Enclosure 3 to E-44181

RAIs and Responses

(Public Version)

GEN-RAI-2-1: Revise the renewal application (Appendix 1K, Appendix 2A and other relevant sections) to:

(a) account for responses to the first request for additional information during the review of amendment 14.

(b) account for any time-limited aging analyses (TLAA) submitted in support of amendment 14, which should be revised to account for the extended period of operation, and

(c) reference correct Final Safety Analysis Report (FSAR) revision where amendment 14 changes were, or will be, incorporated.

The revised renewal application provided a new Appendix 1K, which detailed proposed changes to the HSM-H, DSC 61BTH and DSC 32PTH1 designs currently under review (Amendment 14). Revised Table 2A-1 does not incorporate the latest revisions of the design drawings for amendment 14 (e.g. Table 2A-1 does not cite the latest revision of drawings NUH32PTH1-1006-SAR and NUH32PTH1-1007-SAR). In addition, the application is unclear if time-limited analyses were submitted for amendment 14 (e.g. neutron embrittlement), which the staff should review for their validity through the renewed period. Further, the scoping evaluation of Appendix 2A references Revision 14, which does not include changes in amendment 14. The application should reference the appropriate FSAR revision (future Rev. 15) or provide clarification.

This information is required to ensure compliance with 10 CFR 72.240(c).

RESPONSE TO GEN-RAI-2-1

The renewal application has been reviewed in its entirety and revised, as appropriate, to address Amendment 14 and the Updated Final Safety Analysis Report (UFSAR) update that will incorporate its associated changes, once approved. The scoping evaluation for Amendment 14 is included in Appendix 1K. In addition, the responses to both the first and second requests for additional information (RAIs) for Amendment 14 have been incorporated into the applicable updated portions of the renewal application, including the design drawings listed in Appendix 1K (Tables 1K-2, 1K-3 and 1K-4) and Table 2A-1.

Appendix 1K has been revised to add new Section 1K.3.5 for time-limited aging analyses (TLAAs), which adds an additional discussion of the TLAAs associated with the Aging Management Review for Amendment 14. The TLAAs in Appendix 3 have been prepared to assess structures, systems, and components (SSCs) that have a time-dependent operating life, which demonstrates that the existing licensing basis remains valid and that the intended functions of the SSCs in the scope of the renewal application are maintained during the period of extended operation. A single TLAA evaluation is generally performed to bound all the different component types. As discussed in Appendix 1K, the TLAAs performed in Appendix 3 also remain bounding and applicable for the Amendment 14 SSCs.

The next Certificate of Compliance (CoC) 1004 UFSAR update, to Revision 15, is due August 28, 2016, and the current estimated timing for Amendment 14 to be approved and become effective is late 2016. Therefore, barring any unforeseen circumstances, Amendment 14 will be incorporated into UFSAR Revision 16. If Amendment 14 is changed further, beyond the responses to the second RAI, a separate, but associated, submittal regarding the renewal application impacts will be submitted at the same time as the additional Amendment 14 changes.

Additional clarification has been added to Attachment A to explain that Table A-1 references UFSAR Revision 14 page numbers for the location of the changed UFSAR text; however, the actual page numbers may be different due to the timing of the approval of Amendment 14 and the CoC 1004 Renewal.

Additional clarification has also been added to Attachment B to explain that the change to the Technical Specifications (TS) for Amendment 14, once approved, is expected to be identical to the changes described in Attachment B for Amendments 11 and 13.

Renewal Application Impact:

Sections 1.1, 1.2.1, 1.3, 1.4, 2.2, 2.3, 2.3.1, 2.3.2, 3.3.1, 3.3.2, 3.3.3, Appendix 1K, Appendix 2, Appendix 2A, Appendix 2B, Appendix 2C, Appendix 2E, Appendix 6A, Attachment A and Attachment B have been revised as described in the response.

Tables 1K-3 and 2A-1 have been revised as described in the response.

HSM-RAI-2-1: Revise the application to address the potential for delayed ettringite formation (DEF) and microbiological degradation of the HSM and basemat concrete. Revise, as appropriate, the HSM Aging Management Program (AMP) per the conclusions of these analyses.

The applicant is asked to address the potential of DEF as a degradation mode for the HSM and basemat concrete and provide a technical bases or reference appropriate relevant fabrication specifications that ensure that excessive temperatures required for DEF do not occur during casting and curing. Otherwise, justify how the proposed AMP is adequate for managing aging effects due to this degradation mode or make appropriate revisions.

The staff notes that conditions necessary for DEF occurrence are excessive temperatures during concrete casting, the presence of internal sulfates, and a moist environment. Limiting the internal concrete temperature to about 70 °C [about 158 °F] during casting can mitigate the formation of DEF (Taylor et al., 2001). This can be achieved either by direct specification, or indirectly by limiting the cement content or specifying the use of low or very low heat cement. Field cases reported by Sahu and Thaulow (2004) showed that DEF was the cause of deterioration of precast concrete railroad ties in Sweden. Degradation of cast-in-place concrete structures in southern U.S. has also been attributed to DEF after being 10 years in service (Thomas et al., 2008), Hobbs (1999) and (Johansen and Thaulow, 1999) reported isolated DEF cases in mass concretes with high cement contents in UK within 20 years in service. These concretes were cast in summer where peak temperatures were between 85 °C [185 °F] and 93.3 °C [200 °F]. If the temperature of the concrete is not controlled within a permissible range during casting and curing, the staff considers that the conditions for DEF of concrete may be present in outdoor, below grade, and embedded environments.

