Westinghouse Electric Corporation
Energy Systems

Box 355
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ET-NRC-93-3985
NSRA-APSL-93-0386
Docket No.: STN-52-003

October 8, 1993

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

ATTENTION: R. W. BORCHARDT

SUBJECT: WESTINGHOUSE RESPONSES TO NRC REQUESTS FOR ADDITIONAL INFORMATION ON THE AP600

Dear Mr. Borchardt:

Enclosed are three copies of the Westinghouse responses to NRC requests for additional information on the AP600 from your letters of July 8, 1993 and July 19, 1993. This transmittal completes the responses to the July 8, 1993 letter. A listing of the NRC requests for additional information responded to in this letter is contained in Attachment A. Attachment B is a complete listing of the questions associated with the July 8, 1993 letter and the corresponding Westinghouse letters that provided our response.

These responses are also provided as electronic files in WordPerfect 5.1 format with Mr. Hasselberg's copy.

If you have any questions on this material, please contact Mr. Brian A. McIntyre at 412-374-4334.

Brian A. McIntyre / for

Nicholas J. Liparulo, Manager
Nuclear Safety & Regulatory Activities

/nja

Enclosure

cc: B. A. McIntyre - Westinghouse
F. Hasselberg - NRR

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ET-NRC-93-3985
ATTACHMENT A
AP600 RAI RESPONSES
SUBMITTED OCTOBER 8, 1993

| RAI No. | Issue |
|---|---|
| 620.078 | Unique HF issues to passive plant |
| 720.088 | Pipe rupture frequency used for LOCA IEFs |
| 720.092 | PRHR HX tube failure probabilities |

# ATTACHMENT B
# CROSS REFERENCE OF WESTINGHOUSE RAI RESPONSE TRANSMITTALS TO NRC LETTER OF JULY 8,1993

| Question No. | Issue | NRC Letter | Westinghouse Transmittal Date |
|---|---|---|---|
| 620.075 | Implementation guidance for task analysis outputs | 07/08/93 | 10/04/93 |
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Question 620.78

The issues identified in the V&V plan are all of a general nature as would be expected, given the model-based approach used to facilitate issue identification. However, are there any HF issues that relate uniquely to a passive plant in general, or to AP600 in particular? Will any such issues be incorporated into the test program at a future date (Section 18.8)?

Response:

The set of test issues that is described in SSAR Subsection 18.8.2.3 is considered to be comprehensive. Evaluation of the issues and development of the test program has not identified the need to add AP600-specific evaluation issues to the test plan. Differences do exist between current nuclear power plants and the AP600 design. These differences need to be considered in specifying the detailed test program since they affect the selection of test cases and scenarios used in the validation studies.

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- Design-basis events specific to AP600
- Identification of critical human performance actions
- Identification of AP600-specific scenarios that produce cognitive challenges of the sort identified in the test plan that:
  - May complicate situation assessment by providing degraded or conflicting plant state information
  - May complicate response because of multiple conflicting goals
  - May complicate performance by increasing personnel communication/coordination requirements.

The test scenarios will be defined as described in SSAR Subsection 18.8.2.3.

SSAR Revision: NONE

Question 720.88

Justify the pipe rupture frequency that was used to develop the LOCA initiating event frequencies. If the pipe rupture frequencies from the EPRI ALWR Utility Requirements Document are used for the sequence frequencies associated with passive RHR tube ruptures, small and very small LOCAs would increase by a factor of five.

Response:

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*".... The most readily available data base developed independent of WASH-1400 is reported in NUREG/CR-4407. This report was examined in the preparation of the KAG data base, in an attempt to tie the failure rates more specifically to a clearly-defined pipe section. The report surveyed nuclear plants, and reported average lengths of pipe and numbers of welds for different systems in both PWRs and BWRs. Based on the data in NUREG/CR-4407, failure rates were estimated for piping greater than and less than 2", on a per-section basis (defined as a section between major discontinuities but irrespective of length), as follows:*

$$\lambda = [(\text{No. of failures}) / (\text{No. of plant-years} * \text{avg No. of welds per plant})] * [3 \text{ welds per avg section}]$$

*It was thought that this put the data on an approximately equal footing with WASH-1400, and that the two sources could be considered together to provide the failure rates. The failure rates available from the two sources are as follows (all are on a per-hour, per section basis):*

