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Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

ATTENTION: T. R. QUAY

SUBJECT: WESTINGHOUSE RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION ON THE AP600

Dear Mr. Quay:

Enclosed are Westinghouse responses to NRC requests for additional information (RAIs) on the AP600 Design Certification program. Enclosure 1 contains responses to 16 RAI and follow-on questions pertaining to the AP600 Probabilistic Risk Assessment internal flood analysis. These 16 RAIs are related to DSER open items 19.1.3.2-15, and 19.1.3.2-17 through 19.1.3.2-22.

These responses close, from a Westinghouse perspective, the addressed questions and the associated DSER open items. The NRC technical staff should review these responses.

A listing of the NRC requests for additional information responded to in this letter is contained in Attachment A.

Please contact Cynthia L. Haag on (412) 374-4277 if you have any questions concerning this transmittal.

Brian A. McIntyre, Manager
Advanced Plant Safety and Licensing

/nja

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Enclosure

cc: J. Sebrosky, NRC (1 copy of enclosure)
N. Liparulo, Westinghouse (w/o enclosures)

Attachment A to NSD-NRC-96-4856
Enclosed Responses to NRC Requests for Additional Information

Re: Internal Flood Analysis

From NRC letter dated Oct. 18, 1995:
Questions 1 - 7 -- Related to DSER OI 19.1.3.2-15
Question 1 -- Related to DSER OI 19.1.3.2-17
Question 1 -- Related to DSER OI 19.1.3.2-18
Question 1 -- Related to DSER OI 19.1.3.2-19
Question 1 -- Related to DSER OI 19.1.3.2-20
Questions 1& 2 -- Related to DSER OI 19.1.3.2-22

From NRC letter dated March 5, 1996:
Question related to DSER OI 19.1.3.2-21

720.322 -- Related to DSER OI 19.1.3.2-20
720.323 -- Related to DSER OI 19.1.3.2-21

Enclosure 1 to Westinghouse Letter NSD-NRC-96-4856

October 23, 1996

Re: PRA internal flooding analysis question from NRC letter dated October 18, 1995.

RAI Related to DSER Open Item 19.1.3.2-15 (#2900)

1. The PRA includes layout drawings of the containment and auxiliary buildings only. Please include layout drawings of the annex and turbine buildings.

Response:

The turbine building drawings are in the SSAR section 1.2, Figures 1.2-30 through 1.2-34. The annex building drawings are in the SSAR section 1.2, Figures 1.2-23 through 1.2-26.

PRA Revision: NONE

Re: PRA internal flooding analysis question from NRC letter dated October 18, 1995.

RAI Related to DSER Open Item 19.1.3.2-15 (#2901)

2. The potential flooding sources in each area are now given by system name. Please provide the maximum water available from each of these flooding sources. For those areas where credit is taken for mitigation actions or drainage through the drain system, please also provide the assumed break flow rates.

Response:

The specific information needed to determine the maximum amount of water from a flooding source or the flow rates from an assumed break (such as piping layout, pump curves, etc.) is not yet available for all of the systems discussed in the flooding assessment. The flooding assessment used bounding assumptions (such as the design flow through a system, or the pump output at runout) to determine the effects of a broken line. It is expected the Combined License Applicant (COL) will confirm the flooding assessment with the final design by reviewing site specific items as well as any changes in the design since the flooding assessment was performed.

For the flooding assessment performed the auxiliary building and containment building assumptions on flooding heights are based on the information in the SSAR, Section 3.4. In the annex building, level 135'-3", a flow rate of 2000 gpm from the spontaneous double ended rupture of the 8" fire line was assumed to go into the nuclear island. In all cases, conservative, bounding assumptions were used to determine the equipment that would be affected by flooding. For example, the equipment in a room affected by spray or water flow from a flood was assumed to be made inoperable by the flood. Further, if a part of a nonsafety system (except for electrical distribution systems) was affected, the entire system was assumed to become inoperable. This conservative assumption was made to simplify the analysis.

