Enclosure 1

Westinghouse Responses to the NRC's Request for Additional Information (18 Pages)

Request for Additional Information
Docket No. 72-1026 Westinghouse Electric Company
FuelSolutions™ Spent Fuel Management
System Certificate of Compliance No.1026
Renewal Application

AGING MANAGEMENT REVIEW

RAI 3-1 Please provide a TLAA or supporting analysis to show that the loss of toughness and ductility due to thermal aging is not expected to compromise the intended function of the 17-4 precipitation-hardened stainless steel (PHSS) fuel basket support rod in the W21 Canister during the 60-year extended storage period. Further, please revise the AMR results for the 17-4 PHSS fuel basket support rod in the left half of Tables 2-4a and 2-4b of the application to be consistent with the corresponding AMR line item in Table 4-21 of NUREG-2214 (the MAPS report).

The application AMR results in the left half of Tables 2-4a and 2-4b identify that loss of toughness and ductility due to thermal aging of the 17-4 PHSS fuel basket support rod (helium environment) is addressed by the canister fatigue TLAAs. The application cites Section 3.2.2.8 of the MAPS report as the technical basis for this AMR result. The corresponding MAPS Report AMR line item for this subcomponent in Table 4-21 of the MAPS report states that a "TLAA/AMP or a supporting analysis is required" to address loss of toughness and ductility due to thermal aging of the 17-4 PHSS fuel basket support rod in a helium environment. MAPS Report Section 3.2.2.8 provides specific recommendations for performing a case-specific evaluation of loss of toughness and ductility due to thermal aging in subcomponents fabricated from 17-4 PHSS. The MAPS Report Section 3.2.2.8 states that the degree of embrittlement of a specific subcomponent will depend on the service temperature and time duration, as well as the initial heat treatment condition of the SSC. As such, a review of the thermal aging effects should be performed on a case-by-case basis for all subcomponents constructed from Type 17-4 PHSS. Further, the MAPS Report states that the application should provide a bounding analysis to show that the loss of toughness and ductility due to thermal aging is not expected to compromise the SSC's intended function during the period of extended operation.

Considering the above guidance provided in MAPS Report Section 3.2.2.8, the staff identified that the application does not provide a case-specific evaluation of the loss of toughness and ductility due to thermal aging for the 17-4 PHSS fuel basket support rod in the W21 Canister. The fatigue TLAA, as cited in the applicant's AMR results for this item, is a structural analysis of the effects of cyclic loading on the components and is unrelated to the evaluation of thermal aging and associated loss of toughness and ductility for 17-4 PHSS.

This information is needed to demonstrate compliance with 10 CFR 72.240(c).

Response to RAI 3-1
The following supporting analysis has been provided in new Section 3.3.1.2.1 in the Revised June 2022 FuelSolutions Renewal Application.

Type 17-4 precipitation-hardened (17-4PH) martensitic stainless steel operating at high temperatures may be susceptible to thermal embrittlement depending on several factors including the alloy composition within the allowable specifications, the initial heat treatment, and *the operating temperature. For operating temperatures between 243 °C and 316 °C (470 to 600 °F), Section 3.2.2.8 of NUREG-2214 recommends an evaluation of conditions on a per-component basis considering operating temperature, exposure time, operating environment, stress levels, and material composition.*

The only FuelSolutions System components made of 17-4PH martensitic stainless steel are the support rod subcomponents of the W21T canister. No 17-4PH martensitic stainless steel subcomponents are used in the W21M, W74T or W74M canisters. For normal storage conditions, the W21T support rod subcomponents have a maximum temperature of 472 °F (Table 4.4-2 of the W21 Canister FSAR). This and other W21 Canister FSAR storage case evaluations determined that the maximum support rod subcomponent temperatures were below the reported threshold temperature for 17-4PH thermal embrittlement of 500 °F in Appendix E.3 of Electrical Power Research Institute (EPRI) Report TR-1012081. In addition, there is conservatism in the thermal model used to estimate the support rod temperature as noted in the W21 Canister FSAR (e.g., modeling 25.1 kW for the W21 canister thermal rating instead of the allowed fuel thermal rating of 22 kW).

The time that the support rod subcomponents would be above the recommended 470 °F is limited because of the minimal time that the ambient temperature would be at the normal maximum temperature of 100 °F and the continuing decay of the heat source. Therefore, it is concluded that thermal aging embrittlement is unlikely to affect the mechanical properties of the 17-4PH steel support rod subcomponents during the period of extended storage.

It should be noted that Chapter 4 of the W21 Canister FSAR evaluates a number of other non-storage thermal analysis cases involving canister loading, handling and transfer in which these one-time temperature evolutions only last from several hours to a few days. These one-time short-term evolutions involve worst case W21T canister support rod temperatures which never exceed the ASME Code maximum allowable temperature of 650 °F for 17 4PH martensitic stainless steel. Given the one-time, short-term time periods that the support rod subcomponents may exceed 500 °F, it is concluded that thermal aging is not an issue for these W21 Canister FSAR non-storage cases.

Therefore, thermal aging of the precipitation-hardened martensitic stainless steel is not considered a credible aging mechanism during the period of extended storage.

The information in Table 2-4b for the W21 canisters in the FuelSolutions Renewal Application has been corrected and clarified to reflect the new Section 3.3.1.2.1 supporting analysis.

RAI 3-2 Considering that the W74 canister fuel basket drawing includes steel fuel basket bolts, please clarify the AMR scoping results in Table 2-4a of the application, which state that steel fuel basket bolts are not applicable for the W74 canisters. If steel fuel basket bolts actually do exist for the W74 canisters, then (a) please provide a TLAA, AMP, or supporting analysis to address loss of bolt preload due to stress relaxation during the 60-year extended storage period; (b) please revise the fuel basket bolt subcomponent screening results in the right half of Table 2-4a to address the constituent parts and their quality categorizations; and (c) please revise the AMR results for the steel fuel basket bolts in the left half of Tables 2-4a and 2-4b of the application to be consistent with the response to this request.

