From: Saverot, Pierre
Sent: Thursday, December 16, 2010 4:32 PM
To: 'Troy Hedger'; 'Schrag, Michael R. (GE Power & Water)'; Saito, Earl F. (GE Power & Water)
Subject: Thermal RAIs for the AOS package application

Troy,

Below are the thermal RAIs. I expect that you will present your proposed responses at the 01/18 meeting.

Thanks

Pierre

#1 - Table 1-2

Clarify in Table 1-2 the Ci/Watt values for Co-60 and Sr/Y-90. Also clarify the activity values for Sr/Y-90, the activity values in Ci and TBq for that radioisotope do not appear to be equivalent. This RAI is a follow-up to the first round RAI 3-6 response.

The Ci/Watt values for Co-60 and Sr/Y-90 have changed from Rev. C of the application. The activity values in Ci and TBq for Sr/Y-90 are not equivalent.

This information is needed to determine compliance with 10 CFR 71.33(b).

#2 - Drawings

Correct the inconsistency in gross weight values on the nameplates and note 3 in Licensing Drawing No. 166D8142, sheet 2, and No. 166D8143, sheet 2. Similar inconsistencies also appear to exist for the Model Nos. AOS-50 and AOS-100 packages. This RAI is a follow-up to the first round RAI 1-12 response.

The weight listed on any nameplate should be the package weight (packaging, contents, and impact limiters). It appears that Licensing Drawing number 166D8142, sheet 2 lists the AOS-25 package weight as 168 pounds (packaging, contents, and impact limiters) on the nameplate and note 3, while Licensing Drawing number 166D8143, sheet 2 lists the AOS-25 package weight as 140 pounds (packaging without impact limiters, and contents). While Licensing Drawing number 166D8143 does not show the impact limiters, the weight on the nameplate should include the impact limiters and note 3 should be consistent with the nameplate.

This information is required by the staff to determine compliance with 10 CFR 71.33(a)(2).

#3 - Drawings / Section 3.2.2 / Tables 3-3 and 3-4 / Thermal Models / Chapter 4

Ensure the quality category is correct for each of the containment boundary seals. Ensure temperatures are being provided for the correct containment boundary seals and all containment boundary seals. Ensure the locations in the thermal models for the containment boundary seals are correct. Ensure the above is in agreement with Chapter 4 of the application. Clarify if the copper alloy seals that are mentioned in Section 3.2.2 of the application are containment boundary seals. This RAI is a follow-up to the first round RAIs 1-1 and 4-2 responses.

For example, in drawing 105E9712 for the AOS-100 item numbers 30 and 31 are Category A copper seals, while item numbers 19 and 29 are silicone and Category B. From the SAR Figure 4-1 it appears to the staff that the applicant is stating item numbers 19 and 29 are the containment boundary seals, which is in contrast to the Category B quality category given in drawing 105E9712. Looking further at the vent port in the thermal chapter, it appears that the applicant is pulling a temperature from detail X in the lid area of drawing 105E9712 sheet 3. This also doesn't appear to be in agreement with SAR Figure 4-1. As far as the staff can tell in the thermal chapter and on the licensing drawings the applicant has switched the labeling of the vent port and test port. This appears to be the case for all AOS models, not just the AOS-100. Finally, if the copper alloy seals are not part of the containment boundary, they should be removed from Section 3.2.2. If there are containment boundary seals that are not mentioned in Section 3.2.2, they should be mentioned in that section and their peak temperatures should be provided in Tables 3-3 and 3-4. The drawings quality category and seal location for the containment boundary seals, the seal temperatures provided in Chapter 3, the seal temperature locations from the thermal model, and the containment boundary seals in Chapter 4 of the SAR should all be in agreement. The applicant needs to present a clear understanding of the containment boundary location and its components throughout the entire application.

This information is required by the staff to determine compliance with 10 CFR 71,33(a)(4), 71.51, 71.71 and 71.73.