The applicant is further asked to address the potential of microbially-induced degradation of the HSM and basemat concrete and justify how the proposed AMP is adequate for managing aging effects due to this degradation mode or make appropriate revisions.

The staff notes that biodeterioration of concrete structures is caused by organisms that grow in environments on concrete surfaces that offer favorable conditions (e.g., available moisture, near neutral pH, presence of nutrients, etc.), which facilitates the colonization of microbes on concrete surfaces. Conducive environments may have elevated relative humidity (i.e., between 60% and 98%), long cycles of humidification and drying, freezing and defrosting, high carbon dioxide concentrations (e.g., carbonation), high concentrations of chloride ions or other salts or high concentrations of sulfates and small amounts of acids (Wei, et al. 2013).

There is evidence to show that a wide variety of organisms can cause concrete deterioration. Recent observations in Texas, Alabama, Georgia, and Mississippi have identified several sites where microorganisms have caused deterioration of the columns of concrete bridges (Trejo et al., 2008), Giannantonio et al. (2009), Magniont et al. (2011), Vollertsen et al. (2008), and Ghafoori and Mathis (1997) provide a list of microorganisms that can promote degradation in concrete. According to Bastidas-Arteaga et al. (2008), biodeterioration of concrete is mainly caused by bacteria, fungi, algae and lichens. Once the pH of the surface of the concrete drops below 9 in the presence of sufficient nutrients, moisture and oxygen present, some species of sulfur bacteria like Thiobacillus sp. can attach to the concrete surface and reproduce (Mori et al., 1992). As the pH continues to fall to moderate or weakly acidophilic conditions, T. novellus, T. neapolitanus and T. intermedius establish on the surface of concrete (Milde et al., 1983). This type of bacteria is strongly dependent on the concrete pH and environmental conditions (Okabe, 2007).

According to Sanchez-Silva and Rosowsky (2008), the action of microorganisms affect the concrete mainly by contributing to the erosion of the exposed concrete surface, reducing the protective cover depth, increasing both concrete porosity and the transport of aggressive chemicals. In addition, this degradation mode can promote a reduction in concrete pH, loss of concrete strength, and spalling/scaling. The deterioration of concrete mostly stays on the surface. While the rate of deterioration is slow, it can be present within 40 years of exposure (Hu et al., 2011). Therefore, the application should address the potential for microbially-induced degradation of the HSM and basemat concrete exposed to outdoor and below grade environments.

The staff notes that the above discussions will be part of the draft Managing Aging Processes in Storage report to be issued for public comment later this year.

This information is required to ensure compliance with 10 CFR 72.240(c).

References:

Bastidas-Arteaga, E., M. Sanchez-Silva, A. Chateauneuf, and M. Ribas-Silva. “Coupled Reliability Model of Biodeterioration.” *Chloride Ingress and Cracking for Reinforced Concrete Structures, Structural Safety*. Vol. 30. pp. 110–129. 2008.

Ghafoori, N. and R. Mathis. “Sulfate Resistance of Concrete Pavers.” *Journal of Materials in Civil Engineering*. Vol. 9. pp. 35–40. 1997.

Giannantonio, D.J., J.C. Kurth, K.E. Kurtis, and P.A. Sobechy. “Effects of Concrete Properties and Nutrients on Fungal Colonization and Fouling.” *International Biodeterioration and Biodegradation*. Vol. 63. pp. 252–259. 2009.

Hobbs, D.W. “Expansion and Cracking in Concrete Associated with Delayed Ettringite Formation.” Ettringite, the Sometimes Host of Destruction. B. Erlin, ed. SP177 Farmington Hills, Michigan: American Concrete Institute International. pp. 159-181. 1999.

Hu, J., D. Hahn, W. Rudzinski, Z. Wang, and L. Estrada. "Evaluation, Presentation and Repair of Microbial Acid-Produced Attack of Concrete." Report No. FHWA/TX-11/0-6137-1. Texas Department of Transportation Research and Technology Implementation Office. 2011.

Johansen, V. and N. Thaulow. "Heat Curing and Late Formation of Ettringite." ACI SP-177. Bernard Erlin, ed. Farmington Hills, Michigan: American Concrete Institute. pp. 199–206. 1999.

Magniont, C., M. Coutand, A. Bertron, X. Cameleyre, C. Lafforgue, S. Beaufort, and G. Escadeillas. "A New Test Method to Assess the Bacterial Deterioration of Cementitious Materials." *Cement Concrete Research*. Vol. 41. pp. 429–438. 2011.

Milde, K., W. Sand, W. Wolff, and E. Bock. "Thiobacilli of the Corroded Concrete Walls of the Hamburg Sewer System." *Journal of General Microbiology*. Vol. 129. pp. 1,327–1,333. 1983.

Mori, T., T. Nonaka, K. Tazak, M. Koga, Y. Hikosaka, and S. Nota. "Interactions of Nutrients, Moisture, and pH on Microbial Corrosion of Concrete Sewer Pipes. *Water Research*. Vol. 26 pp. 29–37. 1992.

Okabe, S., O. Mitsunori, I. Tsukasa, and S. Hisashi. "Succession of Sulfur-Oxidizing Bacteria in the Microbial Community on Corroding Concrete in Sewer Systems." *Applied Environmental Microbiology*. Vol. 73. pp. 971–980. 2007.