For the W74 canister, the application AMR results in the left half of Table 2-4a (as well as the corresponding AMR result for the W21 canister) identify that loss of preload due to stress relaxation of steel fuel basket bolts (helium environment) is addressed by the canister fatigue

TLAAs. The application cites Section 3.2.1.10 of NUREG-2214 (MAPS Report) as the technical basis for this AMR result. The corresponding MAPS Report AMR line item for this subcomponent in Table 4-21 of the MAPS report states that a “TLAA/AMP or a supporting analysis is required” to address loss of preload due to stress relaxation of the steel fuel basket bolt in a helium environment. MAPS Report Section 3.2.1.10 provides guidance for aging management of steel bolting in higher temperature environments (such as the canister interior helium or storage cask interior sheltered environments) to look for evidence of loss of bolt preload due to stress relaxation.

The staff noted that the application’s subcomponent screening results in the right half of Table 2-4a identify that the steel fuel basket bolts are not applicable for the W74 canister, although canister drawing W74-120 appears to contain this item.

Considering the above guidance provided in MAPS Report Section 3.2.1.10, the staff determined that if steel fuel basket bolts exist in any available design configuration for the W74 canister, the application should include the appropriate provisions for aging management or specific analysis of the steel fuel basket bolts to address loss of bolt preload due to stress relaxation during the 60-year extended storage period. The fatigue TLAA, as cited in the applicant’s AMR results for this item, is a structural analysis of the effects of cyclic loading on the components and is not related to analytical evaluation or management of loss of bolt preload due to stress relaxation.

This information is needed to demonstrate compliance with 10 CFR 72.240(c).

Response to RAI 3-2
The FuelSolutions Aging Management Review (AMR) scoping results in Table 2-4a for the W74 canisters have been corrected and clarified to state that the W74 canisters do have steel fuel basket bolts which are subject to stress relaxation. The W21 canisters do not have any steel fuel basket bolts and stress relaxation is not a topic of concern for W21 canisters.

The following Fuel Basket Bolt supporting analysis has been provided in new Section 3.3.1.2.2 of the Revised June 2022 FuelSolutions Renewal Application.

Section 3.2.1.10 of the NUREG-2214 MAPS Report provides guidance for aging management of steel bolting in higher temperature environments (such as the canister interior helium environment) to look for evidence of loss of bolt preload due to stress relaxation. W74 canister drawing W74-120 lists a subcomponent which shows that sixteen steel fuel basket bolts are used for each W74 canister fuel basket. The corresponding NUREG-2214 MAPS Report AMR line item for this subcomponent in Table 4-21 of the MAPS report states that a “TLAA/AMP or a supporting analysis is required” to address loss of preload due to stress relaxation of these steel fuel basket bolts in a helium environment.

The sixteen W74 canister 7/16”-14 UNC-2A x 1” long steel fuel canister bolts are all used in conjunction with 7/16” split stainless steel lock washers. As stated in Sections 3.2.2.6, Creep, and 3.2.2.8, Thermal Aging, of NUREG-2214 creep and thermal aging of austenitic stainless steel is negligible at canister internal temperatures which may range up to 752 °F. During a 60-year period of extended of storage the split stainless steel lock washers will compensate for any loss of preload due to stress relaxation of the steel fuel basket bolts in a helium environment.

The actual structural functions of these sixteen steel fuel canister bolts are not important to safety during canister storage periods. Eight of the bolts attach the engagement spacer plate to *the bottom of the top fuel basket during installation of the top fuel basket into the W74 canister after the bottom fuel basket has been loaded with spent fuel assemblies. The eight bolts prevent the engagement spacer plate from falling on the loaded bottom fuel basket. During storage the engagement spacer plate and loaded upper basket is supported by the four lower basket support tubes, and the eight fuel basket bolts serve no structural function. In the unlikely event the spent fuel assemblies were ever to be unloaded from a W74 canister, the eight fuel basket bolts would again function to prevent the engagement spacer plate installed on the bottom of upper fuel basket from falling on the loaded bottom fuel basket as the unloaded upper fuel basket is removed from the W74 canister.*

Four of the other eight fuel basket bolts attach two stainless steel straps to the center of the top spacer plate on the bottom fuel basket, and the other four fuel basket bolts attach a cruciform plate to the center of the top spacer plate on the top fuel basket. The straps prevent spent fuel assemblies from being loaded into the five center guide tubes in the lower fuel basket, and the cruciform plate prevents spent fuel assemblies from being loaded into the five center guide tubes in the top fuel basket. Both the two straps and the cruciform plate are classified as not important to safety and serve no structural or safety function after spent fuel assemblies are loaded into the W74 canister.

Based on the above evaluation, any loss of preload due to stress relaxation of the steel fuel basket bolts during the 60-year period of extended storage does not present a W74 canister safety concern.

RAI 3-3 Explain the basis for the conclusion stated in Section 3.3.5.5 of the renewal application that the rigid polyurethane foam impact limiter does not require an AMP or TLAA. Alternatively, revise the AMR results in Table 2-8 and Section 3.3.5.5 of the renewal application to address how the aging effects that are applicable to the polyurethane foam impact limiter are managed or otherwise dispositioned for the renewal period.

For the rigid polyurethane foam impact limiter in an embedded environment, Table 2-8 of the renewal application for the FuelSolutions system identifies polyurethane degradation due to thermal aging as the aging effect and mechanism. However, this Table 2-8 line item lists "Monitoring of Metallic Surfaces AMP" as the aging management activity and Section 3.2.8 (Coatings) of NUREG-2214 as the technical basis. The staff notes that polymers can be susceptible to both heat- and radiation-induced changes, such as embrittlement, shrinkage, decomposition, and changes in physical configuration, as discussed in Section 3.3.1 of NUREG--2214. The basis for the use of the Monitoring of Metallic Surfaces (MMS) AMP for managing polyurethane degradation due to thermal aging is unclear. Further, the staff noted that the MMS AMP does not include any activity addressing polyurethane degradation due to thermal aging.

