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Re: Docket ID NRC-2015-0241 Draft SFM-Interim Staff Guidance (ISG)-2, Revision 2, "Fuel Retrievability in Spent Fuel Storage Applications

Interim Staff Guidance (ISG)-2 Revision 2 relies on the integrity of the thin spent fuel canisters instead of continuing to require fuel assembly retrievability. The current critical problems with the thin (1/2" thick) spent fuel storage canisters make them unacceptable for this purpose.

Thin canister critical problems:

- Cannot be inspected, repaired or maintained
- May have through-wall cracks in as little as 20 years, resulting in radiation leaks
- Have no early-warning system and no continuous radiation monitoring system
- Have no mitigation plan for canister replacement or failure
- Lack an adequate design for fuel retrievability
- Are not transportable with partial cracks.

If you find yourself in a hole, stop digging. The fact the NRC has approved thin-walled welded canister systems that have critical flaws is no reason to dig another hole by eliminating needed requirement for fuel assembly retrievability. Instead, the NRC should increase minimum standards for dry cask storage and transport systems so existing ISG-2 can be met.

NRC Regulation 10 CFR § 71.85 does not allow transport with even partially cracked canisters.

> *NRC Regulation 10 CFR § 71.85 Packaging and Transportation of Radioactive Materials. Preliminary determinations. Before the first use of any packaging for the shipment of licensed material — (a) The certificate holder shall ascertain that there are no cracks, pinholes, uncontrolled voids, or other defects that could significantly reduce the effectiveness of the packaging.*

NRC transport cask certificates require verification of the integrity of the canister prior to transportation. However, there is no current method to inspect them for cracks or repair cracks.

> *NRC Certificate of Compliance NUHOMS-MP197HB, Certificate 9302*, April 23, 2014 (ML14114A099), [High burnup fuel transport cask] Page 17, "For any DSC [Dry Storage Canister] that has been used in storage, the condition of the DSC must be evaluated, prior to transportation, to verify that the integrity of the canister is maintained."

The NRC approves destruction of empty spent fuel pools yet has no other specific mitigation plans identified for failed spent fuel canisters that could be implemented now.

The DOE Standard Contract requires fuel assembly retrievability in order to place the fuel assemblies in a DOE approved cask and to aid in ensuring flexibility for safer storage in a permanent repository. Even though this is not within the NRC's "required" scope, the NRC Commissioners directed the NRC to consider transportation issues (COMDEK-09-0001). They also directed staff to encourage the adoption of state of the art technology for storage and transportation, internationally. Adopting state of the art technology available internationally should be pursued as directed by the Commissioners. This ISG-2 revision does the opposite. The Commissioners stated:

> **"The staff should undertake a thorough review of the regulatory programs for spent fuel storage and transportation to evaluate their adequacy for ensuring safe and secure storage and transportation of spent nuclear fuel for extended periods beyond the 120 year timeframe considered up to this point**. This review should include the standards, regulations, guidance, review processes, and inspection and enforcement procedures. The staff should also undertake research to bolster the technical basis of the NRC's regulatory framework to support extended periods. The review should identify risk-informed, performance-based enhancements that will bring increased predictability and efficiency to the regulatory processes, and should **investigate ways to incentivize these processes to encourage the adoption of state of the art technology for storage and transportation** in a risk-informed, performance-based manner. The review should be conducted in a transparent, participatory, and collaborative manner with our stakeholders.
>
> The review should also benefit from experience gained through the Multi-National Design Evaluation Process (MDEP) for reactors and consider opportunities for comparing and, where appropriate, **harmonizing, international standards for transport packages and storage casks.**
>
> The staff should develop a project plan for Commission approval, including objectives, plans, potential policy issues, projected schedules, performance measures, and projected resource requirements. Such a plan should leverage, as appropriate, improvement initiatives that the staff already has underway."
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> *Staff Requirements – COMDEK-09-0001 – Revisiting the Paradigm for Spent Fuel Storage and Transportation Regulatory Programs*, February 18, 2010 http://pbadupws.nrc.gov/docs/ML1004/ML100491511.pdf

ISG-2 Rev 2 Page 6 attempts to justify the elimination of the retrievability requirement by referencing COMSECY-10-0007:

> "Consistent with the staff's ongoing work conducting a review of the regulatory framework for spent fuel storage and transportation (see COMSECY-10-0007, Ref. 16), the staff began exploring alternatives to the guidance on the application of ready retrieval. The staff's review has centered on redefining the first part of the guidance on ready retrieval (i.e., the ability of the fuel assemblies to be removed from a canister or cask by

> normal means), but maintaining the second part (i.e., the ability of the canister or cask to be removed from the storage location). By redefining the first part of the guidance (i.e., the ability to remove the individual spent fuel assemblies or canned assemblies by normal means) and providing alternatives, the spent fuel would still be retrieved safely and be readied for transportation consistent with the law and regulations. This way, the spent fuel dry storage confinement continues to be maintained without the potential negative impacts associated with opening the storage system."

However, in COMSECY-10-0007 it states the NRC staff has not identified timeframes for such things such as needed replacement of cask components to ensure continued safer storage and transportability. It also states need to conduct potential risk and environmental assessments.

> Commissioners directed NRC staff "to develop a project plan to conduct a thorough review of the regulatory programs for spent nuclear fuel (SNF) storage and transportation, and to evaluate their adequacy for ensuring safe and secure storage of SNF for extended periods beyond 120 years. The Commission also directed the staff to **undertake research to bolster the technical bases of the regulatory framework in support of extended periods**, and to leverage ongoing improvement initiatives."
>
> "The staff notes that one significant outcome of the various research studies may be **identification of timeframes that require significant mitigation actions** (e.g**., replacement of cask components**) **to ensure continued safe storage and transportability**. **The staff has not yet identified any such timeframes**, and has preliminarily selected an analytical timeframe of 300 years for the scope of the extended storage and transportation regulatory program review elements, such as extrapolating research data, **conducting potential risk and environmental assessments**, and developing aging management and design performance guidelines."
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> *U.S. Nuclear Regulatory Commission. 2010. COMSECY-10-0007 Project Plan for the Regulatory Program Review to Support Extended Storage and Transportation of Spent Nuclear Fuel.*" ADAMS Accession No. ML101390216. http://pbadupws.nrc.gov/docs/ML1013/ML101390216.html

The NRC needs to complete the tasks identified in *NRC Project Plan for the Regulatory Program Review to Support Extended Storage and Transportation of Spent Nuclear Fuel* (COMSECY-10-0007) prior to revising ISG-2 Rev 2. ISG-2 (page 6) states it is consistent with staff's ongoing work in this project. However, part of that project is addressing the lifespan of the dry storage system. The assumption is being made in the ISG-2 revision that the thin 0.50" thick stainless steel canisters will have a sufficient lifespan and will not need replacing and can be used for long-term interim and final disposal. However, this part of the NRC Project Plan has not been completed. In fact, the current work completed raises serious concerns about the lifespan, maintainability and transportability of these thin canisters. The NRC should not base ISG-2 on hope of future solutions for these problems. We cannot afford to continue digging this hole with inferior dry storage technology. Better solutions are available if the NRC would simply require a dry cask solution that can be inspected, repaired, maintained, adequately monitored, doesn't crack and meets current fuel retrievability requirement.

- **Stainless steel thin canisters are subject to chloride-induced stress corrosion cracking and can crack through the wall of the canisters 16 years after crack initiation**.

  Summary of August 5, 2014 Public Meeting with the Nuclear Energy Institute on Chloride Induced Stress Corrosion Cracking Regulatory Issue Resolution Protocol, September 9, 2014 http://pbadupws.nrc.gov/docs/ML1425/ML14258A081.pdf

- **The Koeberg nuclear plant in South Africa had a similar component leak from through-wall cracks of to 0.61" deep in 17 years**. The majority of U.S. thin canisters are only 0.50" thick.

  Chloride-Induced Stress Corrosion Cracking Tests and Example Aging Management Program, Darrell S. Dunn, NRC/NMSS/SFST, August 5, 2014 http://pbadupws.nrc.gov/docs/ML1425/ML14258A082.pdf

- **An EPRI evaluation of a Diablo Canyon spent fuel canister provides evidence of a two-year old canister having all the conditions for cracking after only two years of service**. It had a low enough canister temperature for magnesium chloride salts to dissolve (deliquesce) on the canister which can initiate stress corrosion cracking.

