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Ref. # 10 CFR 52

January 6, 2011

U. S. Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555
ATTN: David B. Matthews, Director
Division of New Reactor Licensing

SUBJECT: COMANCHE PEAK NUCLEAR POWER PLANT, UNITS 3 AND 4
DOCKET NUMBERS 52-034 AND 52-035
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION NO. 5092
(SECTION 3.8.4)

Dear Sir:

Luminant Generation Company LLC (Luminant) submits herein the response to Request for Additional Information (RAI) No. 5092 (CP RAI #185) for the Combined License Application for Comanche Peak Nuclear Power Plant Units 3 and 4. The RAI involves the design of underground tanks.

Should you have any questions regarding this response, please contact Don Woodlan (254-897-6887, Donald.Woodlan@luminant.com) or me.

There are no commitments in this letter.

I state under penalty of perjury that the foregoing is true and correct.

Executed on January 6, 2011.

Sincerely,

Luminant Generation Company LLC

Rafael Flores

Rafael Flores

Attachment: Response to Request for Additional Information No. 5092 (CP RAI #185)

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NRO

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## RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

**Comanche Peak, Units 3 and 4**

**Luminant Generation Company LLC**

**Docket Nos. 52-034 and 52-035**

**RAI NO.: 5092 (CP RAI #185)**

**SRP SECTION: 03.08.04 - Other Seismic Category I Structures**

**QUESTIONS for Structural Engineering Branch 1 (AP1000/EPR Projects) (SEB1)**

**DATE OF RAI ISSUE: 10/25/2010**

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**QUESTION NO.: 03.08.04-86**

This Request for Additional Information (RAI) is necessary for the staff to determine if the application meets the requirements of 10 CFR 50.55a, and Part 50 General Design Criteria (GDC) 2.

In its response to RAI 4542 Question 03.08.04-70 (dated August 9, 2010), Luminant addresses the two parts of the question, Part (a) and Part (b). The answer provided by the Applicant to Part (b) of Question 03.08.04-70 is acceptable. However, the answer to Part (a) is not acceptable. Unlike the structural mass which is independent of the base motion it experiences, the impulsive liquid mass depends on the base motion. More specifically, the distribution of impulsive mass along the height of the tank wall under the horizontal excitation is different from that under the rocking excitation. In the response, the applicant states that NUREG-0800, Standard Review Plan (SRP) 3.7.3 Acceptance Criteria 14 was followed in the analysis, and the analyses use a full three-dimensional model where the vertically acting mass of water is uniformly distributed to the base slab and the horizontally acting impulsive mass of the water is uniformly distributed along the wall height, such that the center of gravity of the impulsive mass is at a height of one-half the water depth. The staff disagrees with the applicant's position. In SRP 3.7.3 Acceptance Criteria 14, the analysis approach that the applicant used is not mentioned. SRP 3.7.3 Acceptance Criteria states that, "Most above-ground fluid-containing vertical tanks do not warrant sophisticated, finite element, fluid-structure interaction analyses for seismic loading." The center of gravity of the impulsive mass depends on the value of liquid height to tank radius ratio. It is not necessary to be at one-half the water depth. Also, the center of gravity of the impulsive mass for the horizontal base excitation is different from that of the rocking base excitation.

The Applicant is requested to provide information that explains how the fluid masses corresponding to the base rocking motion are calculated and included in the model, taking into account the staff's comments cited above.

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**ANSWER:**

The response to this RAI consists of two parts. The first part responds to the center of gravity of the impulsive fluid mass used in the analyses and the second responds to the hydrodynamic modeling for base rocking.

Part 1 – Center of Gravity of Impulsive Fluid Mass

SRP 3.7.3 Acceptance Criteria 14 references NUREG/CR-1161, TID-7024, and ASCE 4-98. According to these documents, the placement of the centroid of the impulsive fluid mass on the walls is at a height of 3/8 of the water depth. The Luminant design-basis analyses placed the impulsive water masses over the entire depth of water resulting in a centroid at approximately 1/2 of the water depth. This placement is typically 3.9 feet higher than the code recommendations and was selected to produce conservative design demands. In general, the demands created by the higher mass placement are conservative or have no effect on the design for the following reasons:

- The response of the cooling towers and pump house are controlled by their primary load path through in-plane shear, and the bulk of these structures is above the water level. The modeling of the impulsive mass elevation will have negligible effect on the primary responses of these structures. The modeling of the impulsive mass elevation can affect the out-of-plane behavior of basin walls.
- The increased elevation of impulsive water mass reduces the modal frequency of the basin walls. However, since all natural frequencies are higher than the frequency of the peak of the input motion, a slight reduction in natural frequency generally results in a higher response.
- Nodal accelerations increase with height along the basin wall; therefore the higher mass placement increases the total global demand on the structure.
- The basin walls are generally supported on three sides with some of the walls having some top support. A higher mass placement produces larger global overturning, and higher in-plane shear demands in the supporting walls.
- The higher mass placement will typically produce higher local bending moment in the walls.
- The UHS basin walls were designed with additional capacity above that required to resist the design demands.

To quantify the demand redistribution and the resulting effect on the structural design, additional confirmatory seismic analyses were performed considering the impulsive mass distributed over a height of 3/4 of the water depth, which represents an impulsive mass centroid located at 3/8 of the water depth. The confirmatory analyses demonstrate that the design-basis distribution of fluid impulsive mass over the full depth of water (impulsive mass centroid located at 1/2 of the water depth) resulted in more conservative flexural and out-of-plane shear demands for large areas of the basin walls. However, at some locations, the confirmatory analyses produced higher demands, particularly out-of-plane shear in lower regions of the walls. For all major walls, the design was reevaluated to verify that adequate design margins remain by adding any increased hydrodynamic demands to the enveloping design-basis demands regardless of the controlling load combination. The reevaluation found that the basin walls contain adequate design margins to resist the increased demands.

Part 2 – Hydrodynamic Modeling for Base Rocking

According to "Rocking Response of Liquid Storage Tanks" by Veletsos et. al. 1987 (Veletsos) a base rocking input motion has a significant effect on distribution of hydrodynamic pressures and effective impulsive mass center of gravity for tall narrow tanks. The analyses performed in (Veletsos) considered a structure rocking about an axis through the tank base, thus producing zero horizontal motion at the base slab and a significant horizontal motion at the water surface. The motion also produced a significant vertical motion away from the rotation axis, but no vertical motion at the centerline.

The SSI analyses use a full three-dimensional structural model supported by the free field soil without nodal constraints and is therefore capable of modeling rocking motion. The extent of SSI-induced rocking for the UHSRS is examined through a comparison of the vertical best-estimate soil 5% damped in-structure response spectra components at node 1, located at the southwest corner of the basin slab, and node 2166, located at the northwest corner of the basin slab. These comparisons are shown in Figure 1 and Figure 2, respectively. Since these locations are at edge corners stiffened by the outer walls, any rocking of the structure due to horizontal input motion is observed as vertical motion of the corner node.

As shown in the figures below, there is very little rocking present in the structure, on the order of 0.02 g peak ground acceleration and nearly zero in the low frequency regions that would excite convective modes. The lack of significant rocking is consistent with the stiff subgrade of this foundation supported on limestone.

Since the UHSRS is not experiencing significant motions representative of base rocking, additional consideration of modeling to capture the effect of base rocking on hydrodynamic pressures is unnecessary.

<u>Reference</u>

Veletsos, AS., and Tang, Y. "Rocking Response of Liquid Storage Tanks." *Journal of Engineering Mechanics*, ASCE, Vol. 113, 17741792, Nov., 1987.

