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February 26, 1982

Docket No.: 50-537

Mr. John R. Longenecker
Licensing and Environmental Coordination
Clinch River Breeder Reactor Plant
U. S. Department of Energy, NE-561
Washington, D.C. 20545

Dear Mr. Longenecker:

SUBJECT: CLINCH RIVER BREEDER REACTOR PLANT, REQUEST FOR ADDITIONAL INFORMATION

As a result of our review of your application for a construction permit for the Clinch River Breeder Reactor Plant, we find that we need additional information in the area of Structural Engineering. Please provide your final responses within sixty days of the receipt of this request.

The reporting and/or recordkeeping requirements contained in this letter affect fewer than ten respondents; therefore, OMP clearance is not required under P.L. 96-511.

If you desire any discussion or clarification of the information requested, please contact R. M. Stark, Project Manager (301) 492-9732.

Sincerely,

Original Signed by
Paul S. Check

Paul S. Check, Director
CRBR Program Office
Office of Nuclear Reactor Regulation

Enclosure:
As stated

cc: Service List

RMS

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DATE	2/26/82	2/ /82	2/26/82	2/26/82			

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STRUCTURAL ENGINEERING REVIEW QUESTIONS (PSAR)
CLINCH RIVER BREEDER REACTOR PLANT (CRBRP)
DOCKET NO. 50-537

CS220.1 — Standard Review Plan Sections 3.3, 3.4, 3.5.3, 3.7, (3.7.1 to 3.7.4) and 3.8 (3.8.1 to 3.8.5) have been revised. Your conformance to the revisions in all of the above mentioned sections of SRP is requested.

CS 220.2 (3.5.4.1, 3.5.4.2) — The revised Petry equation for penetration depth as a function of velocity seems to have been copied incorrectly in that the term in the exponential is dimensionally incorrect and the term V', which is a logarithm, is given with a dimension (the velocity dimension should be incorporated in K). Further the K in the text does not agree with the K in Figure 3.5-1. It is requested that corrections be made. Indicate how you calculate d_m for a noncylindrical or nonspherical projectile?

Also indicate if the wall thicknesses you determined meet the requirements as shown in Table 1 on Page 3.5.3-6 of the revised SRP Section 3.5.

CS 220.3 (3.5.4.5) — On page 3.5-13b ductility ratios for concrete and steel are listed. Some of these ratios are different from those specified in Appendix A to SRP Section 3.5.3. Conformance to SRP Section 3.5.3 ductility ratios is requested unless justification for deviation is provided.

CS220.4 — Seismic design is presented in Section 3.7 supplemented by Appendix 3.7-A. However, a review of the section and its Appendix will reveal that there is quite some repetition in the Appendix of the materials presented in the body of the section.

The Appendix also mentions loads and load combinations which are delineated in Section 3.8. The presentation of the materials in this manner not only consumes effort in preparation by you and in review by the staff unnecessarily, but also may lead to contradiction and confusion. It is therefore proposed that Appendix 3.7-A be revised to eliminate materials which are contained in Sections 3.7 and 3.8.

CS220.5 The major seismic Category I structures of the CRBR plant are supported on a common basemat founded on competent rock with an embedment of 100 ft of back fill. Under such a condition, it appears most appropriate to consider the structures as fixed at the foundation.

The embedment effect can be accounted for by considering the soil-structure interaction between the lateral earth pressure and the structure in contact. The seismic input motion should be applied at the foundation level. The applicant has considered an analysis in which there is soil (rock) structure interaction at foundation level as well as on the lateral side with the seismic input motion applied at the finished grade level. In staff's opinion such an analysis does not represent the realistic condition and the complexity of the analysis as used by the applicant precludes a priori an assessment of the adequacy of the method for staff review. As a resolution of staff's concern it is required that seismic Category I structures, systems and components be designed to seismic effects obtained by enveloping the results of applicant's and the fixed base approach as stated above, or equivalent.

CS220.6 (3.7.1.1) It is stated that for a lumped-mass-spring type of models the seismic design response spectra will be applied at the foundation. The mathematical models as shown in Figures 3.7-16, 3.7-16A, and 3.7-16B are the lumped-mass-spring type. Indicate how the springs and dashpots representing soil are derived from a static finite element model. Provide a description in detail.