#4 - Table 2-6

Confirm that the correct temperatures per Regulatory Guide 7.8 for load case 111 in Table 2-4 of the application are being used. Also confirm that the temperatures from the latest thermal models as reported in the SAR have been used when required for all stress analysis load combinations.

Because there are two thermal load cases with the designation number 111 for each AOS model (for example lc111-t1-mf.025 and lc111-t2-mf.025 for the AOS-025), confirmation that the temperatures from the lc111-t2-mf.XYZ thermal model at the end of the thirty minute fire are being used in the subsequent load combination 350 is needed. It appears that some of the thermal input files were created after the stress analysis was run. It seems that the AOS-25 thermal input files were created on 9/14/2010 and the AOS-50 thermal input files were created on 6/27/2010, while the stress analysis output files appear to have been created between 6/3/2010 and 6/6/2010. Confirmation is needed to determine if the latest thermal models have been used when required for the stress analysis. If confirmation cannot be provided, the stress analysis should be rerun with temperatures from the latest thermal models.

This information is needed to determine compliance with 10 CFR 71.107.

#5 - Tables 3-3 and 3-4

Provide a clear reference for the seal temperature limit of 572°F that appears in Tables 3-3 and 3-4 for the silver jacketed HELICOFLEX seal. This RAI is a follow-up to the first round RAI 3-8 response.

The origin of the 572°F rated seal temperature should be clearly stated in the application.

This information is required by the staff to determine compliance with 10 CFR 71.33(a)(2).

#6 - Section 3.2.1.5

Justify the validity of the simplified approximation of increasing the impact limiter foam density and thermal conductivity based on reduced impact limiter volume due to HAC deformation without actual foam crush data. This RAI is a follow-up to the first round RAI 3-24 response.

The applicant made simplified assumptions on the density and thermal conductivity of the impact limiter foam based on the reduced volume of the impact limiter due to the HAC deformation. These assumptions must be justified with a demonstration that the approximation is bounding for the actual behavior of the foam when it is crushed.

This information is required by the staff to determine compliance with 10 CFR 71.73

#7 - Table 3-12

Editorial: Correct the heat flux shown in Table 3-12 for the AOS-25.

In Table 3-12, the decay heat divided by the cavity area is not equal to the heat flux that is provided in Table 3-12 for the AOS-25.

This information is required by the staff to determine compliance with 10 CFR 71.33(b)(7).

#8 - Sections 3.3.3 and 3.4

Describe and justify how the current thermal models capture the thermal performance of the impact limiters, specifically with respect to the inside ribs that appear in the engineering drawings and their effect on peak temperatures of components such as containment boundary seals.

The thermal models of the impact limiters for the AOS-25, AOS-50, and AOS-100 appear to only consist of the impact limiter foam and the stainless steel outer shell of the impact limiters. In the engineering drawings there is a significant number of stainless steel inside ribs that have not been thermally modeled. Describe the affect of the impact limiter ribs on peak temperatures of components such as containment boundary seals. This may be best addressed by determining the AOS model where the impact limiter ribs would have the largest effect on seal temperatures and then modifying that thermal model to include the inside ribs as part of a sensitivity study.

This information is required by the staff to determine compliance with 10 CFR 71.71 and 71.73.

#9 - Section 3.4.6

Provide an explanation for the decrease in temperature of the lid plug and the cavity shell peak temperatures during the first five to 20 minutes of the fire that can be seen in Figures 3-18, 3-45, 3-72, and 3-97 of the application.

This is a phenomenon that is somewhat unexpected considering the boundary temperature has increased from 100°F to 1475°F. Noting that the air gaps within the package have been closed during the fire makes the phenomenon more realistic. Justification of the behavior should be provided in Section 3.4.6 of the SAR.

