#10

From: Thomas Alexion
To: MILLAR, DANA
Date: 3/22/04 1:38PM
Subject: SECOND RAI FROM MECHANICAL ENG. BR. (REVISED) - METAMIC - ANO-1

Dana,

See the attached.

Tom

- docket 50-313
- PM is T. Alexion

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Subject:	SECOND RAI FROM MECHANICAL ENG. BR. (REVISED) - METAMIC - ANO-1
Creation Date:	3/22/04 1:38PM
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SECOND REQUEST FOR ADDITIONAL INFORMATION (REVISED)
MECHANICAL AND CIVIL ENGINEERING BRANCH
ON USE OF METAMIC IN THE SPENT FUEL POOL
ARKANSAS NUCLEAR ONE, UNIT 1

1. You stated that one set of three artificial time histories (two horizontal and one vertical acceleration time histories) were generated from the design response spectra defined in the Safety Analysis Report (SAR). The staff requests the following additional information in order to evaluate the adequacy of the time histories used in the analyses.

   a) Provide a comparison between the response spectrum (RS) of the artificial time histories and the licensing basis design RS in the SAR.

   b) Demonstrate that the artificial time histories developed from the in-structure response spectra and used in the analyses contain adequate energy at the frequencies of interest, such that the stresses determined by the seismic analyses are adequate. Using the guidance in Standard Review Plan Section 3.7.1, provide either of the following: a) a comparison between the target power spectral density (PSD) and the PSD of the artificial time histories; or b) a comparison between the average of the response spectra of four time histories (generated from the licensing basis response spectra) and the response spectra used in the design analyses.

   c) Your statement that, "... the DBE [design-basis earthquake] horizontal design time histories were developed by simply multiplying the OBE [operating-basis earthquake] time histories by 1.8 and the OBE vertical time history by 2.0 ...", is unclear. Do you mean that the DBE horizontal and vertical design time histories were developed by multiplying the OBE horizontal time histories by 1.8 and the OBE vertical time history by 2.0, respectively? If so, provide the technical basis for using the factor of 1.8, instead of 2.0, for the horizontal time history.

2. The analysis uses the computer code SOLVIA to determine the dynamic fluid-structure interaction analysis. The staff requests the following additional information in order to evaluate the adequacy of the code for this application.

   a) Provide comparisons between code output and experimental results to demonstrate the adequacy of the SOLVIA code and the hydrodynamic modeling used to analyze the fuel assemblies, racks, and walls.

   b) Indicate whether you have performed more detailed dynamic analyses of the interaction between the walls, box-type fuel racks, and fuel assemblies, such as an analysis using 3-D finite element plate, beam, and fluid elements. If so, provide a comparison of the results to demonstrate that the beam model used in the submittal adequately models the interactions of the racks, fuel, and pool walls.

   c) Indicate whether you had any numerical convergence and/or stability problem(s) during the nonlinear, dynamic single- and multi-rack analyses using the SOLVIA code. If so, discuss how the problems were reconciled.

d) Indicate whether you have performed fluid-rack structure interactions where the fluid was treated as air to verify the accuracy and capability of the SOLVIA code. If so, provide the results and conclusions (i.e., numerical stability, convergence, etc.) of the study.

3. The December 31, 2003, submittal describes the method for evaluating the stresses in the fuel assemblies, inserts, and racks, and also provides a summary of results. The staff requests the following additional information in order to evaluate the adequacy of the method and results of the analyses.

   a) The load combinations (page 15) include thermal loads for normal and accident conditions. However, the analyses assumed that the effects of the thermal loads are not significant, and performed the operating basis earthquake (OBE) and safe shutdown earthquake (SSE) stress analyses without the thermal loads. Tables 6.8.1 and 6.8.2 of the submittal show a summary of the stress results. It is noted that several components have high induced stress compared to the allowable stress (e.g. induced stress of 14,240 psi vs. allowable stress of 16,500 psi for the cell to base plate weld). Provide a summary of the analysis results with the thermal loads included, or justify not including the thermal loads.

   b) Page 10 indicates that the area and moment of inertia are the same for the Region 2 and Region 3 racks; however, the Region 2 racks are 11x11 with no inserts and the Region 3 racks are 11x12 with poison inserts. Explain why the areas and moments of inertia are the same for the different rack designs.

   c) Explain the modeling of the hydrodynamic mass. What is the effect on the rack natural frequency, displacements, and stresses of the full and half-full racks.

   d) Section 6.8.8 on miscellaneous equipment loads states "It was concluded that the presence of [2000 lb temporarily on top of the Region 2 racks] does not impact the seismic qualification of the racks," and, "similarly, a 200 lb weight . . . placed anywhere on the top of any rack has an inconsequential effect on the seismic adequacy of the racks." Explain the bases for these conclusions.

   e) It is not clear whether the analysis shows vertical displacement (rack uplift). Indicate whether there is a vertical displacement of the rack in the analysis. If there is, what is the maximum impact load between rack and steel liner, and is this included in the stress values in Tables 6.8.1 and 6.8.2? Explain how the SOLVIA code handles a separation (uplift) between a rack and liner (and include a comparison between SOLVIA and test results, if available, as described in Question 2). Also, discuss whether the analyses considered the potential for fuel racks pedestals to slip off the pads (due to combined rack and pad motion) and directly impact the pool floor.