  Diablo Canyon: conditions for stress corrosion cracking in 2 years, D. Gilmore, October 23, 2014 https://sanonofresafety.files.wordpress.com/2011/11/diablocanyonscc-2014-10-23.pdf

- **No technology and tools exist to inspect canisters for cracks**.

  Summary of August 5, 2014 Public Meeting with the Nuclear Energy Institute on Chloride Induced Stress Corrosion Cracking Regulatory Issue Resolution Protocol, September 9, 2014 http://pbadupws.nrc.gov/docs/ML1425/ML14258A081.pdf

  Mark Lombard, October 6, 2015 https://youtu.be/QtFs9u5Z2CA

- **No feasible method to repair cracks in canisters filled with spent nuclear fuel**.

  Dr. Kris Singh, Holtec President, manufacturer of Holtec canisters), October 14, 2014 https://youtu.be/euaFZt0YPi4

  A Framework to Develop Flaw Acceptance Criteria for Structural Integrity Assessment of Multipurpose Canisters for Extended Storage of Used Nuclear Fuel, ASME 2014 Pressure Vessels & Piping Division Conference, PVP2014, July 20-24, 2014, PVP2014-28990, Savannah River National Lab (SRNL), Poh-Sang Lam, et. al. http://sti.srs.gov/fulltext/SRNL-STI-2014-00151.pdf

- **The NRC has not prioritized investigating other conditions that could cause these thin canisters to prematurely fail**, such as corrosive particles in air pollution (e.g., sulfides). At NRC REG CON 2015 on November 19, Mark Lombard and EPRI stated they do not have plans to investigate any other factors that may cause the thin canisters to fail, even though the *NRC Project Plan* COMSECY-10-0007 states otherwise:

  > "the Commission directed the staff to develop a project plan to conduct a thorough review of the regulatory programs for spent nuclear fuel (SNF) storage

> and transportation, and to evaluate their adequacy for ensuring safe and secure storage of SNF for extended periods beyond 120 years. The Commission also directed the staff to undertake research to bolster the technical bases of the regulatory framework in support of extended periods, and to leverage ongoing improvement initiatives."
>
> "The staff notes that one significant outcome of the various research studies may be identification of timeframes that require significant mitigation actions (e.g., replacement of cask components) to ensure continued safe storage and transportability. The staff has not yet identified any such timeframes, and has preliminarily selected an analytical timeframe of 300 years for the scope of the extended storage and transportation regulatory program review elements, such as extrapolating research data, conducting potential risk and environmental assessments, and developing aging management and design performance guidelines."

Numerous incidences of improper loading of canisters outside of Certificate of Compliance requirements has occurred bringing into question the current basis for assumptions of safe storage. Current basis for safe storage assume improper loading will never happen. Proper loading is critical to integrity of both the canisters and fuel. If licensees cannot be trusted to load fuel properly, even with numerous checks and balances, the need for fuel retrievability becomes even more important. The NRC has not addressed this issue.

- *NUREG-1864 A Pilot Probabilistic Risk Assessment Of a Dry Cask Storage System At a Nuclear Power Plant*, March 2007, A. Malliakos, NRC Project Manager ML071340012 http://pbadupws.nrc.gov/docs/ML0713/ML071340012.pdf

  > Page 13 Executive Summary
  > The pilot PRA assesses the risk to the public and identifies the dominant contributors to risk associated with dry cask storage involving a single cask at a specific BWR site. **Among the items that were beyond the scope** of the study were subsequent versions of the specific cask studied in this report, unloading of the cask, offsite transportation, repository storage, uncertainty analysis, worker risk, **human reliability**, fabrication errors, **mis-loading of spent nuclear fuel**, aging effects, and **combinations of factors that could impact the probability of MPC failure.**

- **Examples of incorrect loading. Since fuel assemblies cannot be inspected, it is unknown whether fuel damage occurred from this misleading.**
  - **Diablo Canyon:** Misloaded all but two Holtec canisters through multiple loading **cycles.** They were loaded in incorrect zones for their cooling period. Both PG&E and Holtec vendor were responsible. *Diablo Canyon Event Number 51134*, June 6, 2015. http://www.nrc.gov/reading-rm/doc-collections/event-status/event/2015/20150610en.html