Section 3.3.5.5 of the renewal application for the FuelSolutions system states that no damage or change in the properties of the polyurethane foam is expected to occur over the life of the impact limiter. Therefore, the applicant concluded in this section that no AMP or TLAA is required to address polyurethane degradation for the polyurethane foam impact limiter. However, thermal aging and radiation embrittlement are identified as credible aging mechanisms for polymers in Section 3.3.1 of NUREG-2214. Therefore, the basis for the application's conclusions that no AMP or TLAA related to address degradation of polyurethane foam is unclear.

This information is needed to demonstrate compliance with 10 CFR 72.240(c).

Appendix A – Aging Management Programs

Note: The technical RAIs below for aging management programs (AMPs) are based on the AMP descriptions provided in Appendix A of the renewal application. Discrepancies between AMP descriptions provided in Appendices A and D of the application are covered in a separate RAI (RAI D-1).

Response to RAI 3-3
The FuelSolutions Aging Management Review (AMR) scoping results in Table 2-8 for the impact limiter polyurethane have been corrected and clarified by removing the reference to the "Monitoring of Metallic Surfaces AMP" and instead refer to the following Rigid Polyurethane Foam supporting analysis which has been provided in new Section 3.3.5.2.1 of the Revised June 2022 FuelSolutions Renewal Application.

Polyurethane is a polymer. NUREG-2214 does not address or mention polyurethane and addresses polymers primarily in the context of a neutron shielding material and the associated environments in which neutron shielding materials function.

As stated in Section 1.2.1.4.2, Equipment for Horizontal Canister Transfer, of the FuelSolutions FSAR WSNF-220, the polyurethane foam material used for the storage cask impact limiter is widely used in licensed spent fuel transportation packages and is well characterized. The rigid foam is encased within a thin-plate carbon steel casing, which is sufficiently strong to allow handling of the impact limiter subassemblies but has a negligible effect on the crush characteristics of the impact limiter. The carbon steel provides a sealed closure to assure foam integrity and is coated for corrosion protection.

The FuelSolutions FSAR WSNF-220 Section 1.5.2.1, Storage Cask Impact Limiter Polyurethane Foam, refers to manufacturer's literature describing the rigid polyurethane foam material used for the storage cask impact limiter (13 pages). The manufacturer, General Plastics Manufacturing Company, refers to the FuelSolutions impact limiter polyurethane foam as LAST-A-FOAM® FR-3700 Series. The literature contains a variety of design data (e.g., polyurethane foam density in pounds per cubic foot and compressive strength in pounds per square) and fire resistance data but does not include any aging related data. (This manufacturer's literature is mentioned in Section 1.5.2.1 of each FuelSolutions FSAR WSNF-220 revision, but while the literature appears in FSAR Revisions 0 and 1, it does not appear in later electronic revisions of FSAR WSNF-220.) The manufacturer's literature states that the last two digits of the FR-3700 Series product numbers represent density. For example, the FuelSolutions impact limiter drawing identifies that the polyurethane foam has a density of 10 pounds per cubic foot which means the foam product number is FR-3710.

An internet search found a report on a General Plastics Manufacturing aging study entitled: Long-Term Aging of LAST-A-FOAM® FR-3700 Series, dated May 10, 2021. This 20-year study evaluates the characteristics of both wood and LAST-A-FOAM (product numbers FR-3704, FR-3708, and FR-3718) polyurethane foam material for aging and the fitness-for-use in long-term applications. The LAST-A-FOAM samples used in this long-term aging study bracket the 10 pound per cubic foot density and the FR-3710 compressive strength of 360 psi used for the FuelSolutions impact limiter polyurethane foam.

FuelSolutions FSAR WSNF-220 Section 3.5.3.2 states that the FuelSolutions storage cask impact limiter must be adequate to support the normal dead and live loads of the cask and J-skid without crushing. The bounding storage cask and J-skid weights are 335,000 pounds and

17,000 pounds, respectively. Section 3.5.3.2 states that the required compressive strength to support this load was "determined to be 99 psi, which is significantly lower than the selected polyurethane foam lower bound strength of 300 psi." The manufacturer's literature states that the FuelSolutions FR-3710 polyurethane foam compressive strength is 360 psi which therefore has some margin for deterioration while maintaining the stated FSAR strength margin.

To simulate the foam embedded conditions in an impact limiter, some of the long-term aging wood and polyurethane foam samples were held in a weather-tight, stainless steel enclosure kept at Portland General Electric's Trojan Spent Nuclear Fuel dry storage facility. Additionally, each of these enclosed samples was packaged with polyvinyl film. LAST-A-FOAM FR-3708 polyurethane foam was used for these enclosed samples which have density and compressive strength properties and environmental exposures close to the FuelSolutions FR-3710 polyurethane foam. During the 20-year aging test the specified 8 pounds per cubic foot (pcf) density was measured six times ranging from 7.99 pcf to 8.11 pcf with the highest density being measured at the end of 20 years. The compressive strength measurements started at 227.3 psi and finished at 221.0 psi, with compressive strength measurements both above and below these psi numbers measured during the 20-years. The conclusion is that the density and compressive strength remained basically flat during the twenty years and no discernable polyurethane foam degradation or aging trends were detected.

Other long-term aging wood and polyurethane foam materials were exposed year-round to the extreme environmental elements of the Pacific Northwest in uncovered storage conditions. These specimens were stored in a subterranean concrete vault which had an open grate at the top. The foam and wood were proportionately exposed to dust, dirt, insects, seasonal Pacific Northwest weather, and organic debris from plant life in the surrounding area. After cleaning up the surfaces of these exposed aging samples and measuring the polyurethane foam properties, there were also no discernable polyurethane foam degradation or aging trends detected. The results of the long-term aging study are discussed below with respect to each of the potential polyurethane foam aging mechanisms.

This Rigid Polyurethane Foam supporting analysis accesses the three environments for polymers listed in Section 3.3.1 of NUREG- 2214 (i.e., Boron Depletion, Thermal Aging, and Radiation Embrittlement). This supporting analysis also accesses the three environments often listed regarding deterioration of polyurethane foam in industry literature (i.e., Ultraviolet Light, Humidity, and Microbiological Contamination). These environments are evaluated below in the order of least relevant to most relevant for an impact limiter containing ridged polyurethane foam embedded in a coated carbon steel casing.