   f) The base accelerations of 200.10 and 135.50 in/sec^2 in x and y directions induce 0.266 and 0.714 inch horizontal displacements for the OBE case, respectively, while the base accelerations of 280.96 and 175.20 in/sec^2 in x and y directions induce 1.464 and 3.2 inches horizontal displacements for the SSE case. The predictions seem somewhat random in that there is no apparent correlation between the base acceleration and rack displacement, regardless of the coefficient of the friction. Discuss the factors attributable to such phenomenon.

g) The staff observes inconsistent shear predictions in Tables 6.8.1 and 6.8.2 with different friction coefficients. For example, the maximum shear decreases by approximately a factor of 2 as the coefficient of friction decreases from 0.5 to 0.2 in all cases except for shear in the x direction in the single rack DBE case. Discuss the factors that would contribute to this apparent inconsistency. Also, provide an additional demonstration of proper functioning of the code/model by evaluating the forces and accelerations to show dynamic equilibrium at a time step.

h) The analyses predicted axial forces of 41,700 lbs and 39,090 lbs for the SSE and OBE cases, respectively, while the SSE time histories are about two times larger that the OBE time histories. Discuss the factors attributable to such phenomenon.

i) How did you define the terms, "Max. Fuel Impact" and "Foot-1"? Do they include impact forces?

j) Page 32 indicates that the maximum pedestal vertical force was 40,200 lb for OBE and 44,940 lb for DBE. However, the dry weight of a fully-loaded rack is approximately 270,000 lb and the model assumes 4 pedestals. Explain this apparent discrepancy. (Note that this result also effects pedestal horizontal friction forces and sliding.)

k) Figure 6.8.3 appears to show the displacement of Zone 1 racks out of phase with the Zone 2 and Zone 3 racks. Is this the expected result?

l) Section 6.3.3 implies that the only stresses on the inserts are due to accelerations. The analyses indicate that the Region 3 racks experience displacements of up to 3.2 inches during a seismic event. Explain how the analyses account for stresses on the inserts induced by twisting and bending of the racks/inserts.

m) The analyses assume that the vertical motion of the rack, fuel, and insert are the same. Provide the basis for this assumption, particularly with respect to the inserts.

n) What was the highest magnitude of negative hydrodynamic pressure obtained from the whole pool multi-rack (WPMR) analyses, and what was the resulting absolute pressure? Also, discuss how SOLVIA accounts for potential voiding if the water reaches saturated conditions.

o) Describe the procedure used in the analysis to calculate the hydrodynamic pressure.

p) Provide the largest magnitude of the hydrodynamic pressure distribution along the height of the rack and pool wall during the fluid and rack interaction for the 3-D single rack analyses.

q) Provide the deformation shape, with magnitudes, of the rack for the single-rack and multi-rack SSE analysis when the maximum displacement at the rack top corner occurs.

4. The submittals indicate that an analysis was performed to evaluate the structural integrity of the spent fuel pool (SFP) for the additional weight of the rack inserts. The staff requests the following additional information in order to evaluate the acceptability of the SFP.

   a) Provide a description of the analysis performed for the SFP. If the analysis included a revision to the seismic inputs, provide the revised inputs and justify their acceptability for demonstrating the structural integrity of the SFP. If the analysis uses a new methodology, describe the methodology and justify its adequacy for demonstrating the structural integrity of the SFP. If the analysis assumes different temperature profiles for the pool slab and walls, provide the temperature profile and its basis. Also, discuss how the hydrodynamic pressure from the WPMR analysis was used in the evaluation of the SFP structural integrity.

   b) The submittal does not include a discussion of the integrity of the pool liner. Provide a justification for not addressing the integrity of the pool liner, or provide the following information: 1) discuss the analytical approaches or methodologies used, including loading conditions, failure (tear and rupture) criteria, and material properties used including concrete bearing strength, 2) provide a summary of the analytical results in a tabular form, and 3) explain how the plug weld and the interface between the liner and the concrete slab are modeled and what coefficients were used for the contact between the liner plate and the concrete slab.

5. The submittal does not provide a detailed description of the inserts or the controls that will be in place during their installation. The staff requests the following additional information in order to evaluate how the inserts will impact the structural integrity of the racks.

   a) Discuss the "hook and wedge" design used for the inserts. In particular, discuss whether the new design will result in additional forces (static or dynamic) on the flux trap walls, and whether these forces were considered in the evaluation of the racks.

   b) Discuss whether the wedges remain aligned, such that the insert maintains its shape, when the rack deflects during a seismic event.

   c) Discuss the procedure for installing the inserts. Discuss the controls that will be in place to prevent dropping an insert on an irradiated fuel assembly in the Region 3 racks, or discuss the effect of such an event. Discuss the controls that will be in place to prevent damaging the rack or a flux trap in the vicinity of an irradiated fuel assembly, or discuss the effect of such an event.