AREVA INC.

DOCKET NO. 72-1004

REQUEST FOR ADDITIONAL INFORMATION

RELATED TO RENEWAL OF THE
STANDARDIZED NUHOMS SYSTEM
CERTICFICATE OF COMPLIANCE NO. 1004

By letter dated November 4, 2014 (ML14309A344), AREVA Inc. submitted an application (ML14309A343) for renewal of Certificate of Compliance (CoC) No. 1004 for the Standardized NUHOMS System.

This request for additional information (RAI) identifies additional information needed by the U.S. Nuclear Regulatory Commission (NRC) staff in connection with its review of this renewal application. The requested information is categorized by topic: General (GEN), Horizontal Storage Module (HSM), Spent Fuel Assemblies (SFA), Dry Shielded Canister (DSC), Transfer Casks (TC), Structural (STRUCT), Thermal/Confinement (THERM/CONFINE), and Shielding (SHIELD). Draft NUREG-1927, Rev. 1, "Standard Review Plan for Renewal of Specific Licenses and Certificates of Compliance for Dry Storage of Spent Nuclear Fuel" (ML15180A011) was used by the staff in its review of the application.

Each individual RAI describes information needed by the staff to complete its review of the application and to determine whether the applicant has demonstrated compliance with the regulatory requirements.

Each RAI below has an "RAI-2" designation included within the alpha-numeric system used to distinguish these 2nd round RAIs from the 1st round of RAIs. Please note that some RAIs are currently being treated as "Proprietary" (see Enclosure 2), but NRC staff has not made a final proprietary determination on the application or responses to previously submitted RAIs.

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).

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.

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).

HSM-RAI-2-3: see Enclosure 2

HSM-RAI-2-4: see Enclosure 2

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).

SFA-RAI-2-2: see Enclosure 2

SFA-RAI-2-3: see Enclosure 2

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.

SFA-RAI-2-5: see Enclosure 2

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.

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.

SFA-RAI-2-8: see Enclosure 2

SFA-RAI-2-9: Revise the second full sentence in Section 4.4, of the renewal application to change “any tollgate” to “the 2nd 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).

DSC-RAI-2-1: see Enclosure 2

DSC-RAI-2-2: see Enclosure 2

DSC-RAI-2-3: see Enclosure 2

DSC-RAI-2-4: see Enclosure 2

DSC-RAI-2-5: see Enclosure 2

DSC-RAI-2-6: see Enclosure 2

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.

TC-RAI-2-2: see Enclosure 2

TC-RAI-2-3: see Enclosure 2

TC-RAI-2-4: see Enclosure 2

TC-RAI-2-5: see Enclosure 2

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).

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).

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).

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).

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).

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 deg 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).

SHIELD-RAI-2-1: see Enclosure 2