Boron Depletion – The ridged polyurethane foam in the impact limiter does not function as a neutron shielding material and contains no boron. Therefore, Boron Depletion is not an issue.

Ultraviolet Light – The ridged polyurethane foam embedded in a coated carbon steel casing is not exposed to any light including ultraviolet light. The LAST-A-FOAM samples exposed to the elements exhibited the yellowing typically expected of polyurethane products due to UV light exposure. The yellowing condition was restricted to the surface and did not affect the measured physical properties of the rigid polyurethane foam.

Radiation Embrittlement – The ridged polyurethane foam in the impact limiter does not function as a neutron shielding material. However, the ridged polyurethane foam is exposed to background levels of radiation and will be briefly exposed to slightly elevated levels of radiation during cask handling periods where the impact limiter serves its function. The FuelSolutions

FSAR WSNF-220 requires the impact limiters to be stored indoors during periods of non-use, primarily to prevent deterioration of the coated carbon steel casing. Any accumulated levels of radiation during periods of use would be minimal compared to the background levels of radiation accumulated during the long periods of storage. The levels of radiation exposure accumulated by polymers performing a neutron radiation shielding function in Section 3.3.1.3 of NUREG-2214, and which could create Radiation Embrittlement, would far exceed the levels of radiation accumulated by the ridged polyurethane foam in an impact limiter. No signs of Radiation Embrittlement were reported for any of the LAST-A-FOAM aging samples.

Humidity -- FuelSolutions FSAR WSNF-220 Section 1.2.1.4.2 states that the impact limiter carbon steel casing provides a sealed closure to assure foam integrity and is coated for corrosion protection. There is no opportunity for the continuing introduction of humidity to the interior of the impact limiter. The LAST-A-FOAM samples exposed to the elements did not exhibit any in depth humidity effects. The humidity effects were restricted to the surface and did not affect the measured physical properties of the exposed rigid polyurethane foam aging samples.

Microbiological Contamination – The enclosed LAST-A-FOAM (product number FR 3708) polyurethane foam aging samples did not show any signs of biological contamination and had no biological related aging deterioration. The exposed LAST-A-FOAM (product numbers FR 3704 and FR-3718) polyurethane foam aging samples had extreme biological surface contamination (e.g., moss growing on the samples). Once the biological contamination and surface area of the foam was cleaned there was no evidence of the biological contamination extending into the interior volume of the polyurethane foam. When cut, the exposed 21-year-old specimens showed virgin material typical of newly produced material. Any moss found to be growing on the LAST-A-FOAM material was a result of organic matter of leaves, dust and dirt, and not the foam material itself. The exposed LAST-A-FOAM samples did not support fungal growth conditions and the results were consistent with previously conducted independent fungal tests. The surface biological contamination did not affect the measured physical properties of the exposed rigid polyurethane foam aging samples.

Thermal Aging – During prolonged impact limiter storage conditions the LAST-A-FOAM polyurethane foam is exposed to normal ambient indoor temperature variations which have a daily range of less than 10 °F. During periods of active impact limiter use the LAST-A-FOAM polyurethane foam is exposed to normal outdoor ambient temperature variations which may have a daily temperature range of 20 to 40 °F and an annual range of about 100 °F. The FuelSolutions impact limiters are not exposed to any non-ambient heat sources and do not function as thermal insulation. LAST-A-FOAM rigid polyurethane has physical properties design data for thermal applications up to 250 °F. In tests performed over a period of 20 years, the density and compressive strength for the two densities of the exposed LAST-A-FOAM samples under evaluation were consistent with typical new product testing variations, with no apparent thermal aging exposure-induced degradations in performance.

In conclusion, whether within an enclosed steel casing or exposed to the elements, the LAST-A-FOAM rigid polyurethane samples did not decay, rot, or lose mechanical properties during the 20-year test period. The evidence indicates that the rigid polyurethane foam enclosed in FuelSolutions impact limiters will be able to maintain its required density and compressive strength properties during the extended 40-year period of intermittent use and prolonged storage.

APPENDIX A

RAI A-RCS1 Please provide technical justification that the visual inspections of the concrete per ACI 349.3R-02, as described in Element 4 of the Reinforced Concrete Structures (RCS) AMP, are an acceptable alternative approach to the use of radiation surveys for managing loss of shielding due to concrete degradation during the 60-year extended storage term.

Section 6.6 of the MAPS Report states that, if supported by a technical justification, visual inspections of the concrete per ACI 349.3R-02 may be an acceptable alternative approach to the use of radiation surveys for managing loss of shielding due to concrete degradation. This section states that the use of the visual inspections per ACI 349.3R02 should be supported by a shielding evaluation that demonstrates that the ACI 349.3R-02 acceptance criteria, which are developed to assess structural performance, are sufficiently conservative to provide for timely identification of concrete degradation and corrective actions before a loss of shielding performance. The NRC staff performed generic shielding evaluations (referenced below) for several storage system designs and identified instances where the use of visual inspections in lieu of radiation surveys may be justified. An applicant may reference the NRC evaluations provided that (1) the applicant can justify that the NRC evaluations apply to, or are bounding for, the applicant's design, including consideration of the assumptions and system parameters (both design and contents) used in the NRC evaluation; and (2) the NRC evaluations indicate that the use of visual inspection for that design would be sufficiently conservative for ensuring against a loss of shielding performance.

Reference: "Study of the ACI 349.3R-02 Tier 2 (i.e., Section 5.2.1) Criteria Impacts on Dose Rates for Several Spent Nuclear Fuel Dry Storage System Designs." Washington, DC, U.S. Nuclear Regulatory Commission. ADAMS Accession No. ML19072A031, 2019.

This information is needed to demonstrate compliance with 10 CFR 72.240(c).

Response to RAI A-RCS1
After reviewing "Study of the ACI 349.3R-02 Tier 2 (i.e., Section 5.2.1) Criteria Impacts on Dose Rates for Several Spent Nuclear Fuel Dry Storage System Designs." Washington, DC, U.S. Nuclear Regulatory Commission, ADAMS Accession No. ML19072A031, 2019, it was decided to reintroduce the use of periodic radiation surveys for managing loss of shielding due to concrete degradation during the 60-year extended storage term. Applying the generic shielding evaluations in the study to the FuelSolutions storage system design is not feasible and the use of visual inspections in lieu of radiation surveys is not justified.