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| *Leak/plug, pipe diameter < 3"* | *8.5E-09* |
| *Rupture*, pipe diameter < 3"* | *4.2E-10* |
| *Leak/plug, pipe diameter > 3"* | *8.5E-10* |
| *Rupture*, pipe diameter > 3"* | *4.2E-11* |

*NUREG/CR-4407*

| | |
|---|---|
| *Leak, pipe diameter < 2"* | *1.4E-09* |
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| | |
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| *Leak/plug, pipe diameter < 3"* | *2.0E-09* |
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**5% of leakage rate, per p.III-78 of WASH-1400.*

***KAG also recommends breakdown according to severity:*
*maximum break, 10 to 30% of total failure rate;*
*large break, 50% of remaining failure rate;*
*small break, residual failure rate.*

*The rationale behind the values in the KAG document is that the failure rates may be lower than those reported in WASH-1400, at least for small pipes, so a value closer to that obtained from NUREG/CR-4407 was chosen. NUREG/CR-4407 did not directly support using a failure rate for larger pipes ten times lower than that for smaller pipes (as was applied in WASH-1400). On the other hand, all of the failures in larger piping reported in the NUREG were very small leaks, so only limited inferences could be made regarding the rate of serious leakage. A lower value was therefore recommended for larger piping in the KAG, although the ratio between the rates for small and large piping was 2.5, instead of 10.*

*To examine further the effects of definition of pipe section on failure rate, the empirical correlation developed by Thomas was applied. This correlation examines data from a number of sources, including WASH-1400, in an attempt to identify the factors that affect failure rate. After normalizing for plant age and service, the rates can be calculated for different sizes and lengths of piping and for different number of welds.... No claim is made that any of these is correct on an absolute basis, or even that the relative differences are correct. This is presented only as an alternative view of data. It should be pointed out, however, that this correlation has been used in several PRAs, especially when it is necessary to characterize the frequency of pipe breaks for assessment of internal flooding. In at least one case (the review of the Oconee PRA), the NRC has found the use of the correlation to be acceptable, although potentially conservative. The conclusions from examining the results ... are as follows:*

- *The size of pipe has very little impact on the rate of failure. This would appear to be borne out by NUREG/CR-4407 results.*
- *The number of welds would not be too important unless there were many in a particular pipe section.*
- *The length of pipe is relatively important, since the failure rate is approximately proportional to the length.*

*A more careful review of NUREG/CR-4407 has been made more recently. It was concluded that any values based on length of pipe or number of welds calculated from that study should be viewed with extreme skepticism....*

*It appears that, without substantial additional effort to supplement the data in NUREG/CR-4407, the failure rates reported in WASH-1400 are still the best available. The following is therefore recommended:*

- *A basic failure rate for leakage from piping of any size of 8.5E-09 /hr per section. This rate applies to all leaks down to very small cracks.*

- *A section is defined as a segment of pipe between major discontinuities (valves, elbows, bends, etc.), up to about 10 ft in length. For straight runs of piping that are of particularly high quality and subject to extraordinary inspection and testing (e.g., reactor coolant pressure boundary) and/or are not subject to severe operating stresses (i.e., operate at relatively low pressures and velocities, carry clean water, etc.), this length may be extended up to about 100 ft, provided there are no discontinuities.*

- *The fraction of this rate corresponding to leakage severe enough to constitute a rupture should be taken as 5%. The 5% value is consistent with both WASH-1400 and Thomas. Of this 5%, 10% should be taken to be essentially a complete break; 30% should be taken to be a large rupture; and the remaining 60% a small rupture. This is the breakdown used in the Oconee PRA, which NRC reviewers found to be acceptable...."*

The basic failure rate 4.25E-10/hr per section [(8.5E-09/hr per section) * (5%)] has been used for evaluation of the AP600 small and very small LOCA initiating event frequencies, as well as for PRHR heat exchanger tube rupture initiating event frequency. Based on the basic failure probability from ALWR Utility Requirements Document, the failure frequency of the PRHR heat exchangers (HXs) is calculated as:

Failure Frequency of PRHR HXs = [1.0E-07/hr per HX] * [8760 hrs/yr] * [2 HXs] = 1.8E-03/yr.