Since the time when the flooding assessment was performed, the fire protection system and the annex building layout for levels 135'-3" and 100' have been revised. As is the purpose of the flooding assessment, the insight gained from the assessment about the effect of the flooding from the assumed spontaneous double ended rupture of the 8" fire main in the annex building was incorporated into the design such that the effects of a flood from this source will be mitigated. The design revision includes a guard pipe (a double wall pipe) and rerouting of some lines to prevent water from the assumed flood source from getting into critical areas. That is, the design was revised to reduce the potential for a break from the fire protection system that would be assumed to cause core damage. This will ensure that the conclusions and insights gained from the flooding assessment are not changed. This design change also makes the core damage frequency determined in the flooding assessment more conservative. Since the design change will make the probability of a fire protection line break in these annex building areas less likely, the probability of core damage caused by such a break is also less likely.

PRA Revision: NONE

Re: PRA internal flooding analysis question from NRC letter dated October 18, 1995.

RAI Related to DSER Open Item 19.1.3.2-15 (#2902)

3. The SSAR (page 9.5-2) indicates that the fire suppression water system must be able to supply a minimum of 500 gpm for fire hoses plus the demand of any automatic sprinkler. Page 56-11 of the PRA states that fire hose stations in the Annex building are assumed to deliver 125 gpm. Please provide an explanation of the difference between these values and if the assumption of a maximum 125 gpm instead of 500 gpm flow rate has an impact on the result of the flooding analysis.

Response:

The flow rate identified in the SSAR, subsection 9.5.1.1.1 is the minimum flow for the entire fire water system. This includes multiple fire hoses. The SSAR also states in subsection 3.4.1.2.2.2 that the flow rate for two fires hoses is 250 gpm. The design can eliminate, and the PRA analyses accounted for, the flow from two fire hose lines at 250 gpm in an area. Therefore, the PRA assumes that each fire hose station can deliver 125 gpm. SSAR Section 3.4 states that the areas in the plant are designed for the potential flooding from fire fighting with two hose stations (250 gpm flow rate). Potential flooding sources with a flow rate of less than 250 gpm were eliminated with respect to their flooding effect, but they were still evaluated for spray effects.

PRA Revision: NONE

Re: PRA internal flooding analysis question from NRC letter dated October 18, 1995.

RAI Related to DSER Open Item 19.1.3.2-15 (#2903)

4. Doors in the AP600 flooding analysis are assumed to remain intact in their normal position (page 56-8). Due to uncertainties in door loading and strengths, and the movement of personnel, this assumption may be optimistic: that is, the door may be open, or fail to remain closed; or the door may be closed, or mistakenly closed by personnel; or due to pressure from the flood water it may not be possible to open or close a door. Please identify the scenarios where the assumption that the doors remain intact in their normal position mitigates the effects of flooding, and justify the assumption that the door will remain intact in that position.

Response:

A door is assumed to remain closed only for those areas in which the door swing is such that the assumed flood waters would push the door in a direction to close it. Credit for flood mitigation is not taken for the ability of a non-water tight door latch to hold a door closed. For non-water tight doors, it is assumed that the flood propagates under the door if it is closed, thus no credit is taken for the closed door.

PRA Revision: NONE

Re: PRA internal flooding analysis question from NRC letter dated October 18, 1995.

RAI Related to DSER Open Item 19.1.3.2-15 (#2904)

5. The Flood Zones and Barriers Plans in the flooding PRA include a '+' symbol indicating "WATER TIGHT FLOOR/ROOF." Please clarify if this indicates that the rooms with that symbol on a given level have a watertight floor, roof, or both. Some cases, assuming that both the floor and roof are water tight, result in inconsistencies between the different level drawings. If such a symbol does not exist for a room, has the possibility of water running through pipe and electrical penetrations between floors been considered?

Response:

Where the "+" symbol indicates a watertight floor, it means that water will not flow through the floor to the areas below that floor. Pipe and cable penetrations in that floor are sealed to prevent any water from penetrating the floor.

The flooding assessment defines roof as the top of the building. The flood zones and barriers drawings in the PRA documentation show the floors and roofs. The roofs are specifically identified on the drawings. Where the "+" symbol indicates a watertight roof, it means that water will not flow through the roof of the building which is over that area. All roofs on the buildings are watertight.

In the rooms where there is no "+", the pipe and electrical penetrations between floors will be designed such that they prevent water from running through the penetrations, although the floor itself may not be watertight.