The FuelSolutions periodic radiation survey requirements and acceptance criteria have been inserted into Element 4 and Element 6, respectively, of the FuelSolutions Reinforced Concrete Structures AMP. The radiation surveys will be conducted on each cask every five years during the period of extended storage using the FuelSolutions Storage System Technical Specification 5.3.5, *Cask Surface Dose Rate Evaluation Program*, methods and acceptance criteria. This is the same Technical Specification approach used in the "Study of the ACI 349.3R-02 Tier 2 Criteria Impacts on Dose Rates for Several Spent Nuclear Fuel Dry Storage System Designs". to verify that cask concrete shielding effectiveness based on the original Technical Specification measured conditions does not degrade during the period of extended storage (i.e., making sure that the concrete shielding effectiveness does not degrade faster than the spent fuel radiation dose levels decay). The five-year concrete radiation survey frequency is based on twenty years of cask concrete operating experience with no detected decrease in concrete shielding effectiveness at the Big Rock Point ISFSI.

The Reinforced Concrete Structures AMP radiological surveys are only being applied to the Technical Specification 5.3.5 cask side wall and bottom inlet vent positions where exposed concrete exists and are not being applied to the Technical Specification 5.3.5 cask top lid and top outlet vent positions where the concrete is embedded behind steel casings or liners. Any degradation of the embedded concrete in these cask top positions will not result in a loss of the concrete material or reduced concrete radiation shielding effectiveness.

RAI A-RCS2 For the visual inspection of lower vent interior concrete areas described in Element 4 of the RCS AMP, please revise the AMP to identify the criteria to be used to select the one storage cask per ISFSI site for visual inspection of the lower vent interior concrete areas.

Element 4 of RCS AMP in the renewal application states that visual inspection of lower vent interior concrete areas (normally inaccessible) is to be performed for one storage cask at each ISFSI site, at least once every five years, using video camera, boroscope, or other remote visual inspection equipment. Element 4 of the RCS AMP described in Table 6-3 of the MAPS report states that cask selection criteria should be predefined and/or justified. Element 4 of the RCS AMP in the renewal application does not include criteria for selection of the one storage cask per ISFSI site for visual inspection of the lower vent interior concrete areas.

This information is needed to demonstrate compliance with 10 CFR 72.240(c).

Response to RAI A-RCS2

The criteria for selection of the one storage cask per ISFSI site for visual inspection of the inaccessible exposed concrete in the lower vent interior cask areas has been added to Element 4 of the RCS AMP. The cask selection criteria are based on the FuelSolutions Storage System FSAR Section 9.2.2 requirement that the interior surface of the first cask placed in service at an ISFSI site be inspected for damage every five years. Alternatively, the RCS AMP states that the site may conduct the five-year interior inspection on the storage cask that contains the canister selected per the Welded Stainless Steel Canister AMP criteria for inspection every five-years to consolidate efforts.

RAI A-TC1 Please address the apparent discrepancy between Element 6 of the Transfer Cask (TC) AMP, which cites acceptance criteria for inaccessible internal surfaces based on no evidence of leakage from the liquid neutron shield jacket or loss of wall thickness beyond a predetermined limit, and the other TC AMP elements, which do not address aging management activities for the liquid neutron shield jacket. Based on the resolution of this discrepancy, please revise the TC AMP in the renewal application, as appropriate.

With respect to aging management of the liquid neutron shielding jacket, Element 6 (third paragraph) of the TC AMP states: "For inaccessible surfaces, the acceptance criteria are no evidence of leakage from the [liquid] neutron shield jacket or loss of wall thickness beyond a predetermined limit established by system-specific design standards or industry codes and standards". This information indicates a reliance on aging management activities for components containing liquid neutron shielding.

However, TC AMP elements 1, 3, 4, and 5 do not address aging management of the liquid neutron shielding jacket.
This information is needed to demonstrate compliance with 10 CFR 72.240(c).

Response to RAI A-TC1
A review of Table 2-6 for the transfer cask verified that the liquid neutron shield jacket is stainless steel and that there are no liquid neutron shield jacket aging mechanisms or effects that require an AMP besides the inspection of the jacket coating.

Review of the Transfer Cask AMP indicated the need for some clarifications and revisions. The use of the phrase “neutron shielding” was clarified to distinguish between when a “liquid nitrogen shielding” topic was being discussed and when a “solid neutron shielding” topic was being discussed. Transfer Cask AMP Elements 1, 4 and 6 were revised to clarify the aging requirements and inspections required. The statement, “For inaccessible surfaces, the acceptance criteria are no evidence of leakage from the [liquid] neutron shield jacket or loss of wall thickness beyond a predetermined limit established by system-specific design standards or industry codes and standards” in Element 6 has been removed as there are no aging management actions required in the Transfer Cask AMP for the stainless steel liquid neutron shield jacket.

Transfer Cask AMP Elements 1, 3, 4 and 6 were updated to clarify the components, aging mechanisms, aging effects and acceptance criteria to address the required SSCs (guide rail, liquid neutron shield jacket coating, trunnion retainers and sleeves, bolts for the top cover, bottom cover, and ram access cover, and the pressure relief device and the solid neutron shielding.

RAI A-HBUF1 Please provide information that justifies the applicability of the EPRI High Burnup Dry Storage Cask Research and Development Project (HDRP) surrogate demonstration program to the W21 canister high-burnup (HBU) fuel considering that the maximum allowable burnup limit for the HBU fuel stored in the W21 canister is 60 GWd/MTU, which is 5 to 10 GWd/MTU greater than the specified nominal burnup of the HBU fuel stored in the HDRP research project cask.

