Docket No. STN 50-605 November 28, 1989

Patrick W. Marriott, Manager
Licensing & Consulting Services
GE Nuclear Energy
General Electric Company
175 Curtner Avenue
San Jose, California 95125

Dear Mr. Marriott:

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION REGARDING THE GENERAL ELECTRIC COMPANY APPLICATION FOR CERTIFICATION OF THE ABWR DESIGN

In our review of your application for certification of your Advanced Boiling Water Reactor Design (ABWR), we have identified a need for additional information. Our request for additional information, contained in the enclosure, addresses the severe accident review information provided in Appendix 19D of your ABWR SSAR.

In order for us to maintain the ABWR review schedule, we request that you provide your responses to this request by January 8, 1990. If you have any concerns regarding this request please call me on (301)492-1104.

Sincerely,

/s/

Dino C. Scaletti, Project Manager
Standardization and Life
Extension Project Directorate
Division of Reactor Projects - III, IV, V and Special Projects
Office of Nuclear Reactor Regulation

Enclosure:
As stated

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ENCLOSURE

REQUEST FOR ADDITIONAL INFORMATION
ABWR SSAR APPENDIX 19D

1. In most of the currently available BWR PRAs, the loss of offsite power sequence with successful recovery of offsite power within 30 minutes (i.e., TM sequence in Fig. 19D.4-4) is transferred to the MSIV closure (i.e., isolation events) event tree. Please provide the basis for transferring it to the reactor shutdown tree (i.e., Fig. 19D.4-1) instead.

2. Should not the event tree top event, Q (Feedwater), appearing in the reactor shutdown event tree (Fig. 19D.4-1) be replaced by "Feedwater and PCS"? Otherwise, a branch should be added to the uppermost sequence (with an end state of OK) to determine the success or failure of the top event, W. Note that condenser problems (hardware or others) can lead to a manual shutdown.

3. Please provide the basis of not crediting automatic depressurization for the safety function, X, in the reactor shutdown event tree (Fig. 19D.4-1).

4. Does ABWR have a design feature which allows the operator to utilize RCIC in steam condensing mode to transfer reactor decay heat to the ultimate heat sink? If yes, why is no credit given to such a feature in evaluating the safety function W (containment heat removal).

5. In essentially all of the event trees shown in Fig. 19D.4-1 through Fig. 19D.4-14, failure of the W function (long-term heat removal) is assigned a probability of failing to run RHRA or RHRB or RHRC rather than failing to start and run RHRA or RHRB or RHRC, if the preceding V function (RHR injection or condenser) is a success. This would be correct if one of the RHR pumps was successfully started and run to accomplish the mission of the V function, and then switched to a long-term heat removal mode. Note, however, that success of the V function can also be achieved, as indicated in Table 19.3-2, by using one condenser pump and one condenser transfer pump. In such a case, the approach taken in the ABWR FSR will underestimate the failure probability of W since the RHR pump has to be started and then run throughout the mission time. Also, can one low pressure RHR pump alone always accomplish the missions of both the V and the W functions for all the transients including a large LOCA?

6. In both the non-isolation event tree (Fig. 19D.4-2) and the isolation/loss of feedwater event tree (Fig. 19D.4-3), the uppermost sequence (with an end-state of OK) should branch out at the top event, W, since success of Q (feedwater) alone does not automatically warrant success of W. The same comment also applies to the IORV event tree (Fig. 19D.4-11).

7. In Table 19D.4-1 through Table 19D.4-17, the branch-point value of the safety function V (LPFLA or LPFLB or LPFLC available) was assigned a value of 1.27E-02, with the source of the data given as Table 19D.4-1. No such data, however, can be found in Table 19D.4-1. Also, for the loss of offsite power event trees, failure of V (LPFLA or LPFLB or LPFLC or one condensate and one condensate transfer pump) is given a value of 7.37E-03. Again, no such data can be found in the tables. Please explain how these values were calculated.

8. For isolation/loss of feedwater events, successful RHR operation using the PCS requires reopening of the MSIVs and the recovery of feedwater if it is initially lost. In Fig. 19D.4-3, which event tree top event takes into consideration the reopening of MSIVs? Also, will the chance of reopening the MSIVs be smaller if there are stuck-open SRVs?