PRA Revision: NONE

Re: PRA internal flooding analysis question from NRC letter dated October 18, 1995.

RAI Related to DSER Open Item 19.1.3.2-15 (#2905)

6. On page 56-10 of the PRA, "t - Assumptions made about the Annex building," states that in Section 3.4 of the SSAR, no credit is taken for floor drains. In the referenced SSAR section on page 3.4-22, however, floor drains are discussed and credited with routing water away from adjacent rooms. Please clarify this apparent discrepancy and identify what impact, if any, the clarification might have on the PRA analysis.

Response:

The assumption mentioned has been superseded by a later revision of the SSAR, and is now incorrect. The PRA flooding assessment does credit floor drains' ability to mitigate an assumed flood when they are sufficiently large to perform that function and they are in the appropriate position. The areas where the floor drains provide flood mitigation are discussed in the SSAR. Assumption "t" was revised in Revision 8 of the AP600 PRA.

PRA Revision: NONE

Re: PRA internal flooding analysis question from NRC letter dated October 18, 1995.

RAI Related to DSER Open Item 19.1.3.2-15 (#2906)

7. Please justify the assumption that 1" line breaks can be neglected in the flooding analysis.

Response:

In those areas where a break of a 1" line was assumed not to result in submergence, there are drains or other provisions in the area that are designed to safely remove the flow from an assumed break of a 4" line. That is, the areas are designed to mitigate a flood from a 4" line as discussed in the SSAR. A 1" line will have less flow through it than a 4" line in the same system. Thus, a flood from an assumed break of a 1" line is not possible and can be neglected.

PRA Revision: NONE

Re: PRA internal flooding analysis question from NRC letter dated October 18, 1995.

RAI Related to DSER Open Item 19.1.3.2-17 (#2907)

1. The SSAR indicates that the fire suppression water system must be able to supply a minimum of 500 gpm for fire hoses plus the demand of any automatic sprinkler. It further states that there are 2, 2000 gpm rated pumps and that pressure switches are used to start the pumps to maintain full line pressure. When the 8" fire line in Annex Building 135'-3" North Handling Equipment Area Ruptures, two hours is allowed for the security guard and operators to mitigate the event before the 1E DC batteries in Auxiliary Building non-RCA 66'-6" level would fail. Please identify and justify the flow rate used to estimate this 2 hour time interval, and address the sensitivity of these flow rates on the flood induced DC power failure probability.

Response:

The flow rate used was the design flow rate of one fire water pump, 2000 gpm. The flooding assessment performed is sensitive to the flow rate and the calculated core damage frequency would change if the flow rate is increased significantly. But, the plant design (revised after the flooding assessment was performed) reduces the potential of a break in the fire protection line of concern. Thus, the potential for core damage from such a break is reduced to a value that is several orders of magnitude less than what is presented in the PRA internal flooding assessment. Thus, the core damage frequency due to flooding is no longer sensitive to the flow rate from this flood source. If the flooding core damage frequency were to be recalculated based upon the current design, it would be smaller since this scenario would no longer significantly contribute to the core damage frequency.

PRA Revision: NONE

Re: PRA internal flooding analysis question from NRC letter dated October 18, 1995.

RAI Related to DSER Open Item 19.1.3.2-18 (#2908)

1. The assumption that human actions in the control room, credited in the internal events models and thus credited in the flooding analysis, are not seriously impacted by the flood is reasonable. Some human actions credited in the internal event PRA are, however, actions taken outside of the control room. These actions include CCN-MAN02, CVN-MAN04, REG-MAN00, and TCB-MAN02. Please verify that the human actions which are performed outside of the control room are;

   a) not credited in the models used in the flood analysis,
   b) not in an area impacted by the flood if they are used,
   c) or that the impact of flooding on the probability of successfully completing the action, will be negligible.

Response:

The ex-control room actions which were not modeled in the PRA internal flooding analysis are: CCN-MAN02, CVN-MAN04, TCB-MAN02, and CIX-MAN00. The ex-control room action REG-MAN00 was credited in several at-power flooding situations. It is not modeled in any shutdown scenarios. This human action takes place in a room near the steam tunnel.