The specified nominal burnup of the HBU fuel stored in the HDRP research project cask is 50 to 55 GWd/MTU, whereas the maximum allowable burnup limit for the HBU fuel stored in the W21 canister is 60 GWd/MTU. Element 1 of the HBU Fuel Monitoring and Assessment AMP described in Table 6-7 of the MAPS report states that the scope of the program provides (among other things) “a description of how the parameters of the surrogate demonstration program are applicable to the design-bases HBU fuel”; that the “maximum burnup of the design-bases HBU fuel [to be stored in the canister] is less than the burnup of the fuel in the surrogate demonstration program”; and “If the criteria cannot be met, justification is provided that the fuel from the demonstration program is reasonably characteristic of the stored fuel, and higher burnups will not change the results determined by the demonstration.”

This information is needed to demonstrate compliance with 10 CFR 72.240(c).

Response to RAI A-HBUF1
FuelSolutions W21 Canister Storage System FSAR Section 4.3.2, *Fuel Cladding Allowable Temperatures*, and associated Westinghouse calculation WCAP-15168, *Dry Storage of High Burnup Spent Nuclear Fuel*, address fuel cladding temperatures and fuel cladding thermal creep differences between 45 GWd/MTU fuel assemblies and 60 GWd/MTU) high burnup fuel assemblies for post irradiation fuel assembly storage times from 0 to 100 years. The FSAR Section 4.3.2 and WCAP-15168 fuel performance calculations are based on extensive fuel rod performance data at burnups up to 60 GWd/MTU.

To supplement W21 FSAR Section 4.3.2 and WCAP-15168, the FuelSolutions W21 Canister High-Burnup Fuel Monitoring and Assessment AMP was developed using the DOE/EPRI High Burnup Dry Storage Cask Research and Development Project (HDRP) surrogate demonstration program to justify storage of high burnup fuel assemblies up to 55 GWd/MTU. In addition, the AMP will monitor current and future industry experience involving storage of high burnup fuel applicable to the FuelSolutions W21 Canister Storage system up to 60 GWd/MTU. There are currently no W21 canisters loaded or scheduled to be loaded with HBU fuel while industry experience with storage of HBU fuel assemblies continues to increase.

The following information has been added to Element 1 of the W21 HBU Fuel Monitoring and Assessment AMP addressing fuel cladding aging mechanisms and the applicability of the HDRP and industry experience to the extended storage of W21 canister high burnup fuel assemblies.

The program covers fuel rod cladding aging in the helium environment for loss of ductility due to hydride reorientation and changes in dimensions due to thermal creep.

The AMP also relies on current and future industry experience with storage of high burnup fuel up to 60 GWd/MTU.

In addition to the HDRP, there are casks that are currently licensed for storage of high burnup fuel up to 68 GWd/MTU. The combination of the HDRP and the current and future industry experience with storage of high burnup fuel will encompass high burnup fuel applicable to the FuelSolutions W21 Canister Storage system up to 60 GWd/MTU. Since there are no high burnup fuel assemblies currently loaded in a W21 canister, industry high burnup fuel storage experience will lead any W21 Canister high burnup fuel storage efforts. The HDRP results shall be used for high burnup fuel up to 55 GWd/MTU. If the W21 canister fuel to be stored exceeds 55 GWd/MTU, industry experience monitored by the Appendix 9.A FuelSolutions Storage System FSAR WSNF 220 tollgate assessments will be utilized. The fuel parameters of the surrogate demonstration program are applicable to the FuelSolutions W21 Canister Storage system high burnup fuel because the allowable W21 canister fuel claddings are of the same type as those being tested, and the temperature limits and time at temperature of the fuel cladding are similar to those being tested.

<u>HDRP Fuel Burnup Range</u>
NUREG-1927 states that the HDRP will use 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, and loaded such that the fuel cladding temperature is as close to the limit as practicable.

NUREG-2214 (the MAPS report) states that the HDRP is a program designed to collect data from an SNF storage system containing HBU fuel in a dry helium environment. The program entails loading and storing an AREVA TN-32 bolted lid cask (the “Research Project Cask”) at Dominion Virginia Power’s North Anna Power Station with intact HBU fuel (of nominal burnups ranging between 50 GWd/MTU and 55 GWd/MTU). The fuel to be used in the program includes four kinds of cladding (Zircaloy-4, low-tin Zircaloy-4, ZIRLO™, and M5™).

The EPRI HDRP Test Plan DE-NE-0000593, February 27, 2014, states that the high burnup assemblies planned for use for the demonstration will range in average assembly burnup between 50 GWd/MTU and 67 GWd/MTU. The EPRI Test Plan also states that two high burnup fuel assemblies (approximately 58 GWd/MTU) with standard Zircaloy-4 cladding, that were previously characterized during poolside fuel examinations, were to be included in the Research Project Cask. However, the EPRI HDRP Final Loading Report TR-3002015076, October 2019, states that no HBU fuel assemblies over 55.5 GWd/MTU were loaded into the Research Project Cask. The EPRI HDRP Final Loading Report TR-3002015076 does state that two of the fuel rods from one of the Zircaloy-4 clad 58 GWd/MTU fuel assemblies were included in the Sister Rods portion of the HDRP program.

<u>HDRP Heat Loads</u>
As stated in Element 3 of the W21 HBU Fuel Monitoring and Assessment AMP, “The parameters monitored and inspected in the HDRP which are applicable to the high burnup fuel stored in the W21 canister are the cladding temperatures during storage that will provide data on high burnup cladding time at temperature for input to hydride reorientation, ductility recovery, and creep evaluations.”

The HDRP TN-32 Research Project Cask was loaded with 32 HBU fuel assemblies with a total Heat Load of 30.5 kW. The W21 canister FSAR Table 4.4-1 states that the W21 Maximum Fuel Thermal Rating is 22.0 kW and the W21 Canister Thermal Rating is 25.1 kW.

The HDRP TN-32 Research Project Cask was loaded with eight HBU fuel assemblies that had Heat Loads above the W21 canister Maximum Heat Load per fuel assembly of 1.05 kW. These eight fuel assemblies had Heat Loads ranging from 1.12 to 1.14 kW.

The above parameters indicate that the HDRP TN-32 Research Project Cask fuel cladding temperatures and cladding times at temperature would be either similar to or perhaps somewhat above those in the smaller W21 canister. The fuel assembly variation in the HDRP TN-32 Research Project Cask would also be similar to the fuel assembly variation in a typical loaded W21 canister.