This information is required by the staff to determine compliance with 10 CFR 71.73

#10 - Sections 3.4, 3.5.4.2.3, and 3.5.4.2.5

Provide a single thermal analysis of the worst-case post-accident condition of the package. The post-fire orientation and boundary conditions should be realistic based on the drop event. In addition, clarify if the "Side crush" that appears in Figures 3-124 through 3-126 is referring to side drop damage of the package. The thermal analysis should also include any crush and puncture damage which has been requested to be addressed in RAIs 2-XX and 2-XX of this package. This RAI is a follow-up to the first round RAI 3-25 response.

Figures 3-124 through 3-126 of the SAR show all drop effects modeled simultaneously. The applicant should justify the **one** HAC drop that results in highest component temperatures and only model the effects of that drop. The worst case orientations (post-fire) should also be justified (i.e. vertical or horizontal) and boundary conditions should be realistic based on the drop event. Section 3.5.4.2.5 provides a sensitivity study for 50% drop deformation versus 100% drop deformation. The consideration of 50% drop deformation is not consistent with providing a single thermal analysis of the worst-case post-accident condition of the package. The staff recommends removing Section 3.5.4.2.5 and applying 100% deformation for the one HAC drop that results in the highest component temperatures and only model the effects of that drop. Crush and puncture damage, if present, should also be included in the thermal models which has been requested to be addressed in RAIs 2-XX and 2-XX of this package.

This information is required by the staff to determine compliance with 10 CFR 71.73

#11 - Sections 3.5.4.4.1 and 3.5.4.4.2

Justify the use of the equation for equivalent convection due to radiation in Sections 3.5.4.4.1 and 3.5.4.4.2 of the application for air gap number 5 for all thermal models. This RAI is a follow-up to the first round RAI 3-16 response.

The equation given in Sections 3.5.4.4.1 and 3.5.4.4.2 is $hr = S*F*4*T^3$ which makes the approximation that the temperature on both sides of the air gap is the same. The air gap number 5 in all thermal models has a rather large temperature difference across the air gap, up to 242.2°F during the AOS-25 post-fire as is seen in Table 3-97. If the use of the equation cannot be justified, an alternative method for modeling the radiative heat transfer across the air gap should be provided and the thermal models, temperature plots, peak temperatures should be updated accordingly.

This information is required by the staff to determine compliance with 10 CFR 71.71 and 71.73.

#12 - Section 3.5.4.6

Editorial: Correct the equation for T_f in Section 3.5.4.6 of the SAR.

The equation in Section 3.5.4.6 of the SAR should be $T_f = (T_w – T_b) / 2 + T_b$. The staff notes that the values for T_f in Table 3-121 of the SAR are from this equation and the values are correct.

This information is required by the staff to determine compliance with 10 CFR 71.35.

#13 - Section 3.5.6

Address the temperatures of the contents, basket, and shielding liners/plates that have not been modeled due to the assumption of uniform decay heat in Section 3.5.6 of the application. This RAI is a follow-up to the first-round RAI 3-31 response.

Regarding the response to RAI 3-31, the applicant has chosen to not perform a thermal analytical model containing the radioactive contents, basket, or removable shielding, but has instead chosen to continue to apply a uniform decay heat to the cavity walls. The applicant has therefore not predicted temperatures for the radioactive contents, basket, or removable shielding. The staff believes that the cask cavity predicted temperatures using an applied uniform decay heat, underestimates the temperature of the contents in the cask cavity (radioactive contents, basket, and removable shielding). This was demonstrated in the physical test where higher temperatures were observed in thermocouples 1 and 2 which were located inside the cask cavity during the physical test. The applicant stated in the RAI response that this was due to the fact that the heat was applied to the center of the cavity.

All types of contents in each package need not be modeled; instead the applicant should evaluate the most bounding contents and determine that the performance of the package is acceptable with those contents. This should include an evaluation of predicted temperatures, MNOP, and HAC cavity pressures.

This information is required by the staff to determine compliance with 10 CFR 71.71 and 71.73.

#14 - Table 4-1

Clarify how the five rows of “Temperature change” values were arrived upon. Also address why an ambient temperature of 1475°F was not included in the table. If any changes to Table 4-1 of the application potentially results in changes to the lid attachment bolt analysis, the analysis and results should be updated.