  - **North Anna:** The applicant inadvertently reversed the upper and lower zones while preparing the DSC loading maps. This resulted in twelve fuel assemblies being loaded into seven DSCs with decay heat greater than specified in the CoC. Currently, the twelve affected fuel assemblies have been in storage for a minimum of 1.3 years and have decayed to meet the required decay heat limits of the CoC. However, this should never have happened. Federal Register Volume 77, Number 65, April 4, 2012, Pages 20438-20440, FR Doc No: 2012-8114, NRC Docket Nos. 72-1030, 72-56; 50-338 and 50-339: NRC-2012-0084, *Independent Spent Fuel Storage Installation, Virginia Electric and Power Company: North Anna Power Station Units 1 and 2* http://www.gpo.gov/fdsys/pkg/FR-2012-04-04/html/2012-8114.htm

The NRC should complete an evaluation of the impact of canister leaks, particularly with high burnup fuel.

- The ACRS stated their concerns in a 2000 letter to the NRC regarding ignition and fire risks in pools. Similar unanswered questions exist for dry storage. Please provide any documents that address impact of a canister leak with high burnup fuel, taking these factors into consideration.

    > "…there were issues associated with the formation of zirconium-hydride precipitates in the cladding of fuel especially when that fuel has been taken to high burnups. Many metal hydrides are spontaneously combustible in air. Spontaneous combustion of zirconium-hydrides would render moot the issue of "ignition" temperature that is the focus of the staff analysis of air interactions with exposed cladding. The staff has neglected the issue of hydrides and suggested that uncertainties in the critical decay heat times and the critical temperatures can be found by sensitivity analyses. Sensitivity analyses with models lacking essential physics and chemistry would be of little use in determining the real uncertainties. The staff analysis of the interaction of air with cladding has relied on relatively geriatric work. Much more is known now about air interactions with cladding. This greater knowledge has come in no small part from studies being performed as part of a cooperative international

    ACRS letter to NRC Chairman regarding *Draft Final Technical Study of Spent Fuel Accident Risk at Decommissioning Nuclear Power Plants*, Dana A. Powers, ACRS Chairman, ACRSR-1885 April 13, 2000
    http://pbadupws.nrc.gov/docs/ML0037/ML003704532.pdf

- **Argonne scientists reported high burn-up fuels may result in fuel rods becoming more brittle over time**. The U.S. Nuclear Waste Technical Review Board (NWTRB) December 2010 report, "Evaluation of Technical Basis for Extended Dry Storage and Transportation of Used Nuclear Fuel", states insufficient information is available on high burnup fuels to allow reliable predictions of degradation processes during extended dry storage. https://sanonofresafety.files.wordpress.com/2013/06/usnwtrb-evaloftechbasisforextendeddrystorageandtransportofusednuclearfuel2010-dec-eds_rpt.pdf

    > "Only limited references were found on the inspection and characterization of fuel in dry storage, and they all were performed on low-burnup fuel after only 15 years or less of dry storage [using the CASTOR V/21 cask, which has very difference specifications than the stainless steel canisters commonly used in the U.S. today (maximum 21 PWR fuel assemblies, maximum initial U-235 enrichment 2.2% – 2.3%, maximum burnup 35 GWd/MTU, maximum fuel assembly heat generation 1kW, side-wall thickness 14.9″, two stainless steel bolted lids (11.4" and 3.5"

thick) and no damaged fuel assemblies allowed.] Insufficient information is available on high-burnup fuels to allow reliable predictions of degradation processes during extended dry storage, and no information was found on inspections conducted on high-burnup fuels to confirm the predictions that have been made. The introduction of new cladding materials for use with high-burnup fuels has been studied primarily with respect to their reactor performance, and little information is available on the degradation of these materials that will occur during extended dry storage.

The NWTRB also states [page 11]: These [degradation] mechanisms and their interactions are not well understood. New research suggests that the effects of hydrogen absorption and migration, hydride precipitation and reorientation, and delayed hydride cracking may degrade the fuel cladding over long periods at low temperatures, affecting its ductility, strength, and fracture toughness. High-burnup fuels tend to swell and close the pellet-cladding gap, which increases the cladding stresses and can lead to creep and stress corrosion cracking of cladding in extended storage. Fuel temperatures will decrease in extended storage, and cladding can become brittle at low temperatures."