For at-power flood scenarios 8, 9, 10, 11, 14, 15, 16, and 17, the assumed flooding is not in that area and will not affect the human action. For at-power flood scenarios 1 through 7, and 12 the action REG-MAN00 is not modeled.

For scenario 13, the action REG-MAN00 is modeled. It is not a significant contributor to the core damage frequency, because action is not required unless the compressed air system fails. In the model it is ANDed with the failure probability of the compressed air system, and it is not of significant importance to the core damage frequency obtained in the assessment.

Thus, for all but one of the flooding scenarios, the human action is not credited in the models or is not in an area impacted by the flood. In scenario 13, the human action is not a significant contributor to the core damage frequency.

PRA Revision: NONE

Re: PRA internal flooding analysis question from NRC letter dated October 18, 1995.

RAI Related to DSER Open Item 19.1.3.2-19 (#2909)

1. The flooding CDF was quantified using approximately 2,500 applicable cut sets from the internal events analysis. A flooding event changes the failure probability of many normally reliable components to 1.0, and major changes to the dominant cut sets can be expected. Please provide the results of the final flooding scenarios based on quantification of the original logic models, not on the reduced set of 2,500 cut sets.

Response:

The 2,500 cutsets evaluated contained the equipment significant to the plant operations and having the highest importance to the risk of a core damage event in the plant. It is highly unlikely that there was some equipment that was not included in the 2,500 cutsets that would be failed by a flood, and would prove to be risk significant. It is even more unlikely that insights could be gained by evaluating equipment with an importance that excludes it from the 2,500 cutsets.

PRA Revision: NONE

Re: PRA internal flooding analysis question from NRC letter dated October 18, 1995.

RAI Related to DSER Open Item 19.1.3.2-20 (#2910)

1. Please verify that, when selecting which initiating event to use in Table 56-5 (e.g. scenario 1 vs. 2 ; 3 vs. 4 ; 5 vs. 6 vs. 7 ; etc.), identical component/system failures were used and only the event trees were changed to identify the most conservative IE to use.

   Unlike the scenarios in the selection process above, Scenarios 15 and 16 are quantified using the same initiating event and initiating event frequency, but 15 has a much wider propagation and many more component failures. It is not surprising that sequence 15 has a greater CDF. If 16 is intended to model the partial flood event assuming successful actions to prevent flood propagation to the auxiliary building, it should have a higher initiating event frequency. Please clarify the reason for evaluating both scenarios 15 and 16 in Table 56-5.

Response:

For scenarios 1 vs 2, 3 vs 4, and 5 vs 6 vs 7 the most conservative initiating event was chosen, and the event trees associated with that initiating event were used in the analysis. .

When evaluating the effects of the rupture of the 8" fire main in scenarios 15 and 16, it was conservatively assumed that the water flowing to the 100'-0" level of the annex building would result in a loss of the equipment on that level. Subsequent calculations based on conservative assumptions and engineering judgement showed that the flood height at the 100'-0" level of the annex building would not affect the equipment in this level. To better understand the differences of these scenarios, they were both analyzed to determine if there was any significant difference in the core damage frequency between them. That is, both scenarios 15 and 16 are based upon the same assumed event, but the assumptions and judgements that lead to the effects of the assumed flood are different, leading to different core damage frequency calculations.

PRA Revision: NONE

Re: PRA internal flooding analysis question from NRC letter dated March 5, 1996.

RAI Related to DSER Open Item 19.1.3.2-21 (#3241)

The flooding scenarios in the focused PRA are developed from the scenarios in the base-line flooding PRA. In four of the five scenarios in Table 52-39 the flood damages no safety equipment, the only differences are damage to non-safety equipment. Comparison of the conditional CDF (CCDF) given the initiating event indicate that sequences 1 and 3 have the same CCDF and sequences 2 and 4 have the same CCDF. Since the focused study does not credit non-safety equipment, please explain why all four are not the same (SBO) scenario.

Response:

Scenario 1 models a loss of CCS/SWS event. As with the other focused PRA sensitivity study event tree models, only safety-related systems are modeled. The event tree for the loss of CCS models the failure of one power-operated relief valve (PORV) and one safety valve (as well as other systems).

Scenario 2 models a loss of MFW to both steam generators. As with the other focused PRA sensitivity study event tree models, only safety-related systems are modeled. The event tree models the failure of one PORV and two safety valves. This is a different value than the model in scenario 1.