Sahu, S. and N. Thaulow "Delayed Ettringite Formation in Swedish Concrete Railroad Ties." *Cement and Concrete Research*. Vol. 34. pp. 1,675–1,681. 2004.

Sanchez-Silva, M. and D. Rosowsky. "Biodeterioration of Construction Materials: State of the Art and Future Challenges." *Journal of Materials in Civil Engineering*. Vol. 20. pp. 352–365. 2008.

Taylor, H.F.W., C. Famy, and K.L. Scrivener. "Delayed Ettringite Formation." *Cement and Concrete Research*. Vol. 31. pp. 683–693. 2001.

Thomas, M., K. Folliard, T. Drimalas, and T. Ramlochan "Diagnosing Delayed Ettringite Formation in Concrete Structures." *Cement and Concrete Research*. Vol. 38. pp. 841–847. 2008.

Trejo, D., P.D. Figueiredo, M. Sanchez, C. Gonzalez, S. Wei, and L. Li. "Analysis and Assessment of Microbial Biofilm-Mediated Concrete Deterioration." Texas Transportation System. The Texas A&M University System. Texas Transportation System. The Texas A&M University System. 2008.

Vollertsen, J., A.H. Nielsen, H.S. Jensen, W.A. Tove, and H.J. Thorkild. "Corrosion of Concrete Sewers—The Kinetics of Hydrogen Sulfide Oxidation." *Science of the Total Environment*. Vol. 394. pp. 162–170. 2008.

Wei, S., Z. Jiang, H. Liu, D. Zhou, and M. Sanchez-Silva. Microbiologically Induced Deterioration of Concrete – A Review. Brazilian Journal of Microbiology. Vol. 44, pp. 1001-1007. 2013.

RESPONSE TO HSM-RAI-2-1

Renewal application Section 3.6.4, Section 3.6.6 and the references in Section 3.11 have been revised to address the potential for delayed ettringite formation (DEF) and microbiological degradation (also called microbiological chemical attack) aging mechanisms. The DEF and microbiological degradation aging mechanisms have been evaluated and added to the discussion of aging mechanisms in Section 3.6.4.2.

The microbiological chemical attack aging mechanism was determined to be applicable to both the HSMs and the concrete pad.

Microbiological degradation is another form of chemical attack with aging effects generally manifested by loss of material, increasing concrete porosity, cracking, and corrosion of reinforcing steel. The aging effects associated with microbiological chemical attack are similar to those caused by other degradation mechanisms, as discussed in Section 3.6.4.2. The acceptance criteria of the HSM AMP described in Section 6A.5.5.6 have been modified to include [ ] In addition, an editorial change has been made to the third bullet item in this list of concrete visual inspection criteria related to “drummy areas” to correct the inspection criteria to [ ] and misspelling of the word “drummy.” In addition, these corrections were also made to summary Table A-4 in Attachment A.

The DEF aging mechanism was determined to be potentially applicable to the concrete pad.

The aging effects of the DEF degradation mechanism are generally manifested by visible volume expansion leading to loss of material due to spalling, and cracking. These aging effects are similar to those caused by other degradation mechanisms that initiate within the mass of the structure and become evident on the surface (e.g., reaction with aggregates (ASR)). Thus, the visual examination of accessible surfaces, as described in the HSM AMP, adequately addresses this aging mechanism, and only the changes to the Section 6A.5.5.6 acceptance criteria for the “HSM Aging Management Program for External and Internal Surfaces,” as described in Section 6A.5, were deemed necessary.

Renewal Application Impact

Sections 3.6.4.1, 3.6.4.2, 3.6.4.6, 3.6.6.5, 3.11, 6A.5.5.6 and Attachment A (Table A-4) have been revised as described in the response.

HSM-RAI-2-2: Revise Section 3.8.6.1 to ensure consistency with response to previously-submitted HSM-RAI-19, and include the below-grade portion of the storage pad within the scope of renewal.

In response to HSM-RAI-19, several sections of the application were revised to include the below-grade portion of the storage pad within the scope of renewal. However, Section 3.8.6.1 remains inconsistent with these changes.

This information is required to ensure compliance with 10 CFR 72.240(c).

RESPONSE TO HSM-RAI-2-2

Section 3.8.6 (including Section 3.8.6.1) of the renewal application has been deleted. The response to HSM-RAI-19 included the addition of Section 3.6.6 to discuss the aging management review results for the concrete storage pad, including below-grade portions; therefore, Section 3.8.6 is a duplication and is no longer needed.

Renewal Application Impact

Section 3.8.6 of the renewal application has been deleted as described in the response.

Proprietary Information on Pages 8 through 12
Withheld Pursuant to 10 CFR 2.390

SFA-RAI-2-1: With respect to Appendix 3J.2 of the renewal application:

1. Revise the calculation for maximum expected boiling water reactor (BWR) internal rod pressure to account for the fission gas and decay gas released during irradiation in storage.

2. Provide more defensible estimates of the internal rod pressures for pressurized water reactor (PWR) rods. Use either the maximum internal pressure allowed by reactor operations, or the sum of the internal rod pressures and maximum fission gas and decay gas released with minimum rod internal volume for each class of acceptable content.

3. Revise the calculation for internal rod pressures for PWR rods to account for increased pressures in ZIRLO™ Integral Fuel Burnable Absorber (IFBA) rods due to decay gas release.