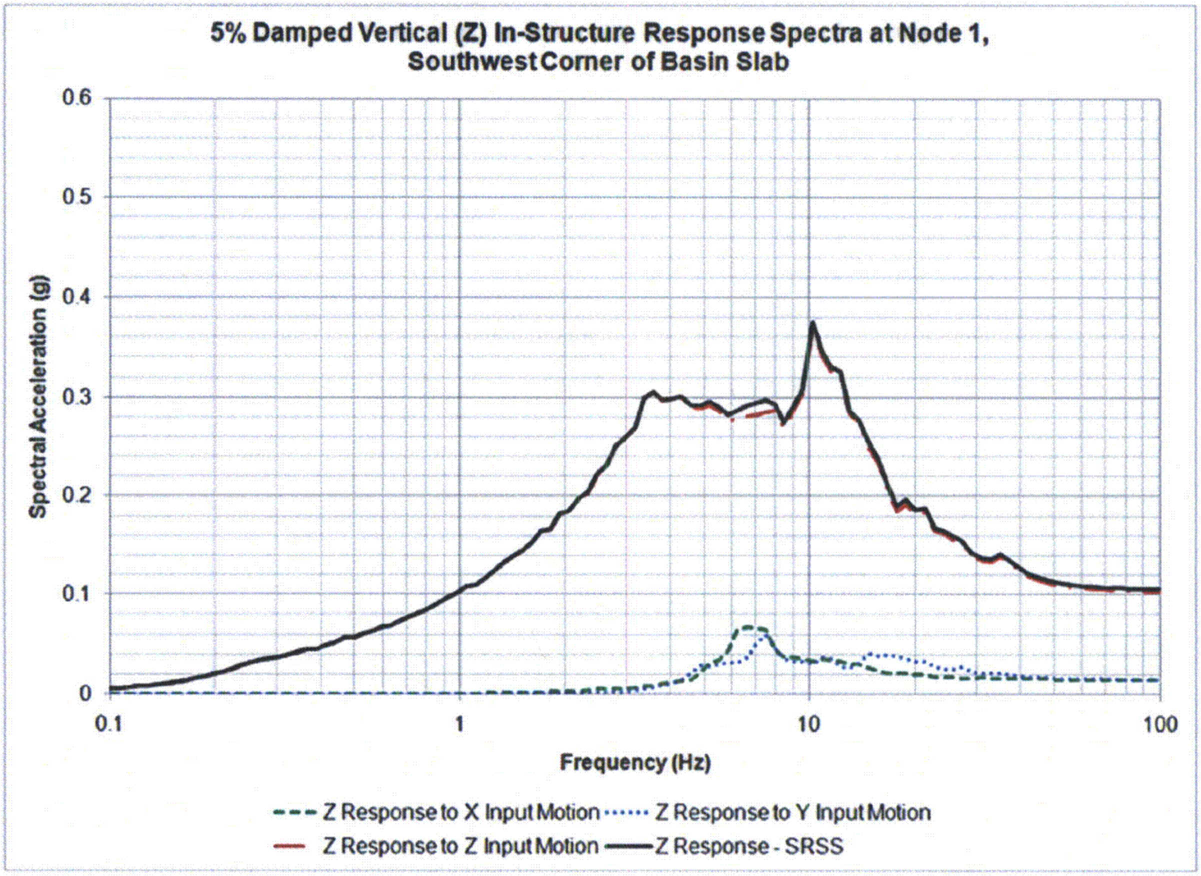


Figure 1

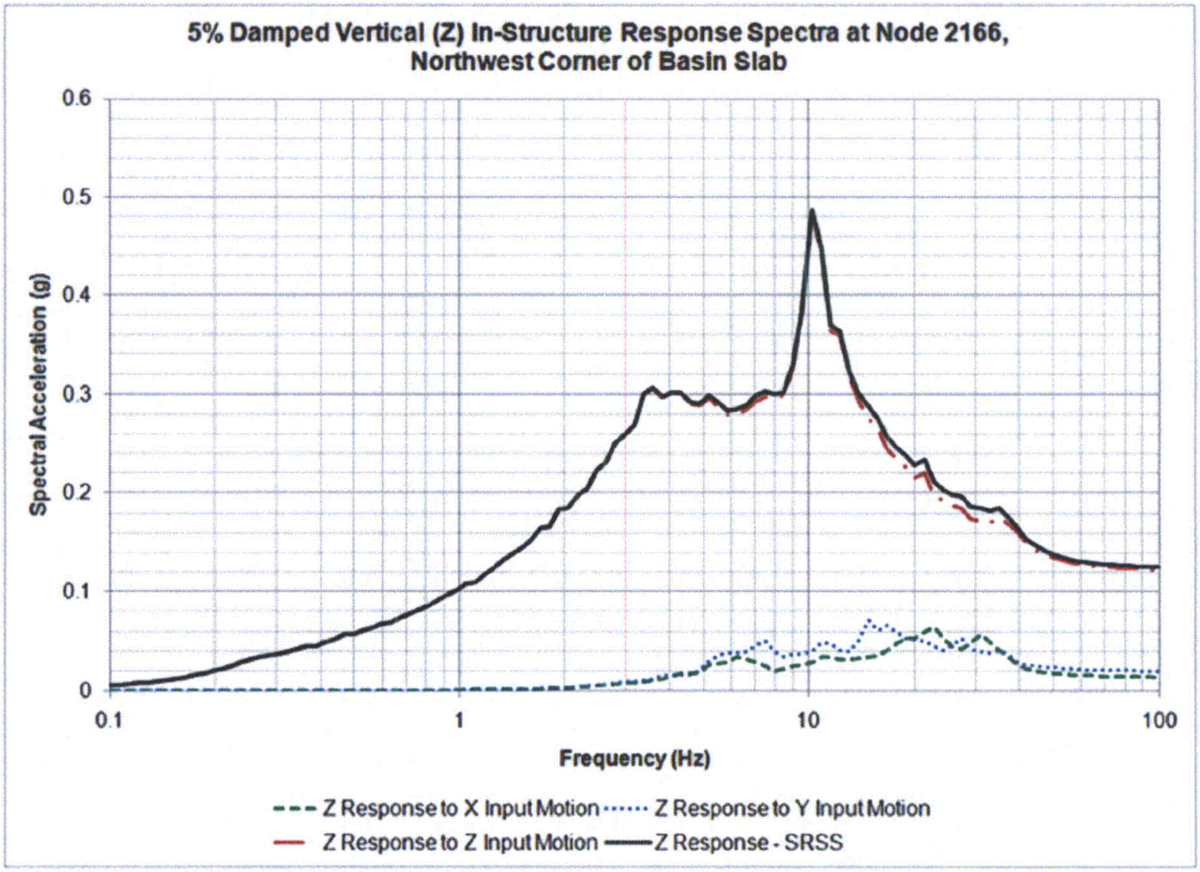


**Figure 2**

Impact on R-COLA

See attached marked-up FSAR Revision 1 page 3KK-6.

Impact on S-COLA

None; this response is site-specific.

Impact on DCD

None.

into rectangular regions to calculate hydrodynamic properties per ACI 350.3-06. The rectangular regions shown in Figure 3KK-4 are chosen since they are bounded by structural walls such that their behavior conforms to the equations derived in the above referenced documents. The key hydrodynamic properties of each region are listed in Table 3KK-7. As indicated in Table 3KK-7, impulsive hydrodynamic mass was modeled over the entire depth of water (which represents an impulsive mass centroid located at 1/2 of the water depth), with the distribution intended to be conservative. Additional confirmatory seismic analyses were performed considering the impulsive mass distributed over a height of 3/4 of the water depth (which represents an impulsive mass centroid located at 3/8 of the water depth) in accordance with documents referenced in SRP 3.7.3 Acceptance Criteria 14 (Reference 3KK-9). The basin walls contain adequate design margins to resist demands considering either impulsive fluid mass distribution. Due to the embedment, squat dimensions, and small intensity base excitations, uplifting of this structure is not considered in the UHSRS model. RCOL2_03.07.03-2 RCOL2_03.08.04-86 RCOL2_03.07.03-2

Following the recommended modeling procedures of ASCE 4-98 (Reference 3KK-3), the water mass within each region is separated into impulsive and convective components ($W_i$ and $W_c$ in Table 3KK-7). The impulsive mass of the water is applied to nodes of walls at each end of the rectangular region, in the direction perpendicular to the wall, and applied uniformly along the walls using directional masses from the bottom of the basin to a height of twice the impulsive pressure distribution ($h_i$, values in Table 3KK-7). The convective mass is included in the analysis using point masses and uni-directional springs which are attached to the end walls of each hydrodynamic region at the height of the convective pressure distribution centroid, hc (see Table 3KK-7). The mass is equal to the convective mass ($W_c$) noted in the attached table and the springs are assigned stiffness such that the mass-spring system has a frequency equal to the convective frequency ($f_c$) noted in the table. Separate mass-spring systems are provided for all hydrodynamic regions. The vertical mass of the water is distributed uniformly across the base mat using directional mass elements. Support flexibility is considered by enveloping demands of a fixed-base model and a model supported on flexible soil springs.

