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MEMORANDUM FOR: Brian W. Sheron, Chief
Reactor Systems Branch
Division of Systems Integration

FROM: George E. Lear, Chief
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Division of Engineering

SUBJECT: REVIEW OF THE GESSAR - II INTERNAL EVENT PRA

In response to your request for assistance in performing containment structural integrity review of the GESSAR - II internal PRA per a note from B. Hardin to D. Jeng dated August 2, 1983, we have completed the review of Appendix G to the GESSAR Standard Safety Analysis Report (SSAR). Our review questions are listed in the enclosure. The review was performed by S. Chan and K. Leu of Structural Engineering Section A of the Structural and Geotechnical Engineering Branch (SGEB).

George E. Lear, Chief
Structural and Geotechnical
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Enclosure: As stated

cc: W. Butler
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ENCLOSURE

GESSAR - II PRA REVIEW
QUESTIONS ON APPENDIX G - SSAR
STRUCTURAL AND GEOTECHNICAL ENGINEERING BRANCH
STRUCTURAL ENGINEERING SECTION A

1. The ultimate capacity calculations by GE for the steel containment based on limit analysis using the ultimate strength of SA 516 grade 70 steel may be questionable. Please provide justification for such an approach.

2. The discussion on fracture, especially in weldments is not presented in a manner that could be evaluated. The contention that cracks will develop only when stresses are between yield and ultimate strengths should be justified.

3. The use of Equation G.8.25 for calculation of buckling of the knuckle region geometry should be justified. It is also not clear how thermal effects are factored into the calculation.

4. In reviewing the pressure time curves for hydrogen detonation (i.e., Fig. G.10-1) with the BNL accident analysis group, we were told that the figure may not represent the time pressure phenomenon accurately. Any impact due to the inaccuracy of the time pressure phenomenon on the containment capacity should be further assessed.

5. The use of dynamic load factors to represent the dynamic effects of H_2 detonation in the analysis of complex structural systems undergoing large plastic deformations is questionable. Provide a discussion to justify such a usage.

6. PP.597: The loss of integrity has been assumed to occur when either the ultimate tensile strength in the high stress region is reached or cracks develop. Reasons for not using other criteria, e.g., maximum strain in the steel containment, are not given. Please discuss the basis for not using other failure criteria.

7. PP.600: Details of determining the crack size in concrete (1/4 in. width) are not provided. Provide the basis for the crack size determination.

8. PP.607: Temperature range that was considered in the analysis has not been identified. Please identify the range and the basis thereof.

9. PP. 609: Details of stress calculations in the knuckle region (Table G.2-1) are not given. Provide details of the stress calculation.

10. PP. 609: Formula for σ_x in the column for P_m should be pr/2h instead of pr/h. In the same column σ_θ should be replaced by σ_ϕ.

11. PP. 610: Is the radius of the containment really 80 ft. as shown in Figure G.2-1? If not, provide the correct radius of the containment.

12. PP. 611: The ring-stiffeners and the crane-girder used in the finite element model (Figure G.2-2) are not described in the report. Please describe these items in sufficient detail for use in analysis.

13. PP. 616: The calculations for P_m in Region 4, and for $P_L + P_b$ in Regions 1, 3 and 4 need to be clarified.

14. PP. 619: It is not clear what the compatibility condition (Eq. G.4-3) represents. Provide a discussion.

15. PP. 620: Details of the pressure carrying capability of the ECCS lines are not given. Please provide a more detailed discussion.

16. PP. 655: The details of the calculation for $\bar{p} = 1.056 \times 10^{-3}$ should be provided.

17. PP. 655 & 656: The notation used in Eq. G.9-2 is not consistent with Eq. G.9-3. In my opinion, in Eq. G.9-2, $F_z(s)$ should be replaced by $f_z(s)$ and x should be replaced by s.

18. PP. 656: How was the expression for the ultimate moment [i.e., 1.5 Mo + (S_{ult}/Sy - 1) Mo] derived?

19. PP. 656: What do the cases A, B and C represent? Please explain.

20. PP. 659: What is the basis for X = 51 psig shown in Fig. G.9-1? Please provide a justification.

21. PP. 659: What is the definition of "normal deviation" in Fig. G.9-1 and Fig. G.9-2?

22. How does the Appendix G fit into PRA analysis? How are the results of Appendix G utilized in PRA? What specific end products of Appendix G are required by PRA?

23. Provide bases and calculations that backed up the results of pressure capabilities listed in Tables G.1-1 and G.1-2. Also explain how the conclusion that "when the applied internal pressure is 58.5 psig, the probability of containment dome loss of integrity is 50%" is arrived at.

24. Provide background information of the ASHSD computer program (Ref. G.2-1). Can this program, which is based on axisymmetrical finite element shell model, be used for non-axisymmetrical loading? If yes, please explain how it is achieved.

25. Indicate the significance and location where various stresses listed in Table G.2-1 occurred, such as P_m, P_l, P_b, Q, etc.

26. At the lower portion of containment shell the 8' concrete shell has been treated as "thin" shell (Equations G.4-2 and G.4-3). What magnitude of error has been introduced by this assumption? compare the calculated capability pressure of 74.9 psi (p. 15.D.3-619) with the calculation of the stress in the steel shell when the concrete wall is treated as thick shell.

27. Typographical error on p. 15.D.3-638? Unit of σ_θ should be in psi and not the reciprocal of psi.

28. NE 3133 of ASME Section III code consists of design formulas and procedures for shells under external pressure. It is not clear what is meant by "the buckling criteria given in NE 3133." (p. 15.D.3-638).

29. It is not clear how the failure mode of maximum shear be considered. It is mentioned in Section G.2, but not in G.8.

30. Define X_m in Eq. G.8.10 and P_{cr} in Eq. G.8.25. Is Q in Eq. G-.8.4 transverse shear or in-plane shear? There are mixed-ups of notations in App. G: σ has been used for stress and standard deviations; P for pressure, load, and probability; and stress can be σ, S, or f.

31. What is the relation between :loss of integrity and "failure"? What is the difference between "fracture" and "crack"? What is "plastic yield"? Is it something different from "yield" or "elastic yield"?

32. What are the bases of making the following assumptions?

    a. Structural capability depends only on geometrical dimension and yield strength of material.

    b. Normal distribution of probability of yield and ultimate strength at testing.

    c. Probability of developing cracks varies linearly between S_y and S_{ult}.

    d. Only $\sigma_x = 0.1\,\bar{X}$ and $\sigma_x = 0.15\,\bar{x}$ are considered.

33. What is the physical significance that DLF is less than 1? Should it be required that static load be used when DLF is less than 1 such as the case indicated in Table G.10-5?

34. Describe how and why does a local detonation affect the structural response (e.g., location and distribution of the pressure pulse, shock wave propagation and refraction/reflection, thermal effects) and how are the dynamic load factors obtained. Indicate locations of potential failures in containment or at drywell and the probability corresponding to each failure.

35. In assessing the response to non-condensible gas generation or to local and global hydrogen combustion, it is stated that loss of containment integrity would eventually occur in the torispherical dome region (15.D.3-661, 662). What are the physical failure boundaries? How would it affect the release of radioactive material to the environment?

36. If the pressure-carrying capability in the torispherical region is significantly higher than that predicted by the analysis, what would be the worst impact on steel containment due to a hydrogen detonation?