9. In the loss of offsite power and station blackout event tree (Fig. 19D.4-4), the probability of failing all three diesel generators (7.99E-04) is used to sort out station blackout sequences (i.e., BE2, BE8, and BE0) from the loss of offsite power sequences (i.e., TE2, TE8, and TE0). Note, however, that "all DG not fail" could mean: (1) one DG is available, (2) two DGs are available, or (3) all three DGs are available. In Figs. 19D.4-5 and 19D.4-6, the unavailability of Uh (HPCF B or C with a probability of 4.52E-03) was computed based on the assumption that two diesel generators are available. If only one DG is available at the onset of loss of offsite power, this unavailability could become larger. It appears that some kind of weight-averaging should be applied to modify this value based on the probabilities of having either one or two DGs when the loss of offsite power occurs. Also, in Fig. 19D.4-4, the failure probability of opening SRVs following an ATWS event was taken to be 1.0E-06. For ATWS events, a large number (15) of SRVs need to be opened for pressure relief, and, hence, the failure probability of opening the required number of SRVs can be expected to be larger.

10. In 11 of the loss of offsite power event trees (Figs. 19D.4-5, 4-6, and 4-7), the failure probability of HPCF (Uh) is taken to be the same irrespective of the offsite power recovery time and regardless of whether there are stuck-open SRVs. Can the heating up of suppression pool for a prolonged period of time due to stuck-open SRVs adversely affect the availability of HPCF?

11. Please provide the basis of not considering stuck-open SRVs in the station blackout event tree (BE2, Fig. 19D.4-8).

12. In the same event tree cited above (item 11), the failure probability of W(RHRA or RHRB or RHRC) is taken to be 5.19E-04, which does not correspond to that (1.58E-03) shown in Table 19D.4-1 for the case of loss of offsite power. Are the values shown in the column under the heading of "Loss of Offsite Power" in Table 19D.4-1 also applicable to station blackout? If not, please explain.

13. In the station blackout event tree (BE8, Fig. 19D.4-9), why does the sequence with success of RCIC need to be branched out for testing the success of HPCF? According to the success criteria listed in Table 19.3-2, successful core cooling using a high pressure system can be achieved by using either RCIC or one train of HPCF for all transients including loss of offsite power. Furthermore, both HPCF and LPFL require ac power which, in this case, is not available for nearly 8 hours. Please explain why both HPCF and LPFL are included as event tree top events.

14. For IORV transients, there is no immediate automatic scram signal, and the operator may be required to manually scram the reactor and start the makeup system before the suppression pool temperature exceeds the heat capacity temperature limit. Please provide the basis of not including "timely manual scram" as an event tree top event in the IORV event tree (Fig. 19D.4-11).

15. Please explain why feedwater (Q) was not credited as a viable means of core cooling in the small LOCA event tree (Fig. 19D.4-12). Note that, according to the success criteria shown in Table 19.3-2, feedwater can be used to successfully cool the core in the event of a small steam LOCA.

16. Please explain why HPCF is given credit in the large LOCA event tree (Fig. 19D.4-14) despite the high degree of depressurization caused by the large LOCA.

17. Please provide justification of not considering vapor suppression in the large LOCA event tree.

18. In constructing the ATWS event tree (Fig. 19D.4-15), no distinction was made between ATWS events with MSIV closure (isolation) and those with bypass available (non-isolation), although the former is generally more severe and limiting. Please explain why the same branch-point probabilities were used in quantifying the ATWS sequence frequencies despite differences in the success criteria, such as the time available for the operator to inhibit ADS or the unavailability of normal heat removal system for containment heat removal (see Table 19.3-3).

19. It appears that the low core-damage frequency (9.1E-09/RY) found for ATWS sequences is mainly driven by the low initiating event frequency (9.34E-09/RY), which was obtained by taking scram failure probability (C) to be 1.0E-08. Please explain in detail how this scram failure probability was calculated. From the fault tree developed for a single control rod drive (Fig. 19D.6-17a, Figure 1), the probability of failure to insert an individual control rod can be estimated to be roughly 3.0E-06. No explanation, however, is given as to how this probability is used to generate the probabilities of the basic events shown in the fault tree of control rod drive system (Fig. 19D.6-19a, Figure 1). Also, no probability data is given for the event RPS (RPS fails to initiate scram) appearing in the fault trees for reactivity control (Fig. 19D.6-16b).

20. In Table 19.3-3, the time available for the operator to initiate one train of SLC is given to be 10 minutes for both isolation and non-isolation ATWS events. Should not the time available for the former be shorter because the suppression pool is heated up sooner?