The calculations for rod internal pressures should account for fission and decay gases released/generated during storage. Reference [3J.5.3] (source of the internal pressurization equation for PWR fuel rods) has raised some controversy in recent Extended Storage Collaboration Program (ESCP) meetings due to the limited set of data used and the corresponding uncertainty (σ values). In addition, this reference does not account for ZIRLO™-IFBA rods, which per Table 2-2 are allowed for storage in the DSC 24PHB. The majority of the data in Reference [3J.5.3] pertains to zircaloy-4 clad fuel rods, which do not account for the expected significant increase in rod internal pressure due to helium generated from B-10 depletion in the zirconium diboride (ZrB_2) of IFBA rods. The applicant should account for the uncertainty of increased cladding stresses in ZIRLO™-IFBA rods. The staff notes that the U.S. Department of Energy, "Used Fuel Disposition Campaign," is expected to issue a report on FRAPCON/FRAPTRAN modeling predictions for rod internal pressures for over 60,000 rods irradiated in Watts Barr Unit 1 during cycles 1-10. The modeling will include standard ZIRLO™ and ZIRLO™-IFBA rods.

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

RESPONSE TO SFA-RAI-2-1

1. Appendix 3J, Section 3J.2 has been revised to note that the BWR fuel rod internal pressure used for the stress calculations is bounding of the effects of fission gas and decay gas released during irradiation in storage. This conclusion is based on added discussion in Section 3J.3 and added Reference [3J.5.7] in Section 3J.5.

2. Section 3.8.5.2 and Appendix 3J, Sections 3J.2, 3J.3, and 3J.4 have been updated, along with Table 3J-3, using a revised PWR fuel rod internal pressure of 2300 psi, which is bounding of the typical PWR system pressure (based on added Reference [3J.5.6]). The revised pressure is also shown to conservatively bound the effects of fission gas and decay gas released during storage. A discussion of this conclusion is added in Section 3J.3 based on the results reported in new Reference [3J.5.7] added to Section 3J.5.

3. Appendix 3J, Section 3J.2 has been revised to show that the revised PWR fuel rod internal pressure used for the stress calculations bounds the internal pressure predicted for ZIRLO™- IFBA rods reported in added Reference [3J.5.5] in Section 3J.5, which accounts for increased pressures due to decay gas release.

Renewal Application Impact:

Section 3.8.5.2 and Appendix 3J, Sections 3J.2, 3J.3, 3J.4 and 3J.5 have been revised as described in the response. Table 3J-3 has been revised as described in the response.

Proprietary Information on Pages 15 through 29
Withheld Pursuant to 10 CFR 2.390

SFA-RAI-2-4: Revise Table 2D-1 and Sections 3.8.1/3.8.2 to identify the materials of all subcomponents of the spent fuel assemblies within the scope of renewal, in addition to the spent fuel cladding (i.e. spacer grid assemblies, fitting/nozzle, etc.). Revise Section 3.8.4 to include a discussion on the aging management review of these subcomponents, which identify any aging effects requiring an aging management activity. Revise Section 3.8.5, as needed, to address revisions to Section 3.8.4.

In a previously-submitted RAI (RAI Request #1, SFA-RAI-1), the staff requested that the scoping evaluation for the spent fuel assemblies, as discussed in Section 2.3 and tabulated in Table 2D-1, be revised to identify the materials of construction of all subcomponents of the spent fuel assemblies within the scope of renewal (including hardware such as spacer grids, upper end fitting/nozzle, etc.). These changes were not made as part of the response to SFA-RAI-1.

Similarly, the aging management review (Section 3.8.1 and 3.8.2) does not identify the materials of construction for each of the subcomponents listed in Section 3.8.1. Further, Section 3.8.4 did not include a discussion of potential aging mechanisms considered based on the materials/environment of the assembly subcomponents (e.g. stress corrosion cracking, galvanic corrosion, creep, general corrosion, fatigue, radiation embrittlement), and conclusions on whether any aging effects on these subcomponents require an aging management activity (TLAA or AMP).

The staff notes that both the zirconium-based cladding and fuel assembly hardware provide structural support to ensure that the spent fuel is maintained in the analyzed configuration in the design bases. Therefore, the aging management review must address potential aging effects of the assembly hardware, which are to be dispositioned with an aging management activity (TLAA or AMP).

This information is needed to determine compliance with 10 CFR 72.236(d) and 72.240.

RESPONSE TO SFA-RAI-2-4

An additional column has been added to Table 2D-1 and additional clarification added to the table to identify the materials of construction of the subcomponents of the spent fuel assemblies within the scope of renewal. In addition, the description of the fuel assembly components in Section 3.8.1 has been revised to add the materials of construction for each of the subcomponents.

Section 3.8.2 states that the fuel rod cladding is considered the limiting component with respect to fuel assembly hardware since it serves as a barrier to fission products and is, therefore, the primary focus of the AMR. This is further supported by the discussion in EPRI TR-108757 (Reference [3.11.40] of the Renewal Application), which indicates that the impact of irradiation on stainless steel and nickel-based superalloys during storage is less than in the reactor environment. Section 3.8.2 has been revised to include additional supporting information from EPRI TR-108757 on aging management for spent fuel assemblies in a dry storage environment.