Further, the mathematical models in Figures 3.7-16, 3.7-16A, and 3.7-16B lack numerical details. No one could judge the adequacy of plans for a plant model based on the material given on these diagrams. A full discussion with tables should be provided delineating the numbers, their meanings, etc.

CS220.7 In Table 3.7-2A damping values are related to the shear strain values. Indicate how such relations are obtained.

CS220.8 (3.7.1.6) It is stated that the input motions shall be applied at the surface level (finished grade) on an assumed rock outcrop and shall consist of the rock motions used in the analysis of the nuclear island and that no credit shall be given for soil cover on overburden in the deconvolution. Clarify this statement and provide a full discussion on how the analysis will be done.

CS220.9 (3.7.1.6) On page 3.7-3a, you mentioned the backfill of lean concrete and use of compact class A fill for the space between the side of excavation and the plant structure. Discuss the merit of such a fill and how it is considered in your analysis.

CS220.10 (3.7.1.6) In last paragraph on page 3.7-4, you stated that a fixed base approach would be justified. However, in order to account for soil-structure interaction effects, you made a number of simplifying assumptions and also conducted a scoping study to take into account variations in spring constants and damping values. Indicate if you have taken the fixed base condition into consideration in your scoping study since this is more representative of the actual condition.

CS220.11 (3.7.1.6)

a) How different are the vertical translation soil-basemat interaction spring constants calculated from the N.S. direction and the E.W. direction soil foundation interaction models? What physical effects are implied by this difference and how are these effects accounted for elsewhere?

b) On the top of page 3.7-4, the word "rotation" is probably missing from the last sentence of the first paragraph. Was the unit of the rotation applied to an element that was "rigid" by comparison, or by a rigid link method? or perhaps another method?

c) The finite element models in Figures 3.7-21, 3.7-23, and 3.7-24 are labeled "not to scale," yet the element aspect ratios appear reasonable. What are the magnitudes of the average and extreme aspect ratios for these meshes?

d) How are the boundaries of the 2-D plane strain model determined? Provide and justify the criteria used for such determination.

CS220.12 (3.7.2.1) You used the terms geometrical damping and critical damping. However, in Section C.1.2 of Appendix 3.7A, terms such as interaction dumping radiation damping and internal damping are used. Explain in detail the differences in these terms. If two different terms mean the same thing, use one term consistently in order to avoid confusion.

CS220.13 (3.7.2.1) At top of page 3.7-6a, it is indicated that in the model the dome of the steel containment has been idealized using equivalent springs which account for the "breathing" of the dome during a vertical vibration. Explain clearly how through such a lump-mass model "breathing" of the dome can be taken into consideration. Define "breathing."

CS220.14 (3.7.2.1) Two computer programs: HGTHA and VETHA are mentioned. Indicate if these two computer programs are validated in accordance with the procedure described in SRP Section 3.8.1 (P.3.8.1-10).

CS220.15 (3.7.2.1) On page 3.7-8, it is stated that you perform a non-linear time history analysis. Provide more details of such an analysis.

CS220.16 (3.7.2.6)

On page 3.7-9b, it is stated that two methods of combining the seven spectra, one by square root of sum of squares and the other by absolute sum. Indicate the conditions under which each of the methods will be used.

CS220.17 (3.7.2.13)

The discussion on overturning of seismic Category I structure appears to be for a structure on a single foundation mat not on a combined foundation. Indicate what your consideration will be for the overturning of structures on a combined foundation mat. Express with the help of a figure the location of H_1 and the distance h_1 in the equation on page 3.7-10a and the basis of their determination.

CS220.18 (3.7.2.14)

In this section you discussed the analysis procedure for damp ing. Indicate if there is any difference between what you described in this Section and that in Section 3.7.2.1.1 on pages 3.7-5 and 3.7-6. Explain in mathematical forms the following: composite damping, modal damping, proportional damping, and their relationships to the critical damping values as specified in Table 3.7.2, together with the conditions under which they are used.

CS220.19 (3.7.3.11)

In this section it is stated that the response spectra produced will be widened by ±10% by frequency to account for uncertainties in the structural model and input. However, in Section 3.7.1.6 on page 3.7-3, it is stated that the response spectra will be widened by ±15% in frequency. Indicate which percentage of widening is actually used and if its use is in conformance with SRP Section 3.7.2 criteria.