21. For an ATWS event which is initiated or accompanied by closure of all MSIVs or loss of condenser, can adequate core coolant inventory be maintained by RCIC alone (as indicated in Table 19.3-3)? For some BWRs of current design, such an event requires HPCI or a combination of HPCI and RCIC.

22. In quantifying ATWS sequence frequencies, the same branch-point value was used for W (containment heat removal) regardless of whether there are stuck-open SRVs. Was suppression pool heating due to stuck-open SRVs taken into account in estimating the failure probability of W?

23. Is there any reason why the event tree top event "ADS inhibit" in the ATWS event tree is placed before "Feedwater or HPCF" and "RCIC" although it appears more logically correct to place it after the latter top events?

24. Was any functional event tree or fault tree developed to analyze the unavailability of feedwater, condensate, and condenser system? How was the unavailability of feedwater (Q), for example, evaluated for different transient initiators?

25. In the event tree quantifications, the frequency of a particular accident sequence was obtained by multiplying together the initiating event frequency and the branch-point probabilities of the failed safety functions, such as U, V, or W, appearing in the sequence description. This approach is proper if the branch point probabilities were evaluated by properly accounting for the common-mode failures among the event tree top events by linking together the relevant fault trees. Were these fault tree linkings done in the ABWR analyses to obtain the upper-bound of minimal cut sets for safety function failures, such as UV, QUV, or UVW? If not, please explain how the branch-point probabilities were calculated for the individual safety functions, such as U, V, or W.

26. Were all the system failure probabilities (except for RCIC) listed in Table 19D.4-1 obtained by quantifying the fault trees shown in Section 19.D.6? Were the probabilities of failing all ECCS systems computed by linking the high pressure and low pressure system fault trees? If so, which mode of the low pressure system was used? Also, were these values actually used in the event tree quantifications?

27. Were the fault trees for the support systems, such as electric power system, service water system and instrumentation system, individually quantified? Are the results of such fault tree quantifications (in terms of minimal cut sets) available for comparison with BNL calculations?

28. What modifications to the fault tree input data were made to obtain the system failure probabilities corresponding to loss of offsite power (last column of Table 19.D.4-1)? Was the failure of switchgear taken into consideration when the failure probability of the W function (for example, in Fig. 19.D.4-7) was calculated?

29. Please briefly describe the possible impacts of omitting the development of system fault tree for plant air system on the frontline and the support systems.

30. It was noted that a very small fraction of the failure data shown in Table 19.D.6-2 through 19 D.6-7 are inconsistent with those shown in the relevant fault trees (for example, DIV2MUX, HMV14BHW and HXV032CQ in Table 19 D.6-2). Which values were actually used in the fault tree quantifications?

31. The break areas for the various LOCAs (large, medium, and small) are defined to be significantly larger than those used in, for example, the Limerick PRA. Do the initiating event frequencies used in the event tree quantification reflect these changes in the definition of break sizes?

32. How does the RWCU (reactor water cleanup) system work to remove decay heat? What suction lines are used? What is the heat sink? Does the non-generative heat exchanger have enough capacity to remove decay heat?

33. For RHR shutdown cooling mode, suction is taken from RPV. Where are the points of suction for the three suction lines? Also, where are the discharge points for the core cooling subsystem return lines?

34. Questions on Table 19D.4-1.

(i) What modifications were made to the fault trees to obtain the failure probabilities corresponding to large or medium LOCAs?

(ii) Are the RCIC failure probabilities calculated by quantifying the revised fault trees in Amendment 8?

(iii) What are the failure probabilities corresponding to station blackout?

35. What modifications were made to the fault trees to obtain the core damage frequency corresponding to incorporation of (a) gas turbine generator; and (b) fire system water connection?

36. Following loss of offsite power, feedwater pumps (motor driven) are tripped and MSIVs are likely to be closed. Are the FW pumps or the RWCU pumps connected to DG power source? Is re-opening of MSIVs considered in calculating the probability of NHR for the W function? In other PRAs, feedwater is considered unavailable following LOOP.

37. Class II sequence frequency was calculated to be 4.29E-6. The input to the Class II containment event tree, however, is 2.5E-06. Please explain the difference. Was the CDF for Class II sequences (4.29E-10) obtained by taking 0.01% of 4.29E-06?

38. ATWS transient scenarios vary significantly depending on whether MSIV are closed or whether offsite power is available. How can a single ATWS event tree properly handle all ATWS events of different initiators?