Response spectra analyses are performed in ANSYS (Reference 3KK-2) to obtain seismic design demands, which include all structural and hydrodynamic effects as described above. The impulsive hydrodynamic modes include the basin flexibility directly in the FE analysis. All structural and impulsive modes (frequencies > 1Hz) are assigned 5% damping. The convective modes are assigned 0.5% damping by increasing the input response spectrum for frequencies less than 1 Hz (only includes the convective modes). Modal combination is performed in accordance with RG 1.92 (Reference 3KK-6), using Combination Method B for combination of periodic and rigid modes, using the low frequency correction $\alpha$=0 for frequencies below the peak of the spectra. Periodic modal response is combined using the grouping method. Spatial combination is performed using the Newmark 100-40-40 percent combination rule. RCOL2_03.08.04-32 RCOL2_03.07.03-2

## RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

**Comanche Peak, Units 3 and 4**

**Luminant Generation Company LLC**

**Docket Nos. 52-034 and 52-035**

**RAI NO.: 5092 (CP RAI #185)**

**SRP SECTION: 03.08.04 - Other Seismic Category I Structures**

**QUESTIONS for Structural Engineering Branch 1 (AP1000/EPR Projects) (SEB1)**

**DATE OF RAI ISSUE: 10/25/2010**

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**QUESTION NO.: 03.08.04-87**

This Request for Additional Information (RAI) is necessary for the staff to determine if the application meets the requirements of 10 CFR 50.55a, and Part 50 General Design Criteria (GDC) 2.

In response to the follow-up RAI 4542 Question 03.08.04-74 (dated August 9, 2010), Luminant addressed both parts (b) and (c) of the staff's initial question. The staff considers the response to part (c) of the question to be acceptable. However, the staff finds that the response to part (b) of the question not to be acceptable. In its response to part (b) of the RAI, the applicant states that a discussion of the hydrodynamic fluid modeling and base rocking is provided in its response to Question 03.08.04-70. The staff reviewed the response to Question 03.08.04-70 and considered the response to be not acceptable. As such, the applicant is requested to address the staff's question as stated in RAI 03.08.04-70(b) as it also applies to RAI 03.08.04-74 (b).

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**ANSWER:**

The response to this question is provided in the second part of the response to Question 03.08.04-86 above.

<u>Impact on R-COLA</u>

None.

<u>Impact on S-COLA</u>

None; this response is site-specific.

<u>Impact on DCD</u>

None.

## RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

**Comanche Peak, Units 3 and 4**

**Luminant Generation Company LLC**

**Docket Nos. 52-034 and 52-035**

**RAI NO.: 5092 (CP RAI #185)**

**SRP SECTION: 03.08.04 - Other Seismic Category I Structures**

**QUESTIONS for Structural Engineering Branch 1 (AP1000/EPR Projects) (SEB1)**

**DATE OF RAI ISSUE: 10/25/2010**

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**QUESTION NO.: 03.08.04-88**

This Request for Additional Information (RAI) is necessary for the staff to determine if the application meets the requirements of 10 CFR 50.55a, and part 50 General Design Criteria (GDC) 2.

In its response to RAI 4542 Question 03.08.04-81 (dated August 9, 2010), Luminant provided information supporting their discussion that the frequency of the tank system does not affect the results of the seismic soil-structure interaction (SSI) response. In its response, the applicant states that three additional tank support stiffness cases were performed to compare the original SSI analysis using the rigid tank support. The staff reviewed the applicant results and concluded that the results did not address the question raised by the staff, concerning the rigid beam assumption used for the tank, not the tank support. Thus, the applicant is requested to provide data for the fundamental frequency of the tank filled with fuel to confirm that the assumption of a rigid tank in the SASSI dynamic analysis is acceptable.

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**ANSWER:**

In the response to Question 03.08.04-81, Luminant explained that the tanks have not been selected and therefore modes could not be provided. The fuel tank design will consider fluid-tank modes.

To prepare the response to Question 03.08.04-81, Luminant performed three additional analyses of the tank vault. Each analysis used a different stiffness of tank supports to achieve a frequency match with the

- Peak of the input motion response spectra
- SSI frequency mean soil case
- Peak of base slab response spectra.

Modeling the entire tank-fluid mass at a point and tuning the supports for a specified frequency is intended to have a greater effect on the SSI response than modeling various tank-fluid modes because it forces all the tank mass to act at a single frequency.

Each of these three analyses resulted in an insignificant difference in SSI spectra, demonstrating that the response is not sensitive to the dynamic characteristics of the tank and its supports. This is likely because 1) the tank vault is supported on rock, therefore there are few SSI effects observed in the entire structure, and 2) the tanks in the vaults are not heavy enough to alter the SSI response. Since this method showed no significant SSI effects, no SSI effects would be observed for analyses accounting for the fundamental frequency of the tank filled with liquid fuel, and the assumption of a rigid tank is justified for the SSI analyses.

Impact on R-COLA

None.

Impact on S-COLA

None; this response is site-specific.

Impact on DCD

None.