confinement boundary should be tested at the fabrication shop, with only a leakage test performed on the bolted lid closure seals (including drain and vent port seals) tested in-field by the DSS user.

Recommendation:

The staff recommends that Sections 5.V1b, 9.V1b, and 9.V1c of NUREG-1536, "Standard Review Plan (SRP) for Dry Cask Storage Systems," and Sections 5.5.1.1 and 9.4.1.1 of NUREG 1567, "Standard Review Plan (SRP) for Spent Fuel Dry Storage Facilities," be modified to reflect the guidance contained in this ISG.

Approved: **/RA/ D. Weaver for** **August 18, 2010**
Vonna Ordaz, Director
Division of Spent Fuel Storage
and Transportation
Date

Attachment: Comment Resolution Table

References:

[1]ASME "Boiler and Pressure Vessel Code," Section III, Division 1, Subsections NB and NC, Class 1 Components, Rules for Construction of Nuclear Facility Components, American Society of Mechanical Engineers (ASME), 2007.

[2]U.S. Code of Federal Regulations, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste," Part 72, Title 10, "Energy." (2010)

[3]Interim Staff Guidance 5 Rev. 1 (ISG-5), "Confinement Evaluation," Spent Fuel Project Office, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC May 1999.

[4]Interim Staff Guidance 15 (ISG-15), "Materials Evaluation," Spent Fuel Project Office, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, DC, January 2001.

[5]Interim Staff Guidance 18 Rev. 1 (ISG-18), "The Design and Testing of Lid Welds on Austenitic Stainless Steel Canisters as the Confinement Boundary for Spent Fuel Storage," Division of Spent Fuel Storage and Transportation, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC, October 2008.

[6]ANSI N14.5-1997, "Radioactive Materials – Leakage Tests on Packages for Shipment," American National Standards Institute, 1998.

[7]NUREG-1536, "Standard Review Plan for Dry Cask Storage Systems," Spent Fuel Project Office, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC, January 1997.

[8]NUREG-1567, "Standard Review Plan for Spent Fuel Dry Storage Facilities," Spent Fuel Project Office, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC, March 2000.