CS220.20 (Appendix 3.7-A)

In Section 6.1 on page 3.7-A.8, your definition of significant dynamic modes is not consistent with that in SRP Section 3.7.2 and should be revised. Further, the sentence before the last sentence in the third paragraph stated that different response spectra will be applied for the particular support location. An explanation should be given to this statement.

CS220.21 (Appendix 3.7-A) In Sections 8.1.1.1 and 8.1.1.2 on page 3.7-A, the listed load combinations contain the term "operating." Define specifically what are the loads included in this term.

CS220.22 There are a number of misprints, unclear statements and typographical errors which need your correction and/or clarification.

a) Section 3.7.1.6 page 3.7-3C misprints in both items 2) and 3).

b) The equation for the damping values β_j in Section 3.7.2.1.1 is in error. (Probably misprint)

c) In Section 3.7.2.6.1 on page 3.7-9, it is stated that each node has three degrees of freedom in the horizontal directions. This is a wrong statement, since each node should have six degrees of freedom. A correction of this statement should be made.

d) Section 3.7.2.7 on page 3.7-9b, the last three sentences need some correction or clarification in order to be understandable.

e) Section 3.7.2.14, misprint in the fourth paragraph.

f) Section 3.7.3.1, in the last sentence, is the word "assured" used for "assumed"?

g) Section 3.7.4.2, next to last paragraph under 1, on page 3.7-17, the word "Time-History."

h) In Table 3.7-5, you used a poisson ratio of 0.3 for both limestone and siltstone. Indicate how this value is obtained and why it is same for both.

i) The Figures 3.7.17D and 3.7.18 have the same title, but it is not clear how they are related. Clarify.

j) Appendix 3.7 in "Attachment A," the equation for a simplified analysis appears to have incorrect units. Also the transformation equations appear to be incorrect.

CS220.23 (3.8.2.1) It is stated to the effect that the steel shell in the lower portion of the containment structure is sandwiched between two concentric concrete walls and neither of the two concrete walls are considered to be part of the containment steel. However, the outside concrete wall is indicated to be designed to prevent the buckling of the steel shell. Indicate what are the design criteria for the two concrete walls, especially the outside concrete wall, and which ACI Code will be used in your design.

CS220.24 (3.8.2.1) The containment description should include basic shell thicknesses and state if the shell is stiffened. The containment vent and purge system should be mentioned in the list of components.

CS220.25 (3.8.2.2) On page 3.8-1, it is stated that ASME Section III Division 1, 1974 Edition with Addenda through winter 1974 and ASME Section III Division 2, 1975 Edition will be used for the design of the steel containment and the steel lined concrete containment foundation mat respectively. Indicate what will be the effect on the design if the latest editions of the ASME Section III Divisions 1 and 2 including Code Case N-284 (1980) are used.

CS220.26 (2.8.2.2.2) It is stated that potential corrosion of the portion of steel containment embedded in concrete as a result of concrete cracking is precluded due to fact that there is a minimum of 22 inches of concrete embedment and the cracking under the worst of cases is minimal. Indicate what size of cracks is expected as a result of the containment structural integrity test. Note that these cracks will terminate at the steel containment shell.

CS220.27 (3.8.2.3.1) The design temperature of 250°F must not apply to the complete containment including that portion embedded in concrete. The PSAR should define the design temperature distribution for the complete containment.

Also the Symbol W used in Table 3.8-1 is not defined in text.

CS220.28 (3.8.2.4) The applicant should substantiate the statement that the con tainment will not be subjected to non-axisymmetric temperature distributions above the operating floor.

CS220.29 (3.8.2.4) Indicate if there are any mechanical connections between the confinement structure and the containment above the operating floor that could transmit mechanical loads. Can the relative displacement between the confinement structure and containment become large enough to allow contact between the containment and components attached to the confinement structure (such as the partition supports)?

CS220.30 (3.8.2.4) The ultimate capacity of the steel containment should be addressed.

CS220.31 (3.8.3.1.3) On page 3.8-10, it is stated that the interior surfaces of the cells are lined with carbon steel plates with the lower portion of the plate designed to contain hot sodium spills. Indicate the difference in the design of the lower and upper portion of the cell lines.