Section 3.8.4 has been revised to clarify that only the potential degradation mechanisms requiring management for the SFAs are discussed. Therefore, only creep, hydrogen embrittlement, and radial hydride formation (for high burnup fuel) are considered potential degradation mechanisms for SFAs. Aging effects, such as stress corrosion cracking, galvanic corrosion, general corrosion, and fatigue, are not discussed because they are not significant for the SFAs while stored in an inert environment in the DSC. Based on the changes to Sections 3.8.2 and 3.8.4, no revision to Section 3.8.5 is needed since the considerations for the fuel cladding effects bound that of other subcomponents, and since significant changes are not expected for the materials of construction of these other subcomponents.

Renewal Application Impact:

Sections 3.8.1, 3.8.2 and 3.8.4 have been revised as described in the response.

Table 2D-1 has been revised as described in the response.

Proprietary Information on This Page
Withheld Pursuant to 10 CFR 2.390

SFA-RAI-2-6: Clarify the basis for including Alloy-A and Anikuloy zirconium alloy in the renewal application as allowable cladding types for contents under this certificate.

Revision 14 of the UFSAR does not identify Alloy-A and Anikuloy zirconium alloy as allowed for storage in the DSC 24PHB. Therefore, the staff cannot verify the basis for including these in the renewal application.

This information is needed to determine compliance with 10 CFR 72.236(d) and 72.240.

RESPONSE TO SFA-RAI-2-6

Tables 2-2, 3.8-1, 2D-1 and 3J-3 have been revised to remove cladding types Alloy-A and Anikuloy zirconium alloys to be consistent with CoC 1004 UFSAR Revision 14.

Alloy-A and Anikuloy zirconium alloys are fuel claddings used with CE 16x16 Standard and CE 16x16 System 80 fuel assemblies. Users of this type of fuel include Palo Verde Nuclear Generating Station, which has not loaded using the standardized NUHOMS® system (CoC 1004) in the past. Alloy-A and Anikuloy fuel cladding are not explicitly mentioned in the CoC 1004 UFSAR, Revision 14, and AREVA Inc. has not evaluated these fuel cladding types for acceptability. Therefore, this material will be excluded from the scope of the CoC 1004 License Renewal to be consistent with the CoC 1004 UFSAR. Should any future customers plan on loading Alloy-A or Anikuloy clad fuel, evaluation of the effects of long-term storage on these fuel cladding types will be performed at that time.

Application Impact:

Tables 2-2, 3.8-1, 2D-1 and 3J-3 have been revised as described in the response.

SFA-RAI-2-7: Revise element 7,"Corrective Actions" and element 8, "Confirmation Process" of the High Burnup Fuel Aging Management Program, as necessary, to provide additional specificity on actions to be taken in the event that any of the acceptance criteria are not met.

The provisions in both element 7 and element 8 of the High Burnup Fuel Aging Management Program in the renewal application provide limited detail on actions to be taken in the event that any of the acceptance criteria are not met.

This information is needed to determine compliance with 10 CFR 72.240(c)(2). See draft NUREG-1927, Rev. 1 (ML15180A011) for guidance.

RESPONSE TO SFA-RAI-2-7

Section 6A.8.2.7, "Corrective Actions", and Section 6A.8.2.8, "Confirmation Process", have been revised to address actions taken in the event that the acceptance criteria are not met for the High Burnup Fuel Aging Management Program. The summary table for this AMP in Attachment A (Table A-7) has also been revised.

Renewal Application Impact:

Section 6A.8.2.7, Section 6A.8.2.8, and Attachment A (Table A-7) have been revised as described in the response.

Proprietary Information on This Page
Withheld Pursuant to 10 CFR 2.390

SFA-RAI-2-9: Revise the second full sentence in Section 4.4, of the renewal application to change “any tollgate” to “the 2^{nd} or further tollgates”.

As written in the current revision of the renewal application, the statement is inconsistent with the guidance of ISG-24 and Appendix B of draft NUREG-1927, Rev. 1, both of which indicate the expectation for destructive evaluation data to provide confirmation of HBU fuel performance and that degradation of HBU fuel has not resulted in an unanalyzed configuration during the period of extended operation (as defined by the acceptance criteria in the HBU fuel AMP).

This information is needed to determine compliance with 10 CFR 72.240(c)(2).

RESPONSE TO SFA-RAI-2-9

The second sentence in Section 4.4 has been changed as requested. The revised text provides consistency with the guidance of ISG-24 and Appendix B of draft NUREG-1927, Rev. 1 regarding evaluation of destructive examination data to confirm HBU fuel performance.

Renewal Application Impact:

Section 4.4 has been revised as described in the response.

Proprietary Information on Pages 37 through 46
Withheld Pursuant to 10 CFR 2.390

TC-RAI-2-1: Justify the description of the transfer cask external environment as being "sheltered" for the trunnions and bottom end forging in the AMR results Table 1G-20 (OS197 TC), given that these components appear to be intermittently exposed to fuel pool water and exposed to ambient outdoor conditions during loading campaigns.

In response to TC-RAI-1, the stated environments for several transfer cask components in the AMR results tables were adjusted to reflect the fact that some components experience some exposure to fuel pool water and ambient outdoor conditions. However, the environment for the components listed above were not adjusted.

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

RESPONSE TO TC-RAI-2-1

Consistent with the changes made to the AMR results tables in the response to TC-RAI-1, AMR results Table 1G-20 has been revised to show environments consistent with similar subcomponent parts for other transfer casks (e.g., Tables 1A-13, 1H-23).