39. In the ATWS event tree, failure to initiate SLCS is given a probability of 0.2 (time available for the operator = 10 min.). A typical value used for this action in most of other BWR PRAs is 0.87 (with time available for the operator = 8 min.). Please explain the difference.

40. In the ATWS event tree, the probability of failing to inhibit ADS is taken to be 0.1. A typical value used in other PRAs is 0.5 if high pressure core injection is a failure, and 0.005 if HPCI is a success. To be able to make such a distinction, the order of the event tree top events for "HPCI" and "failure to inhibit ADS" must be interchanged.

41. For loss of offsite power initiators, stuck open relief valves (SORVs) were considered in Amendment 4, but were eliminated in Amendment 8. Please explain why.

42. For isolation/loss of FW events, the unavailability of feedwater is taken to be 0.43 (= 40%(1) + 60%(0.05)). Is not the value, 0.05, too optimistic for the MSIV closure initiators?

43. In order to expedite the staff's review, please provide a copy of the MAAP code and requisite input information that was used in the ABWR evaluation.

44. Please provide a copy of the magnetic medium containing all system level fault trees and functional level fault trees modeled for all the initiating events applicable to the ABWR.

Back-End PRA

45. Please provide the input files for the MAAP calculations.

46. The probability of containment failure resulting from loss of heat removal is given as 3.4e-6 in Section 19.1.2. However, the frequency of containment structural failure resuling from loss of containment heat removal is given as 2.5e-7 per reactor year in Section 19D.5.12.4. Please clarify.

47. Is the failure pressure of the upper drywell (UDW) head above 500 degrees F independent of the UDW temperature? If it is a function of temperature, please provide the function. Please also provide the leak area for the high temperature failure. Is high temperature failure considered to be P(penetration) or D (drywell head failure) in the release mode from containment when binning the accident sequence?

48. What is the location and sizes of the passive flooders? Please describe the melting process of the passive flooder fuse including the temperature distribution in the fuse. What is the reliability of these flooders? Are there any examples of their use in other indusries?

49. CET for Class IV accidents was not developed because of negligibly low occurence frequencies (Section 19D.5.11.1.). However, CETs for the accident classes with similar or lower frequencies (Classes IB-3 and IIIA) were developed. Please explain.

50. With respect to Firewater Addition (FA)

    a. Is it necessary to have a separate "FA" category for a mitigating feature? It appears that "FA" included in "IV." (e.g., Figures 19E.2-6 describes a sequence of SBRC-FA-DO. However, this sequence is binned as SBRC-IV-DO in CET IB-2, Figure 19D.5-8.) The CETs do not show any sequences with "FA."

    b. It is stated that credit is not taken for firewater (FW) for preventing core damage due to reactivity concerns. However, it appears that FW is credited for some of the core melt arrest in the RPV. Is there any study available regarding the reactivity in a partially damaged core?

    c. How is the firewater addition or spray handled in the CETs? It appears that it is included sometimes in "ARV"(e.g.,Seq.3 of CET IA) and sometimes in "ARC" (e.g., Seq.6 of CET IA-1). Would it not simplify and clarify the CETs if FW is designated as a separate heading? FW appears to play a major role in reducing the release fractions by scrubbing in case of containment failure. (A suppression pool loses its scrubbing function once the vessel fails). Therefore, it is important to know if FW is available for a particular sequence.

51. It is repeatedly stated that corium cools in the LDW after vessel failure by the water which was retained in the lower plenum in many of the accident descriptions. Why did this water not cool corium in the vessel before vessel failure? How much of water is available in this manner? Would accidents progress differently if the water cooled the core in vessel?

52. Questions on Figures 19E.2-2 (Accident Sequence LCLPPFDM)

    a. In Figure C, why does the upper drywell temperature continue to increase throughout the accident?

    b. In Figure E, why does the drywell water level change between the PF opening and the DW head failure?

    c. In Figure B, why does the drywell pressure decrease after water boils away? (The gas temperature does not show any corresponding drop during this period.)

53. Questions on Figures 19E.2-5 (Accident Sequence LCHPPFPH)

a. Figure A shows a pressure drop at about 17 hours. This was explained in the text as being due to the flow of water from the suppression pool into the drywell (A similar phenomenon was shown in Figure 19E.2-11.). Please clarify. It appears that the DW pressure should be higher than the WW pressure during this period. This pressure drop appears to delay the DW head failure by about 10 hours. What impact will this have on the final release fraction?