- **Data from high burnup fuel rods shows increased oxide thickness with increased burnup.** Page 55 and 60 of NWTRB report states: "Hydride precipitation can be evenly distributed or dominate in certain areas. Both cladding hydrogen content and effective wall-thickness are correlated to the amount of oxidation that occurs on the outer surface of the cladding. Plotting more than 4,400 measurements from commercial fuel-rods taken from reactors around the world, Figure 20 shows the maximum outer-surface oxide-layer thickness data in low-Sn Zircaloy-4 cladding plotted as a function of burnup.

  Taking these oxide thickness measurements, the maximum wall thickness average (MWTA) hydrogen content can be calculated using a hydrogen evolution model. Figure 21 plots the wall-average hydrogen content in low-Sn Zircaloy-4 cladding as a function of burnup from both measured and model-calculated data. For a discharge burnup in the range of 60-65 GWd/MTU, the maximum oxide thickness is 100 µm and the average hydrogen concentration is 800 ppm, which corresponds to a metal loss of 70 µm using conservative assumptions."

  See Figure 20 and 21 on next page.

Figure 20. Cladding Outer Surface Oxide Layer Thickness versus Rod Average Burnup

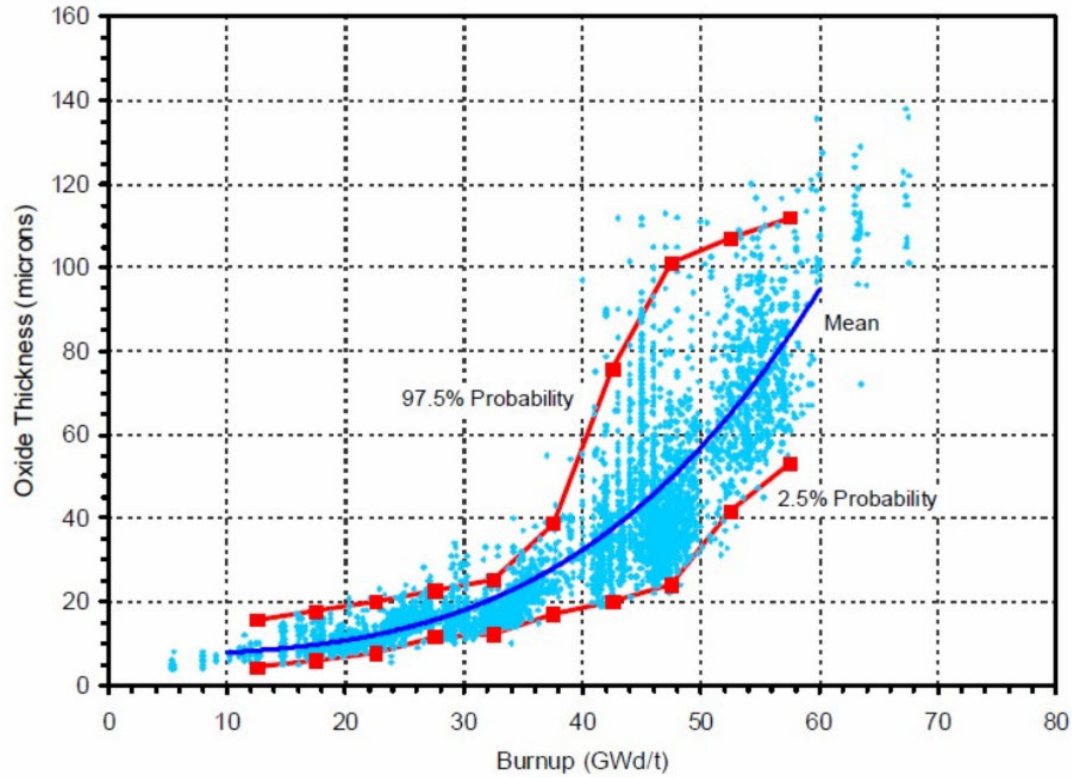
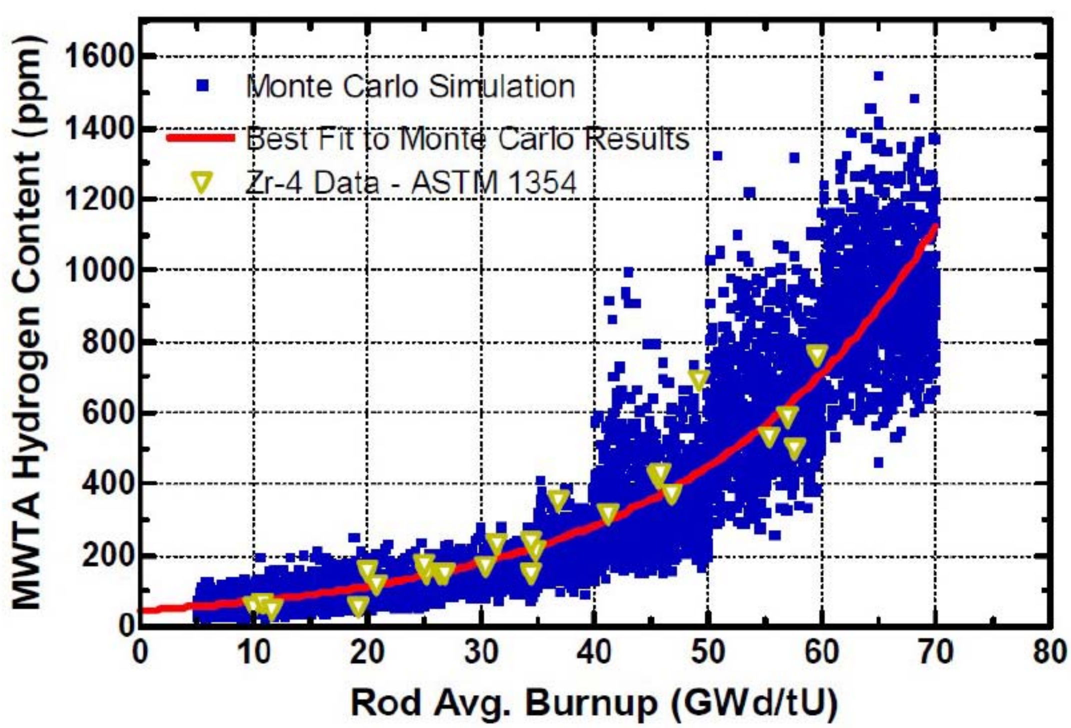