In addition, the description of TC changes implemented via UFSAR Revision 10 in Section 1G.1.3.5 has been revised to clarify in the "Description of Change" column that 72.48 license review (LR) 721004-410 included an alternate bottom closure configuration.

Renewal Application Impact:

Section 1G.1.3.5 has been revised as described in the response.

Table 1G-20 has been revised as described in the response.

Proprietary Information on Pages 48 through 51
Withheld Pursuant to 10 CFR 2.390

STRUCT-RAI-2-1: Clarify the bounding load case used for the evaluation of the DSC with reduced shell thickness due to Chloride-Induced Stress Corrosion Cracking (CISCC) under normal and off normal conditions of storage during the renewal period in Appendix 3N.

Load case UL-6 for the 32PTH1 DSC (Appendix U of the UFSAR) is cited as the bounding load case for the evaluation of the DSC with reduced shell thickness due to CISCC under normal and off normal conditions of storage during the renewal period. Appendix 3N states that Appendix U of the UFSAR describes the analysis, loads and load combination results for the 32PTH1. The staff reviewed Table U.3.7-18 (referenced in Appendix 3N of the license renewal application) and found results for load combination UL-6; however, the staff could not find a description of UL-6 in Appendix U of the UFSAR. UL-6 is not listed in the Summary of 32PTH1-DSC Load Combinations (Table U.2-13) for horizontal storage module (HSM) unloading. The staff did find UL-6 in Table 8.2-24 of the UFSAR, but the loading conditions described do not match those described in Appendix 3N of the license renewal application. The staff believes that UL-5 may be the correct load combination from Appendix U based on the description of the loads.

This information is required to show compliance with 10 CFR 72.240(c)(2).

RESPONSE TO STRUCT-RAI-2-1

Unloading load combination UL-6 referred to in Table 8.2-24 of the UFSAR (Revision 14, September 2014) is different from the unloading load combination UL-6 defined in Appendix U, Table U.3.7-18 of the UFSAR for the NUHOMS® 32PTH1 DSC.

The load combination UL-6 defined in Appendix U, Table U.3.7-18 is an off-normal unloading-hot condition (117 °F ambient temperature thermal storage condition in HSM) with 20.0 psig internal pressure and 80 kip pull extraction load from the HSM. This load combination is identical to the UL-5 load combination defined in Table U.2-13. For clarity, an editorial correction has been made to UFSAR Table U.2-13 to change the call-out for load combination “UL-5” to “UL-6”.

Renewal Application Impact:

No changes as a result of this question.

STRUCT-RAI-2-2: Justify why Service Level C or D load combinations from Table U.2-13 are not considered for the evaluation of the DSC with reduced shell thickness due to CISCC.

Appendix 3N of the license renewal application addresses the evaluation of the DSC with reduced shell thickness due to CISCC under normal and off-normal conditions of storage during the renewal period, but there is no evaluation of environmental phenomena or accident conditions. The service level C and D conditions (Earthquake Loading Hot and Cold) listed in Table U.2-13 for HSM storage are as likely to occur during the renewal period as they were during the original licensing period. Since the unloading scenario (UL-6) is evaluated in Appendix 3N, it is reasonable to assume that the DSC will be back-hauled to a transporter on the storage pad, and vulnerable to a side drop. Based on Table U.3.7-19 and U.3.7-20, load case HSM-8 was the bounding Service Level C load case and TR-10 was the bounding Service Level D load case. HSM-8 produced a stress ratio of 0.97 in the DSC shell and TR-10 produced a stress ratio of 0.86 in the DSC shell with nominal shell thickness. The staff believes the DSC should be evaluated with reduced shell thickness due to CISCC for all reasonable conditions of storage during the renewal period and that these cases should be included in the analysis especially since TR-10 and HSM-8 load cases provide little margin in the original analysis .

This information is required to show compliance with 10 CFR 72.240(c)(2).

RESPONSE TO STRUCT-RAI-2-2

The purpose of the Appendix 3N evaluation is to determine the minimum shell thickness required to ensure that the confinement boundary is maintained and the requirement for retrievability of the DSC from the HSM is met under normal conditions of storage for the period of extended operation. Thus, the Appendix 3N evaluation and determination of the associated minimum shell thickness can be considered a "defense-in-depth" evaluation for this specific purpose. There is no reasonable basis for performing an evaluation with similar "across the board" shell thickness reduction for accident conditions for the reasons provided below.

The purpose of the AMP presented in the renewal application is to ensure that the design basis is maintained through the period of extended operation. The DSC AMPs presented in Sections 6A.3 and Section 6A.4 of the renewal application rely on periodic inspections of the external surfaces of the DSC to provide assurance that this intended purpose is met. The DSC AMPs have provisions to evaluate the condition of the DSC based on the results of the inspections. [

].

Renewal Application Impact:

No changes as a result of this question.

THERM/CONFINE-RAI-2-1: Clarify the confinement dose evaluation activities provided in calculation package 67009-TLAA22 (Table 7-1, 7-2, 7-3, and 7-4) and calculation package 67009-TLAA09 (Table 7-1 and 7-2).

a) Provide the Co-60 activity calculation for 20, 40 and 60 year storage periods.

b) The total for "Light Elements" does not equal the sum of the tritium and cobalt activities.

This information is needed to determine compliance with 10 CFR 72.240(d).