<u>Conclusion</u>
Based on the above parameters it is premature to conclude that the HDRP results will not be representative of the W21 canister HBU fuel. It also may be premature to conclude that the measured HDRP fuel cladding temperatures and cladding time at temperature numbers to be used for input to hydride reorientation, ductility recovery, and creep evaluations will not be representative of W21 HBU fuel cladding performance. As stated in the Element 1 of the W21 HBU Fuel Monitoring and Assessment AMP, if the HDRP are not representative of the W21 canister HBU fuel performance, there will be substantial industry HBU fuel storage experience before any W21 HBU fuel reaches the start of its period of extended storage.

Element 5, *Monitoring and Trending*, of the W21 Canister HBU Fuel Monitoring and Assessment AMP has been revised to include the following statement, “Formal evaluations of the aggregate information from the HDRP, available operating experience, NRC-generated communications, and other information will be performed by the Tollgate Assessments in Appendix 9.A of the FuelSolutions Storage System FSAR WSNF 220.” This is consistent with the NUREG-1527, Revision 1, Appendix D statement, “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.”

RAI A-HBUF2 Please identify the parameters monitored and inspected in the HDRP that are applicable to the W21 canister HBU fuel and describe how they meet the guidance in Appendix D of NUREG-1927, Revision 1.

Element 3 of the HBU Fuel Monitoring and Assessment AMP described in Table 6-7 of the MAPS report states that 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 in Appendix D of NUREG-1927, Revision 1." Element 3 of the applicant's W21 Canister HBU Fuel Monitoring and Assessment AMP does not include the specific parameters monitored and inspected in the HDRP that are applicable to the W21 canister HBU fuel and how they meet the guidance in Appendix D of NUREG-1927, Revision 1.

The staff notes that the HDRP is a broad program that includes both the demonstration cask and the related sibling pin testing, and it is monitoring a wide range of parameters. All parameters may not be specifically relied on to manage aging in the HBU Fuel Monitoring and Assessment AMP. For clarity in the future implementation and oversight of the AMP, identification of the specific parameters monitored is requested.

This information is needed to demonstrate compliance with 10 CFR 72.240(c).

Response to A-HBUF2
Element 3 of the W21 Canister HBU Fuel Monitoring and Assessment AMP has been revised to include the following statement regarding the specific parameters monitored and inspected in the HDRP that are applicable to the W21 canister HBU fuel.

The parameters monitored and inspected in the HDRP which are applicable to the high burnup fuel stored in the W21 canister are the cladding temperatures during storage that will provide data on high burnup cladding times at temperature for input to hydride reorientation, ductility recovery, and creep evaluations.

Given that the HDRP HBU fuel assembly burnups, cladding materials, temperatures, pressure and helium environment are similar to those specified by the Technical Specifications for W21 canister fuel assemblies, the use of HDPR temperature monitoring data meets the guidance in Appendix D of NUREG-1927, Revision 1.

RAI A-HBUF3 Please identify the methods for detecting aging effects in the HDRP that are applicable to the W21 canister HBU fuel and describe how they meet the guidance in Appendix D of NUREG-1927, Revision 1.

Element 4 of the HBU Fuel Monitoring and Assessment AMP described in Table 6-7 of the MAPS report states that 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 in Appendix D of NUREG-1927, Revision 1." Element 4 of the applicant's W21 Canister HBU Fuel Monitoring and Assessment AMP does not include the methods for detecting aging effects in the HDRP that are applicable to the W21 canister HBU fuel and how they meet the guidance in Appendix D of NUREG-1927, Revision 1.

This information is needed to demonstrate compliance with 10 CFR 72.240(c).

Appendix D – Aging Management FSAR Changes

Response to RAI A-HBUF3

Element 4 of the W21 Canister HBU Fuel Monitoring and Assessment AMP has been revised to include the following statement regarding the methods for detecting aging effects in the HDRP that are applicable to the W21 canister HBU fuel.

The information from the HDRP will provide temperature measurements that will be used to address loss of ductility due to hydride reorientation and changes in dimensions due to thermal creep.

Given that the HDRP HBU fuel assembly burnups and temperatures are similar to those specified by the Technical Specifications for W21 canister fuel assemblies, the use of the HDRP thermocouple temperature data for detecting aging effects meets the guidance in Appendix D of NUREG-1927, Revision 1.

APPENDIX D

RAI D-1 Please revise the renewal application to address all of the discrepancies between the AMP descriptions provided in Appendix A, “FuelSolutions Aging Management Programs,” of the renewal application and the corresponding AMP descriptions included in Appendix D, “Aging Management FSAR Changes,” of the renewal application.

The following are examples of significant discrepancies between the AMP descriptions provided in Appendix A of the renewal application and the corresponding AMP descriptions included in the proposed FSAR change pages in Appendix D of the renewal application:

• For Element 4 of the Reinforced Concrete Structures (RCS) AMP, the description in Appendix A differs significantly from the description in the Appendix D FSAR change pages for the FuelSolutions Storage System (WSNF-220). In particular, the Appendix A description of RCS AMP Element 4 does not include any provision for the performance of radiological surveys of the storage cask, whereas the Appendix D description of RCS AMP Element 4 does include radiological surveys.

• For Elements 3 and 5 of the W100 Transfer Cask (TC) AMP, the description in Appendix A includes monitoring for deterioration of the solid neutron shielding material performance, whereas the description in the Appendix D FSAR change pages for the FuelSolutions Storage System (WSNF-220) does not include this activity.

• Element 4 of the W100 TC AMP in Appendix A includes radiological surveillance inspection of the RX-277 or NS-3 solid neutron shielding material performance in the top, bottom, and ram access covers of a loaded transfer cask, whereas the description in the Appendix D FSAR change pages for the FuelSolutions Storage System (WSNF-220) does not include this activity.

Note that the above list just identifies just some of the most significant discrepancies. There are also other discrepancies between the AMP descriptions in Appendix A and the corresponding AMP descriptions in Appendix D. The NRC staff did not attempt to locate and itemize all of the discrepancies between the information in the Appendix D FSAR change pages and the corresponding information provided in the preceding sections of the renewal application. The applicant should ensure that such issues are addressed in its submittal.