Scenario 3 models a transient with MFW available. As with the other focused PRA sensitivity study event tree models, only safety-related systems are modeled. The event tree models the failure of one PORV and one safety valve, as is done in scenario 1. This is a different model than is in scenario 2.

Scenario 4 models a loss of the condenser. As with the other focused PRA sensitivity study event tree models, only safety-related systems are modeled. The event tree models the failure of one PORV and two safety valves, as is done in scenario 2. This is a different model than is in scenarios 1 and 3.

The conditional core damage frequencies (CCDFs) in scenarios 1 and 3 are the same because the same safety-related equipment is modeled. This is also true for scenarios 2 and 4. That is, the same safety-related equipment is modeled. But when comparing the models in scenarios 1 and 3 to the models in scenarios 2 and 4, it can be seen that different equipment is modeled (a different number of safety valves), and a different CCDF is derived from those models.

PRA Revision: NONE

Re: PRA internal flooding analysis question from NRC letter dated October 18, 1995.

RAI Related to DSER Open Item 19.1.3.2-22 (#2911)

1. Due in large part to assumed human mitigating actions, the frequency of flooding the non-RCA Auxiliary building 66'-6" level and failing the 24 hour 1E DC batteries is estimated to be 4.4E-08/yr. Since this appears to be the lowest level in the plant, flooding events caused by check valve failures and backflow through the drain system may occur with comparable or higher frequency. Please provide a discussion indicating why drainage to this lowest level is expected to be less frequent than 4E-08/yr.

Response:

The sump line from the auxiliary building 66'-6" level sump to the tanks in the turbine building is not connected to any other lines. Therefore, back flow due to stuck check valves is not possible. The sump line into the turbine building is piped directly into two tanks. A high point vent prevents backflow due to siphoning. The other way to get back flow in this line would be if the turbine building were to flood to a level high enough for the water to flow into the sump line high point vent. The final routing of the sump line will be such that back flow is not possible in the event of turbine building flooding. Thus, the frequency of flooding in that area is expected to be about 4.4E-08/year.

PRA Revision: NONE

Re: PRA internal flooding analysis question from NRC letter dated October 18, 1995.

RAI Related to DSER Open Item 19.1.3.2-22 (#2912)

2. The PRA states that the site is to be chosen such that the annual frequency of occurrence of a flooding event is less then 10E-06 year and thus external flooding need not be evaluated. The staff notes that the 1E DC battery rooms are at 66'-6" (the lowest level) in the non-RCA part of the Auxiliary building. The 1E DC Buses are at 82'-6", one level higher. Grade level is 100' so both areas are below grade. Consequently, extreme measures would be necessary to prevent external flooding from failing all 1E DC and preventing any foreseeable recovery. Chapter 2, Site Characteristics, of the SSAR discusses the 10E-06 per year criteria on page 2-2, but appears to exclude external floods from consideration under this criteria. Floods are discussed separately on page 2-6, where information collection requirements are discussed but no criteria are given. Please explain why an external flood will not lead to "severe consequences", or identify where the maximum acceptable annual frequency of 10E-6 for external floods will be addressed in the AP600 documentation.

Response:

The plant is designed to withstand the maximum probable flood as discussed in the SSAR and defined in the Standard Review Plan (SRP) section 2.4. The discussion in the SSAR about the COL evaluating such events indicates that the COL will evaluate the site for the maximum probable flood based upon the criteria discussed in the SRP. The maximum probable flood is expected to occur with a frequency of 1E-06 or less. Thus, the criteria for the evaluation are described in the SRP and SSAR section 2.