54. The suppression pool bypass due to stuck open WW-DW vacuum breakers is of concern only for cases involving wetwell venting. Please explain the consequence ratio of 825 used in the equation on Page 19E.2-40. In the same equation, the fire water unavailability of 1.5% was assumed, which is considerably lower than 10% used elsewhere. Please explain.

55. The CET top event "ARC" (core melt arrest in containment) can occur if any of the following conditions exist, RHR is available, or RHR is recovered, or FW is available, or PF operates.

Except for FW, other features are already designated as top events of CETs (CHR,RCH,PF). Is it nessary to have "ARC" as a separate heading? It appears to be duplicative and confusing regarding how "ARC" occured.(It is confusing since some of the top events are operation/availability of systems while some of them are events caused by operation of the same system.)

56. High temperature failure (HTF) occurs if corium is carried to the UDW and no spray is available. Does the probability 0.01 include the probability of both of these occuring? Wouldn't it be clearer if this heading is replaced by "Corium in the UDW" and "Spray available"? (See also Question 18.a)

57. Questions on Class IA/IA.1 and IIIA/IIIA.1 CETs

a. High temperature failure probility is identical whether RHR is available or not in these CETs. However, if RHR is available, the probability to have UDW spray appears to be higher and ,therefore, the probability of high temperature failure smaller. (See the previous question)

b. Why isn't the probability for "ARC Yes" 1.0 when RHR is available (i.e., what does the probability of 1.e-5 represent in Sequence 4 of CETIA?)

c. Sequence 3 of CET IA is binned as ..FSNN. Does this imply that core melt is arrested in the containment due to FW? Why not RHR?

d. How is core melt arrested in the containment without RHR for Sequences 4 and 6? Is this due to FW?

e. What is the basis for the containment failure probability at the time of vessel failure, 0.001, or high temperature failure probability, 0.01? What is the sensitivity of the final consequence to uncertainty in these numbers?

58. Questions on Class IB-1/IB-1.1 and IB-3/IB-3.1 CETs.

a. How is the core melt arrested in the containment for Sequences 2 and 4 of these CETs? Are these probability same for IB-1 a.d IB-3 because they are solely due to FW? b. Why isn't the RHR recovery probability 100% for Sequences 2 and 5 for IB-1?

c. Why is probability of the RHR recovery failure significantly higher for Sequnce 7 than for Sequence 4 in IB-1?

d. Why is the probability of RHR recovery failure 5 times higher for Sequence 4 of IB-3 than Sequence 4 of IB-1, while they remain the same between Sequences 7 of IB-1 and IB3? (Incidentally, the "RCH No" branch probability for Sequence 7 of IB-3 appears to be misprinted. It should be 0.1, not 0.01.)

e. Sequence 7 of IB-1 is binned as PFDH while Sequence 7 of IB1.1 as PSDN. This implies that the consequence of the low pressure vessel failure is more significant than that of high pressure. Please explain. (The same uestion for IB-3.)

59. Questions on Class IB-2 CET.

a. The core damage frequency for this class is not the same as that of Table 19.3-6. Please clarify which is correct.

b. The probability of failure to depressurize the reactor is 3 times lower for Class IB-2 compared to Class IB-1/3 (0.002 vs. 0.006). Is this due to the time available before depressurization? Does this probability depend on how much time is available before the demand of this equipment? (i.e., what action can be taken to improve availability of this equipment before challenge regardless of how much time is available?)

c. Please provide the basis for the "ARV No" branch probability of 0.006 for Sequences 4 to 7 and 0.6 for Sequence 12.

d. Why is the "ARC No" branch probability of Sequence 7 significantly higher for this CET than others (0.05 vs. 0.01)? Why isn't this branch further divided depending on the RHR recovery? (This is done for cases which have even smaller probabilities.)

e. Sequence 6 is binned as FSDH. This is the only place where a sequence is binned as "High" when FW scrubbing is available. Please explain.

f. Why is RHR unavailability significantly lower for Sequence 11 compared to the similar sequences for other CETs(0.01 vs. 0.05 for IA)?

g. Why isn't Sequence 12 further branched like the similar sequences of IB-3.1?

60. Questions on Classes ID and IIID CETs.

a. How is core melt arrested in RPV? Is this solely due to FW? (This branch existed in Amendment 4 which did not have FW.)

b. Why is the probability of RHR recovery failure significantly higher in this CET than in others?

61. Questions on CET II

a. The "CC No" branch fraction is significantly reduced from Amendment 4 to Amendment 8(0.001 from 0.1). Besides the availability of firewater, what else tributed to this reduction?