This information is needed to demonstrate compliance with 10 CFR 72.240.

Response to RAI D-1

The AMP descriptions in Appendix D (FSAR Markups) have been reviewed and updated to ensure that they agreed with the AMP descriptions in Appendix A of the FuelSolutions Renewal Application.

Note that the Appendix D AMP descriptions DO NOT have revision markings for the changes made (AMP revisions are marked in Appendix A) since the Appendix D AMPs are the changes/additions that will be implemented into the existing FuelSolutions FSARs and the complete AMP would have revision markings for the FSAR updates.

The following are the responses to the bulleted statements:

Bullet 1: As identified in the response to A-RCS1 the radiological survey requirement was added to the Element 4 of the Reinforced Concrete Structures AMP, both in Appendix A and in Appendix D (See RAI response to A-RCS1)

Bullet 2: The W100 Transfer Cask AMP has been revised as identified in the RAI response to A-TC1 to clarify the requirements of the TC AMP, both in Appendix A and in Appendix D. Revised TC AMP Elements 1, 3, 4 and 6. We have verified that the monitoring for deterioration of the solid neutron shielding material performance requirements in TC AMP Elements 3 and 5 read the same in both Appendix A and Appendix D.

Bullet 3 - The W100 Transfer Cask AMP has been revised as identified in the RAI response to A-TC1 to clarify the requirements of the TC AMP. Revised AMP Elements 1, 3, 4 and 6. We have verified that the radiological surveillance inspection requirements for the solid neutron shielding material in the transfer cask covers in TC AMP Element 4 read the same in both Appendix A and Appendix D.

We have reviewed the AMP descriptions in Appendix A and the corresponding AMP descriptions in Appendix D and corrected the discrepancies. All of these Appendix A and Appendix D pages now have a “June 2022” date to minimize the potential of a previous Appendix A AMP page being compared to a wrong previous Appendix D FSAR AMP change page. See the RAI response to RAI D-2 for a further explanation of what may have happened regarding the Appendix A and Appendix D AMP discrepancies.

RAI D-2 Please address whether the following three AMP descriptions included in the renewal application Appendix D FSAR change pages for the FuelSolutions W21 Canister (WSNF-221) need to be removed from that location:

- Table 9.A.1-2, FuelSolutions Reinforced Concrete Structures AMP
- Table 9.A.1-3, FuelSolutions Monitoring of Metallic Surfaces AMP
- Table 9.A.1-4, FuelSolutions W100 Transfer Cask AMP

The renewal application Appendix D FSAR change pages for the FuelSolutions W21 Canister (WSNF-221) indicate, in the table of contents and in the summary of AMPs (FSAR Appendix 9.A), that the above three AMP descriptions are supposed to be located in the FSAR change pages for the FuelSolutions Storage System (WSNF-220) and not in the FSAR change pages for the FuelSolutions W21 Canister (WSNF-221). However, the above three AMP descriptions are currently located in the FSAR change pages for both the FuelSolutions W21 Canister (WSNF-221) and the FuelSolutions Storage System (WSNF-220). Further, there are several discrepancies between the above three AMP descriptions located in the FSAR change pages for the FuelSolutions W21 Canister (WSNF-221) and the corresponding AMP descriptions located in the FSAR change pages for the FuelSolutions Storage System (WSNF-220).

This information is needed to demonstrate compliance with 10 CFR 72.240.

Response to RAI D-2
We cannot be sure what happened regarding this D-2 RAI comment, but one possible explanation follows.

On March 30, 2021, Westinghouse submitted letter LTR-NRC-21-14 Revision 0, “Responses to Requests for Supplemental Information for the Application for the FuelSolutions™ Spent Fuel Management System Certificate of Compliance (CoC) Renewal Application.” Enclosed with this letter (see ADAMS Accession Number ML21090A2060) were revisions of the following three AMPs marked as FSAR replacements for the same three original renewal application AMPs for the FuelSolutions Storage System FSAR (WSNF-220).

• Table 9.A.1-2, FuelSolutions Reinforced Concrete Structures AMP
• Table 9.A.1-3, FuelSolutions Monitoring of Metallic Surfaces AMP
• Table 9.A.1-4, FuelSolutions W100 Transfer Cask AMP

Immediately following these AMP tables, the Westinghouse letter included a revised Table 9.A.1-1, FuelSolutions Welded Stainless Steel Canister AMP marked as a replacement for the same original renewal application AMP for FuelSolutions W21 Canister FSAR (WSNF-221). It appears possible that all four revised FSAR AMP replacement tables were filed in the Appendix D AMP FuelSolutions W21 Canister FSAR (WSNF-221) markups. This would have left the new Appendix A AMPs and the old original Appendix D FSAR WSNF-220 AMPs for the Reinforced Concrete Structures AMP, the Monitoring of Metallic Surfaces AMP, and the W100 Transfer Cask AMP with discrepancies pretty much as described in RAI D-1.

The D-2 RAI is correct in stating: "The renewal application Appendix D FSAR change pages for the FuelSolutions W21 Canister (WSNF-221) indicate, in the table of contents and in the summary of AMPs (FSAR Appendix 9.A), that the above three AMP descriptions are supposed to be located in the FSAR change pages for the FuelSolutions Storage System (WSNF-220) and not in the FSAR change pages for the FuelSolutions W21 Canister (WSNF-221)."

To avoid any possible repeat of the above-described type of problem, a complete revised FuelSolutions Renewal Application with all of the RAI response page changes incorporated is being submitted with all of the pages marked "June 2022". While most FuelSolutions Renewal Applications pages have not been revised, the June 2022 RAI revisions are highlighted in color, excepted for Appendix D where the FSAR changes are colored red and the FSAR AMP pages where the entire AMP is colored red. The Appendix E CoC and Technical Specification page markups are unchanged and still also colored red.

The resubmitted June 2022 FuelSolutions W21 Canister FSAR (WSNF-221) page changes do not include the three misplaced AMP Tables. The three newly revised RCS, MMS, and TC AMP Tables do correctly appear in the change pages for the FuelSolutions Storage System FSAR (WSNF-220).