CS220.32 (3.8.3.2.1) It is stated that concrete internal structures will be designed in accordance with ACI 318-77. Since ACI 349," Code Requirements for Nuclear Safety Related Concrete Structures" is specifically for the design of such structures and has been endorsed by NRC in Regulatory Guide 1.142, use of this code is required.

CS220.33 (3.8.3.4) The general structural analysis procedure using the strip method is not totally clear. If possible, the method should be referenced to the ACI-349(76) code. If not, more detail is needed on how the interaction of surrounding cells will be handled when analyzing individual cells. Can significant additive moments be introduced from adjacent cells at a common juncture? Will the method described take into account the high tensile loads developed on the diagonals of two way slabs near the corners?

CS220.34 There are a number of misprints, unclear statements and typographical errors which need your correction and/or clarification.

a) Figure 3.8-9 should label elements discussed in the text (3.8.3.1.1). Details of concrete reinforcing are needed to evaluate the support ledge.

b) Is the load of 50,000 kips mentioned in Section 3.8.3.3.4 to be evenly distributed around the support ledge?

c) The text at the top of page 3.8-16 is generally confusing. In particular, the text seems to negate the need for having both cases 10 and 11. The PSAR should delineate how the appropriate dynamic load factor will be determined. Load combination 10 and 11 need more justification for not including T_a unless A is meant to include thermal effects. In that case, the definition of A in 3.8.3.3.1.4 needs to be changed.

d) In combinations (4) and (8) inclusive in Section 3.8.3.3.10.2.B, are thermal loads to be neglected when it can be shown that they are secondary and self-limiting in nature <u>and</u> or <u>or</u> where the material is ductile?

e) In Section 3.8.3.4, on page 3.8-18, the figure numbers referenced are incorrect.

f) In Section 3.8.3.5.2, more description is needed of the "energy absorption check."

g) In Section 3.8.3.7, if internal structures that are designed to hold more than 10 psig pressure are not to be tested at 1.15 times their design pressure, provide justification for not performing such tests.

h) In Section 3.8.4.4.1, how are equivalent static loads obtained?

i) The Sections 3.8.2.6 and 3.8.2.7 are missing and should be provided. It appears that your Section 3.8.2.5 should be revised.

CS220.35 (Appendix 3.8-A)

a) Code Case N-284 (1980) should be referenced and applied as applicable.

b) The abscissa on Figures 3.8A-1, 3.8A-4, and 3.8A-6 should be labeled R/t and not R/1.

c) Both quadratic and linear interaction curves are used. Most authors recommend using linear interaction curves. Are the nonlinear interaction curves conservative?

d) The R/t range for the containment shell is in a borderline region where either elastic or plastic buckling could occur. For fabricated shells of this type, imperfections can greatly influence the elastic buckling loads. Also, plastic buckling can be influenced by large residual stresses that can be present. For these reasons the factors of safety given in Table 3.8A-2 seem to be low. Please justify these factors.

e) How will buckling be evaluated for dynamic loads?

CS220.36 (Appendix 3.8-B)

a) Corrosion effect is included by reducing the plate thickness by 1/16 in. (3.1.1.5). Is it possible that liner corrosion could introduce local flaws that would not reduce overall stiffness but introduce significant stress concentration points?

b) Handling the corrosion by reducing plate thickness gives a lower stiffness. However, could the stiffness reduction erroneously give thermal stresses that are too low? Generally, the more flexible the structure, the lower the thermal stresses.

c) Near very stiff areas on the liner boundary, for instance close to the pipe penetrations, the neighboring structure will have to exhibit considerable "give" or the liner attachment to anchors could be over stressed (Reference Figure 3A.8-8 where a steel anchor is apparently within 3 in. of the penetration collar). This will occur because the liner plate cannot buckle for short, unsupported spans. At what location in the structure will this situation be the worst and what are the shearing forces and displacements at the studs?

d) At the top of page 3A.8-6 an analysis is described in which the panel corners at the stud anchors are assumed to be rigidly supported. This requires no unbalanced lateral forces on the anchors. If all panel sections buckle in the same direction this assumption is good. However, especially in the case of flat liner plates, the most probable buckling pattern may involve a shape where adjacent panels alternately buckle in and out. Has this case been analyzed and are the resulting shear loads in the panel at anchor attachment points acceptable?

e) In all analyses presented, uniform temperature distributions over the liners are assumed. Are these areas where this assumption is not valid? If so, are the stresses generated acceptable? Unequal thermal expansion on either side of a stud could generate considerable lateral force on the stud.

f) When the liner buckles and bears against the insulating concrete, considerable tensile loads are generated in the studs. If the studs don't give, the liner could fail in a shearing mode at the stud connection. Has this possibility been evaluated? If so, what are the results?