PRA Revision: NONE

Question: 720.322 (#3055)

RAI Related to DSER Open Item 19.1.3.2-20

Westinghouse stated on page 56-43 that normal RHR pipe rupture scenarios are included in the shutdown LOCA analysis and not in the flooding analysis. The staff notes that RHR pipe rupture was the dominant flooding scenario in the AP600 original flooding analysis. Upon review of the shutdown PRA, the staff found that RHR pipe ruptures are analyzed in the shutdown PRA using event trees. The event trees indicate that operation of the passive systems, including gravity injection, is not affected by any rupture of RHR piping. The staff accepts this method for analyzing RHR pipe ruptures, if Westinghouse can verify that passive system operation is not affected by any rupture of RHR piping. Therefore, the staff is asking Westinghouse to:

a. Document in the Shutdown Flooding PRA that passive system operation is not affected by any rupture of RHR piping for both hot/cold shutdown and midloop/vessel flange operation.

b. Document in the Shutdown Flooding PRA that losses of IRWST inventory from containment can not occur as a result of any rupture of RHR piping for both hot/cold shutdown and midloop/vessel flange operation.

Response:

The response to the questions is contained here. It is not considered necessary to repeat this information in the Shutdown Flooding PRA.

a. At shutdown the passive systems that are risk significant are the CMTs (for modes 2 through 4), the passive RHR (for modes 2 through 4), and the IRWST gravity injection with ADS actuation as appropriate (for modes 2 through 5). A rupture of the RNS piping would represent a loss of cooling accident for any of these modes. The passive system response to a loss of cooling accident is CMT injection followed by IRWST gravity injection (with ADS actuation when appropriate), followed by natural recirculation through the recirculation lines. When in mid-loop operations, the IRWST would be the first response, as the CMTs would be isolated.

   The RNS piping is able to withstand the full RCS operating pressure. A spontaneous rupture of the RNS piping is a very unlikely event at the reduced pressures in modes 2 through 5. During mid-loop operations when the pressure is at containment pressure, a spontaneous rupture of the RNS piping is not credible. Nonetheless, a spontaneous rupture of the RNS piping would not prevent operation of the passive injection systems because the RNS lines are not utilized for the safety-related injection function, and the safety-related equipment is protected against the flood that may result from the rupture.

b. When the RNS is aligned to the RCS for cooling, there are two valves blocking the flow path from the IRWST to the RNS. A spontaneous RNS piping rupture will not drain the IRWST in this case.

   If the RNS is aligned to the IRWST, it will be to provide pumped injection into the RCS after ADS actuation (i.e., an accident). Thus, the probability for a RNS pipe rupture after an accident is in the E-10 range. Nonetheless, there are multiple valves available for isolation of such a break, and the large volume of the IRWST available for injection provides a relatively long time for the isolation of the broken line to occur. Even more time would be available for the operators to provide additional water to the IRWST.

PRA Revision: NONE

Question: 720.323 (#3056) -- RAI Related to DSER Open Item 19.1.3.2-20

The flooding scenario following the rupture of the fire water line in Annex Building 135'-3" disables both non-1E dc switchgear rooms, and eventually disables the 1E batteries in the auxiliary building basement if no mitigation is taken. This scenario is included in both the shutdown and at power analyses.

The shutdown analyses stated that the DAS would be failed by the flooding in the switchgear rooms. Distribution panel EDS3-EA-1 (Table 27-4) is included in the failed equipment list. The power analysis stated that the PCS (PLS) would be failed by flooding the switchgear room. Distribution panels EDS1-EA1 and EDS1-EA2 (Table 28-4) are included in the failed equipment list. Thus, it appears that both DAS and PLS will be failed in these flooding sequences.

Since power dependency is explicitly modeled in the logic models the PLS failure due to power failure should be logically included in the requantification. Use of a factor of 100 for scenarios 5 and 6 in the shutdown PRA to account for failures of the DAS and PLS is acceptable, but please identify and explain what values are assigned to the DAS and ALL-IND-FAIL basic events during the evaluation of sequences 15 and 16 in the at-power analysis.

Response:

The failure probability for DAS is consistent throughout all of the models. It is the same in the different sequences and in the shutdown and at-power analyses. The failure probability for ALL-IND-FAIL is similarly used in a consistent manner. The failure probability for DAS is 1E-2 and the failure probability for ALL-IND-FAIL is 1E-6.

The DAS failures were not explicitly modeled in the shutdown sequences quantification. They were approximated by the factor of 100 that is referred to in the RAI. In the at-power quantification, the failures of DAS and PLS were explicitly modeled, with the failure probability of DAS equal to 1E-2 and the failure probability of ALL-IND-FAIL (in the PLS model) equal to 1E-6.

PRA Revision: NONE