RESPONSE TO THERM/CONFINE-RAI-2-1

Revision 0 of Calculations 67009-TLAA09 and 67009-TLAA22 were provided in response to a February 26, 2015 e-mail request from NRC staff with a submittal provided via E-41361 [1]. Enclosure 2, Item B.c requested these calculations. The calculation associated with Appendix 3F of the renewal application is 67009-TLAA09. This calculation has been revised (currently at Revision 2), and is provided in Enclosure 7 of this transmittal. The calculation associated with Appendix 3K of the renewal application is 67009-TLAA22. This calculation has also been revised (currently at Revision 2). This calculation is included in Enclosure 8 of this transmittal. The requested clarification of the confinement dose evaluation activities associated with Revision 2 of these calculations is described below.

a. The Co-60 activity is due to crud (i.e., surface contamination). It is computed by multiplying the fuel rod surface area for a fuel assembly by the crud contamination at the decay time of interest, see Section 7.1 in 67009-TLAA09, Revision 2, and 67009-TLAA22, Revision 2. Co-60 activities are provided in these calculations for 20-, 40-, and 60-year storage periods (corresponding to a decay time of 25, 45 and 65 years) and presented in Table Therm/Confine-RAI-2-1-1 below. The crud activity at discharge is 140 $\mu Ci/cm^2$ for PWR and 1254 $\mu Ci/cm^2$ for BWR fuel assemblies based on NUREG/CR-6487 [2]. As such, the Co-60 activity is independent of the DSC type. Co-60 activities for 20 years after the time of initial storage are provided in 67009-TLAA09, Revision 2 Table 7-1, and Co-60 activity levels after 40 and 60 years are provided in 67009-TLAA22, Revision 2 Table 7-1.

TABLE THERM/CONFINE-RAI-2-1-1
Cobalt-60 Activity at 20, 40, and 60 Years

		Cobalt-60 Activity per Assembly (Ci)		
	Fuel Type	20 Years	40 Years	60 Years
BWR	GE 7x7	4.19E+00	3.02E-01	2.17E-02
PWR	B&W 15 x 15	1.46E+00	1.05E-01	7.58E-03

References:

1. Letter E-41361 from Paul Triska (AREVA Inc.) to U.S. NRC Document Control Desk, “Response to Request for Information – AREVA Inc. Renewal Application for the Standardized NUHOMS® System –CoC 1004 (Docket 72-1004, TAC No. L24760),” March 16, 2015.

2. NUREG/CR-6487, “Containment Analysis for Type B Packages used to Transport Various Contents,” U.S. Nuclear Regulatory Commission, November 1996.

Renewal Application Impact:

Tables 3F-1, 3F-2, 3F-5, 3F-6, 3K-1, 3K-2, 3K-3, 3K-4, 3K-5, and 3K-6 have been revised as described in the response. Section 3K.3 has been revised as described in the response.

THERM/CONFINE-RAI-2-2: Provide an example calculation (e.g., Thyroid 7.76E-4 mrem/yr at 100 m, Table 8-2), or spreadsheet, that show the steps taken to determine the potential doses are below regulations.

Calculation No. 67009-TLAA09 provides the basis for the dose calculations. However, the steps to determining the dose (e.g., Table 8-2) are not clear.

This information is needed to determine compliance with 10 CFR 72.240(d).

RESPONSE TO THERM/CONFINE-RAI-2-2

Revision 0 of Calculation 67009-TLAA09 was provided in response to a February 26, 2015 e-mail request from NRC staff with a submittal provided via E-41361 [1]. Enclosure 2, Item B.c requested this calculation. The calculation associated with Appendix 3F of the Renewal Application is 67009-TLAA09. This calculation has been revised (currently at Revision 2), and is provided in Enclosure 7 of this transmittal. An example calculation is provided in Section 8.2 of 67009-TLAA09 for the thyroid dose at 100m for PWR normal operations. Because the example provided in the calculation does not explicitly show the contribution from each source nuclide, the associated spreadsheet from the calculation is provided in Enclosure 12 of this transmittal.

References:

1. Letter E-41361 from Paul Triska (AREVA Inc.) to U.S. NRC Document Control Desk, "Response to Request for Information – AREVA Inc. Renewal Application for the Standardized NUHOMS® System –CoC 1004 (Docket 72-1004, TAC No. L24760)," March 16, 2015.

Renewal Application Impact:

No changes as a result of this question.

THERM/CONFINE-RAI-2-3: Provide the FLUENT input and output files described in Appendix 3G and provide details on the solution convergence for X-velocity, Y-velocity, Z-velocity, turbulence equations, energy equation, and DO-intensity.

a) Appendix 3G of the application describes the results of a thermal analysis (e.g., weld temperatures) using the FLUENT code, but a review could not be performed because the FLUENT files were not provided.

b) A review of the thermal analysis requires details of the convergence residuals, such as plots of residuals as a function of iterations and the fraction of mass, momentum, and energy balances.

This information is needed to determine compliance with 10 CFR 72.240(d).

RESPONSE TO THERM/CONFINE-RAI-2-3

The response to this RAI is divided into two sections. Part "A" addresses the submission of FLUENT computer files, and Part "B" addresses the details and criteria used to evaluate the convergence of the computational fluid dynamics (CFD) models, as noted in the RAI question. In addition, Part "B" also includes

- Justification to address the staff's concerns about the modeling of heat generation rate, as discussed during the conference call on May 3, 2016, and
- A detailed description of the various inputs used in the CFD models, as discussed during the conference call on April 19, 2016 and May 3, 2016.