The evaluated frequency of 1.8E-03 is less conservative than the failure frequency of the PRHR heat exchanger tube rupture, 5.0E-03/yr [(4.25E-10/hr per section) * (1342 sections) * (8760 hrs)], used in the AP600 PRA. The recommended frequency for small LOCA, in the ALWR Utility Requirements Document, is 1.0E-03/yr. In the AP600 PRA, the small and very small LOCA initiating event frequencies are 5.2E-04/yr and 5.5E-04/yr, respectively; these frequencies account for 1.0E-03/yr.

The data changes recommended by SAROS have been reviewed and approved by EPRI. These data changes are expected to be incorporated into the next revision of the URD (Revision 6).

PRA Revision: NONE

Question 720.92

Describe how the data bases that were used to develop the failure probability for the PRHR heat exchanger tubes were qualified for the AP600 design.

Response:

The response to RAI 720.88 provides the response for this question.

PRA Revision: NONE

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Unique aspects of the AP600 design are important in the selection of test scenarios that exemplify different cognitive challenges that will be included in the evaluation studies. The specific test scenarios will be selected based on consideration of:

- AP600 specific design features
- Design-basis events specific to AP600
- Identification of critical human performance actions
- Identification of AP600-specific scenarios that produce cognitive challenges of the sort identified in the test plan that:
  - May complicate situation assessment by providing degraded or conflicting plant state information
  - May complicate response because of multiple conflicting goals
  - May complicate performance by increasing personnel communication/coordination requirements.

The test scenarios will be defined as described in SSAR Subsection 18.8.2.3.

SSAR Revision: NONE

Question 720.88

Justify the pipe rupture frequency that was used to develop the LOCA initiating event frequencies. If the pipe rupture frequencies from the EPRI ALWR Utility Requirements Document are used for the sequence frequencies associated with passive RHR tube ruptures, small and very small LOCAs would increase by a factor of five.

Response:

WASH-1400 data for pipe rupture was selected and used in the AP600 PRA. The reason for this selection as discussed in SAROS letter to EPRI, "Key Assumptions and Groundrules Document Recommended Changes to Data Annex," dated March 8, 1991, is as follows:

*".... The most readily available data base developed independent of WASH-1400 is reported in NUREG/CR-4407. This report was examined in the preparation of the KAG data base, in an attempt to tie the failure rates more specifically to a clearly-defined pipe section. The report surveyed nuclear plants, and reported average lengths of pipe and numbers of welds for different systems in both PWRs and BWRs. Based on the data in NUREG/CR-4407, failure rates were estimated for piping greater than and less than 2", on a per-section basis (defined as a section between major discontinuities but irrespective of length), as follows:*

$$\lambda = [(\text{No. of failures}) / (\text{No. of plant-years} * \text{avg No. of welds per plant})] * [3 \text{ welds per avg section}]$$

*It was thought that this put the data on an approximately equal footing with WASH-1400, and that the two sources could be considered together to provide the failure rates. The failure rates available from the two sources are as follows (all are on a per-hour, per section basis):*

*WASH-1400*

| | |
|---|---|
| *Leak/plug, pipe diameter < 3"* | *8.5E-09* |
| *Rupture*, pipe diameter < 3"* | *4.2E-10* |
| *Leak/plug, pipe diameter > 3"* | *8.5E-10* |
| *Rupture*, pipe diameter > 3"* | *4.2E-11* |

*NUREG/CR-4407*

| | |
|---|---|
| *Leak, pipe diameter < 2"* | *1.4E-09* |
| *Leak, pipe diameter > 2"* | *1.4E-09* |

*Current KAG***

| | |
|---|---|
| *Leak/plug, pipe diameter < 3"* | *2.0E-09* |
| *Leak/plug, pipe diameter > 3"* | *8.0E-10* |

**5% of leakage rate, per p.III-78 of WASH-1400.*

***KAG also recommends breakdown according to severity:*
*maximum break, 10 to 30% of total failure rate;*
*large break, 50% of remaining failure rate;*
*small break, residual failure rate.*