It is not clear how the five rows of temperature change values were arrived upon; the values do not appear to match up with thermal model temperature changes across surfaces or temperatures of surfaces. The staff also notes that if the values are temperature changes, a delta T of 80°C is not equal to a delta T of 176°F. It is also not clear to the staff why an ambient temperature of 1475°F was not included in the table.

This information is required by the staff to determine compliance with 10 CFR 71.51(a)(2).

#15 - Section 7.1.3.4

Ensure every package for shipment undergoes a temperature survey to verify that limits specified in 71.43(g) are not exceeded. This RAI is a follow-up to the first round RAI 7-3 response.

Based on NUREG-1609, "Standard Review Plan for Transportation Packages for Radioactive Material," Section 7.5.1.3, every package for shipment undergoes a temperature survey to verify the limits specified in 71.43(g) are not exceeded. Section 7.1.3.4 of the SAR states: "Note: Step k does not need to be performed for routine shipments of the same payload, after three (3) initial thermal surveys are conducted. From then on, step k should be conducted every 10 shipments. Step k must always be conducted for shipments in which the content decay heat value is equal to or greater than 80% of the maximum authorized decay heat value." does not appear to follow the guidance provided in NUREG-1609.

This information is required by the staff to determine compliance with 10 CFR 71.43(g).

#16 - Table 8.5 and Section 3.3.1

Justify how the thermal analysis parameters for the LAST-A-FOAM provide bounding peak temperatures when the material tests described in Table 8.5 allow for +/- 15% or 20% tolerance from thermal parameter nominal values. Table 8.5 also shows only one nominal value for LAST-A-FOAM density and thermal conductivity, clarify if the material test will be performed for each density and respective thermal conductivity of LAST-A-FOAM used.

Table 8.5 shows that the material testing of LAST-A-FOAM allows for +/- 15% tolerance from the nominal density value, +/- 15% tolerance from the nominal thermal conductivity value, and +/- 20% from the nominal specific heat value. The LAST-A-FOAM density and thermal conductivity values used in the NCT analysis are nominal values or are based on nominal values for the HAC analysis which may not be providing the maximum temperatures based on the allowable tolerance for the LAST-A-FOAM material tests. This should be addressed in Section 3.3.1 of the application. If it cannot be justified, the NCT and HAC models should be rerun with the bounding LAST-A-FOAM parameters and peak temperatures should be updated. The staff also notes that only one nominal value for LAST-A-FOAM density and thermal conductivity was provided in Table 8-5. The staff needs clarification if the material test will be performed for each density and respective thermal conductivity of LAST-A-FOAM shown on the engineering drawings. This should be addressed in Table 8-5 of the application.

This information is required by the staff to determine compliance with 10 CFR 71.71 and 71.73.

#17 - Section 8.1.7

Justify how the first fabricated packages used in the thermal test, as shown in Figure 8-1 of the application, will demonstrate the heat transfer capability of the packages as shown in the engineering drawings. Clarify if new thermal analytical models will be created to compare the predicted temperatures to the thermal test temperatures. This RAI is a follow-up to the first round RAI 8-3 response.

The purpose of the thermal test is to demonstrate the heat transfer capability of the packaging and that the heat transfer performance determined in the evaluation is achieved in the fabrication process. There are clearly some differences between the AOS models shown in the engineering drawings and the thermal test model shown in Section 8.1.7 (no impact limiters or lid plug). The applicant should address that the majority of fabrication gaps have been captured by the thermal test model as shown in Figure 8-1 and in conjunction with the material tests for the impact limiter foam, the heat transfer performance of the packages will be demonstrated. Clarify in Section 8.1.7 if new thermal analytical models will be created to compare temperature predictions with the results of the thermal tests.

This information is required by the staff to determine compliance with 10 CFR 71.85(a) and 71.87(b).