Part A

The FLUENT input and output files used in Appendix 3G were submitted on January 14, 2016 as Enclosure 3 of E-44184. Two sets of input and output files were submitted for each HSM model evaluated in Appendix 3G; one set for the maximum heat load, and one set for the minimum heat load.

[

] These files replace those submitted for HSM Model 152 in E-44184. The updated computer files are listed in Enclosure 11.

Proprietary Information on Pages 59 through 61
Withheld Pursuant to 10 CFR 2.390

References:

1. Updated Final Safety Analysis Report for the Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel, NUH-003, Revision 14.

2. TN Document E-38701, Application for Amendment 14 to Standardized NUHOMS® Certificate of Compliance No.1004 for Spent Fuel Storage Casks, Revision 0, dated April 16th 2015.

3. [

4.]

5. USNRC, "Safety Evaluation Report for License Renewal Calvert Cliffs Nuclear Power Plant Independent Spent Fuel Storage Installation," License No. SNM-2505, Docket No. 72-08, October 2014.

6. [ ]

Renewal Application Impact:

Sections 3C.2, 3G.2.3.1, 3G.3, and 3G.5 have been revised as described in the response.

Table 3G-1, Table 3G-2, Table 3G-3, Figure 3G-7 and Figure 3G-8 have been revised as described in the response.

Table 3G-4 and Figure 3G-9 have been added as described in the response.

THERM/CONFINE-RAI-2-4: Explain the sensitivity of the average annual temperature, which is a boundary condition used to determine the maximum and minimum DSC temperatures, on the CISCC crack growth rates.

Appendix 3G assumed a 70 °F average temperature when determining maximum and minimum DSC temperatures. According to page 3G-7, this information was used in Appendix 3C and Appendix 5B. If necessary, provide thermal results and crack growth rates assuming realistic, or bounding, ambient temperatures.

This information is needed to determine compliance with 10 CFR 72.240(d).

RESPONSE TO THERM/CONFINE-RAI-2-4

This response is divided into two parts. The first part of the response addresses the sensitivity of canister surface temperature to variations in the average annual ambient temperatures. The sensitivity is performed for average annual ambient temperatures ranging from 7 °C to 30 °C. The second part of this response addresses the variation of CISCC crack growth rate (CGR) and corresponding crack penetration depth with the ambient temperature (in a range between 7 °C to 30 °C).

Proprietary Information on Pages 64 through 74
Withheld Pursuant to 10 CFR 2.390

[ ]

References:

1. Letter E-42059 from Paul Triska (AREVA Inc.) to Document Control Desk (NRC), "Revision 1 to Renewal Application for the Standardized NUHOMS® System - CoC 1004, Response to First Request for Additional Information (Docket No. 72-1004, TAC No. L24964)," October 16, 2015.

2. ASME Boiler and Pressure Vessel Code, Section XI "Rules for Inservice Inspection of Nuclear Power Plant Components," Subsection IWB, Article IWB-3000, IWB-3640.

Application Impact:

No changes as a result of this question.

SHIELD-RAI-2-1: Provide justification of why the gamma irradiation level from 62 GWD/MTU (3.4% enrichment and 8.5 years) is selected over 32 GWD/MTU (2.6% enrichment and 3 years cooling time) which has higher gamma source term.

It is stated in the SAR that: "[

]

In addition, Enclosure 2 to E-42059, which was submitted in response to DSC-RAI-17, states

"Though the dose rate could be on the order of 10^4 rad/h over less than a year (based on dose rate estimation in Figure 3E-5), it is unlikely that radiolysis due to gamma radiation of 10^4 rad/h would accelerate the canister pitting and crevice corrosion. At a low dose rate on the order of 10^3 rad/h, no significant effect of gamma radiation on localized corrosion of the canister is expected based on the observation of limited propagation." Therefore, the higher dose rate should be considered in assessing the effect of radiation on the corrosion rate.

This information is required to demonstrate compliance with 10 CFR 72.236(b) and 72.236(d), and 10 CFR 72.240.

RESPONSE TO SHIELD-RAI-2-1

A new figure (Figure 3E-6) has been added to Appendix 3E that shows a comparison of the energy deposition rate on the DSC outer surface as a function of storage time for two design basis sources for the 32PTH1 DSC. [

] Clarification has been provided in the last paragraph of Renewal Application Section 3E.3.

As discussed in the response to DSC-RAI-17 (Enclosure 2 of [1]), there is insufficient relevant data to determine the effect of radiation on chloride induced stress corrosion cracking, but the existing data suggest that radiolysis due to gamma radiation on the order of 10^4 rad/h is not expected to accelerate localized corrosion (i.e., pitting, crevice corrosion). Therefore, the irradiation effects of gamma rays on canister CISCC was included as a potential aging effect requiring management in Section 3.5.4.2 (discussion of aging mechanisms) and in the aging management program, Sections 6A.3.3

and 6A.4.3 of Revision 1 of the CoC 1004 License Renewal Application (Enclosure 4 of [1]).

Reference:

1. Letter E-42059 from Paul Triska (AREVA Inc.) to U.S. NRC Document Control Desk, “Revision 1 to Renewal Application for the Standardized NUHOMS® System – CoC 1004, Response to First Request for Additional Information (Docket No. 72-1004, TAC No. L24964),” October 16, 2015.

Renewal Application Impact:

Section 3E.3 in Appendix 3E has been revised as described in the response.

Figure 3E-6 has been added as described in the response.