*The rationale behind the values in the KAG document is that the failure rates may be lower than those reported in WASH-1400, at least for small pipes, so a value closer to that obtained from NUREG/CR-4407 was chosen. NUREG/CR-4407 did not directly support using a failure rate for larger pipes ten times lower than that for smaller pipes (as was applied in WASH-1400). On the other hand, all of the failures in larger piping reported in the NUREG were very small leaks, so only limited inferences could be made regarding the rate of serious leakage. A lower value was therefore recommended for larger piping in the KAG, although the ratio between the rates for small and large piping was 2.5, instead of 10.*

*To examine further the effects of definition of pipe section on failure rate, the empirical correlation developed by Thomas was applied. This correlation examines data from a number of sources, including WASH-1400, in an attempt to identify the factors that affect failure rate. After normalizing for plant age and service, the rates can be calculated for different sizes and lengths of piping and for different number of welds.... No claim is made that any of these is correct on an absolute basis, or even that the relative differences are correct. This is presented only as an alternative view of data. It should be pointed out, however, that this correlation has been used in several PRAs, especially when it is necessary to characterize the frequency of pipe breaks for assessment of internal flooding. In at least one case (the review of the Oconee PRA), the NRC has found the use of the correlation to be acceptable, although potentially conservative. The conclusions from examining the results ... are as follows:*

- *The size of pipe has very little impact on the rate of failure. This would appear to be borne out by NUREG/CR-4407 results.*
- *The number of welds would not be too important unless there were many in a particular pipe section.*
- *The length of pipe is relatively important, since the failure rate is approximately proportional to the length.*

*A more careful review of NUREG/CR-4407 has been made more recently. It was concluded that any values based on length of pipe or number of welds calculated from that study should be viewed with extreme skepticism....*

*It appears that, without substantial additional effort to supplement the data in NUREG/CR-4407, the failure rates reported in WASH-1400 are still the best available. The following is therefore recommended:*

- *A basic failure rate for leakage from piping of any size of 8.5E-09 /hr per section. This rate applies to all leaks down to very small cracks.*

- *A section is defined as a segment of pipe between major discontinuities (valves, elbows, bends, etc.), up to about 10 ft in length. For straight runs of piping that are of particularly high quality and subject to extraordinary inspection and testing (e.g., reactor coolant pressure boundary) and/or are not subject to severe operating stresses (i.e., operate at relatively low pressures and velocities, carry clean water, etc.), this length may be extended up to about 100 ft, provided there are no discontinuities.*

- *The fraction of this rate corresponding to leakage severe enough to constitute a rupture should be taken as 5%. The 5% value is consistent with both WASH-1400 and Thomas. Of this 5%, 10% should be taken to be essentially a complete break; 30% should be taken to be a large rupture; and the remaining 60% a small rupture. This is the breakdown used in the Oconee PRA, which NRC reviewers found to be acceptable...."*

The basic failure rate 4.25E-10/hr per section [(8.5E-09/hr per section) * (5%)] has been used for evaluation of the AP600 small and very small LOCA initiating event frequencies, as well as for PRHR heat exchanger tube rupture initiating event frequency. Based on the basic failure probability from ALWR Utility Requirements Document, the failure frequency of the PRHR heat exchangers (HXs) is calculated as:

Failure Frequency of PRHR HXs = [1.0E-07/hr per HX] * [8760 hrs/yr] * [2 HXs] = 1.8E-03/yr.

The evaluated frequency of 1.8E-03 is less conservative than the failure frequency of the PRHR heat exchanger tube rupture, 5.0E-03/yr [(4.25E-10/hr per section) * (1342 sections) * (8760 hrs)], used in the AP600 PRA. The recommended frequency for small LOCA, in the ALWR Utility Requirements Document, is 1.0E-03/yr. In the AP600 PRA, the small and very small LOCA initiating event frequencies are 5.2E-04/yr and 5.5E-04/yr, respectively; these frequencies account for 1.0E-03/yr.

The data changes recommended by SAROS have been reviewed and approved by EPRI. These data changes are expected to be incorporated into the next revision of the URD (Revision 6).

PRA Revision: NONE

Question 720.92

Describe how the data bases that were used to develop the failure probability for the PRHR heat exchanger tubes were qualified for the AP600 design.

Response:

The response to RAI 720.88 provides the response for this question.

PRA Revision: NONE