CS220.37 (CRBRP-3, Vol. 2)

a) Table 3-14 gives results for a submerged liner without creep. The applicant should quantify how much actual strains are reduced when creep is taken into account. Does the applicant really mean creep, or is stress relaxation a more appropriate term? Under conditions of creep, will the ultimate strain capability of the liner material change significantly?

b) In Section C.3.4.4, the applicant proposes to use "von Mises effective strain" for the liner failure criterion. Keeping in mind that the strain is not necessarily linearly related to stress beyond yield, a rigorous definition of what "von Mises strain" means beyond the yield point is needed.

Ultimate strength is often used to predict failure when the facture mode is known to be simple cohesive failure. For general ductile fracture, especially when shear fracture is a strong possibility, maximum shear stress is a preferred failure criterion. The liner can be expected to develop considerable shear stresses, especially near the anchor studs.

Considering the above comments, what is the justification for using "von Mises strain" as the failure criterion? Should maximum shear stresses also be considered?

CS220.38 During the TMBDB accident scenario several modes of failure for concrete internal structures are considered. One of these is termed "section failure" and occurs when the moment capacity of a section is exceeded (for example, the floor of a pipeway cell). This failure mode involves large displacements (rotations) and therefore could result in failing the cell liner allowing additional sodium-concrete interaction.

The applicant has provided information showing that such section failures do not occur before TMBDB requirements are met. Additional details should be provided to show how close these internal structures come to failure as the TMBDB scenario progresses. Rates at which failure is approached and times that failure is expected should also be provided. This should be done for all critical sections. This is particuarly important because no factor of safety is applied to the section failure capacities.

CS220.39 Information detailing the current version of the MPHI computer code must be provided along with benchmark information for validation of the code and its use in this particular application.

CS220.40 a) The applicant needs to determine the most likely buckling mode for the cell liner. If the shear symmetric mode is expected, local stresses near stud anchors must be evaluated to determine shear stress state and provided in the PSAR.

b) Evaluate the effects of pre-existing cracks and of cracks generated during the life of the plant; discuss possible propagation of these cracks in the liner.

c) In addition to the nonuniform temperature distribution in liner to be considered, (Ref. Question 220.36e) the response to a shallow pool spill (for instance localized in a very stiff area such as a corner) should be evaluated.

CS220.41 The portion of containment at cells that experience pressures over 10 psig may have to be qualified as ASME Section III, Division 2 concrete pressure vessels because the concrete is relied upon to carry a portion of the pressure load, unless applicant can justify his position in the PSAR.

CS220.42 The applicant has performed bounding seismic response calculations by using "soft" and "stiff" soil springs. The applicant is required to show that intermediate values of soil stiffness will not increase the response levels. This could be shown by comparing modal frequencies of major contributing modes to the response spectrum.

CS220.43 a) The applicant used a finite element axisymmetric structural computer code to evaluate containment buckling from thermal stresses derived from other analysis. This is probably inappropriate because of the short wave length (load wrinkling effects) actually expected from thermal stresses in the shell. This local buckling result must be reconsidered in the applicant's evaluation of the containment shell in the PSAR.

b) The applicant must consider the torospherical wrinkling caused by internal pressure in their containment evaluation in the PSAR.

c) The applicant has not evaluated buckling of large openings and buckling near local penetrations in the PSAR. We require this analysis be included.

d) Provide a discussion on your analysis of the containment buckling in the region adjacent to polar crane support.

CS220.44 We require additional detail for the reactor vessel support ring before evaluating that structure. In particular, the means for transferring load from the ring to primary concrete structure needs to be provided. The applicant should also provide their analysis of this load transfer path and the predicted safety margin.

CS220.45 From your presentation on seismic analysis it appears that in your mathematical model, you used the 2-D finite element analysis to derive the spring constants for soil and used damping values on the basis of half space theory. The staff has reservations in such an analysis approach and your justification for such an approach is requested.