Figure 21. Maximum Wall Thickness Average (MWTA) Hydrogen Content in Low-Tin Zircaloy-4 Cladding



The below NRC recommended changes to ISG-2 Rev 2 NRC should be rejected for the reasons stated above.

This ISG recommends the following definition to be used by staff when evaluating Part 72 applications:
Ready retrieval: The ability to safely remove, with no operational safety problems, the spent fuel from storage for further processing or disposal. Acceptable means for removing the spent fuel from storage includes the ability to do one or a combination of the following:

> *A. remove individual or canned spent fuel assemblies from wet or dry storage,*
> *B. remove a canister loaded with spent fuel assemblies from a storage cask/overpack,*
> *C. remove a cask loaded with* spent fuel assemblies from the storage location.

The staff recommends the definitions for ready retrieval be incorporated into NUREG-1536, NUREG-1567, and NUREG-1927. These definitions do not necessitate any actions for currently approved storage systems.

If an applicant for an initial ISFSI license or an applicant for an ISFSI license amendment relies upon Option B or Option C to demonstrate ready retrieval, the applicant should also address the storage system's continued ability to ensure ready retrieval. One possible approach would be for the applicant to implement a program designed to identify, monitor, and mitigate possible degradation that could impact the intended function of the dry storage system's SSCs and subcomponents that are relied upon for compliance with the retrievability requirements.

For applicants for renewal of an ISFSI license, in order to verify that the 10 CFR 72.122(l) retrievability requirement is met, the reviewer should ensure that the approved design bases for the item being relied upon in the option(s) chosen (fuel assembly, cask, or canister) to demonstrate ready retrieval, including any programs implemented, has not been altered. Additionally, the reviewer should ensure that the AMPs and TLAAs provide reasonable assurance that the approved design bases will be maintained during the period of extended operation. This includes reviewing operating experience for incident-free storage, including inspections and analyses performed during the initial storage period for ensuring SSCs relied upon for ready retrieval were maintained. The reviewer should refer to Draft NUREG-1927, Rev. 1 (Ref. 8) for additional guidance.

http://pbadupws.nrc.gov/docs/ML1523/ML15239A695.pdf