Westinghouse Electric Corporation Energy Systems

Box 355
Pittsburgh Pennsylvania 15230-0355

NSD-NRC-96-4850
DCP/NRC0629
Docket No.: STN-52-003

October 17, 1996

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

ATTENTION: T. R. QUAY

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

Dear Mr. Quay:

Enclosed are three copies of the Westinghouse responses to NRC requests for additional information on the AP600 topics. Responses to RAIs on the code WGOTHIC and several miscellaneous subjects are included in this transmittal. A list of the specific RAIs is included as Attachment A.

The NRC technical staff should review these responses as a part of their review of the AP600 design. These responses close the nine RAIs.

Please contact Brian A. McIntyre on (412) 374-4334 if you have any questions concerning this transmittal.

Brian A. McIntyre, Manager
Advanced Plant Safety and Licensing

/nja

Enclosures

cc: T. Kenyon, NRC (w/o enclosures)
N. Liparulo, Westinghouse (w/o enclosures)

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Attachment A

List of Attached RAIs

WGOTHIC	Miscellaneous Topics
480.285	410.115-R1
480.286	410.255-R1
480.289	410.296
480.302	440.579
480.335	
480.336	
480.353	
480.354	
480.355	
480.356	
480.357	
480.358	
480.372	
480.395	
480.412	
480.415	

Question 480.285

Re: (WGOTHIC MODELS AND PHENOMENA)ADEQUACY OF THE MIXED CONVECTION TREATMENT Are the older (i.e., Version 1.0) results cited in the model and margin assessment report (PCS-GSR-001) and in the SAR, obtained using free convection or forced convection?

Response:

Westinghouse has changed its approach to use a bounding evaluation model, which affects the applicability of the above question. The change in the evaluation model addressed the staff's previous concern.

The report, PCS-GSR-001(Reference 480.285-1), was documentation of work in progress, and was written to provide a status of WGOTHIC code development and a comparison of results between code versions. (Please see response to RAI 480.346 for clarification of the report purpose and results.)

The WGOTHIC 1.0 results are based on user-specified free convection on the interior PCS surfaces and forced convection on the exterior PCS surfaces. The WGOTHIC 1.2 results are based on the mixed convection correlation on both interior and exterior PCS surfaces. For results in PCS-GSR-001 quoted from each code version, these correlations were applied consistently for both LST and AP600 calculations.

References

480.285-1 NTD-NRC-94-4174 (PCS-GSR-001), "AP600 PCS Design Basis Analysis (DBA) and Margin Assessment," June 30, 1994.

SSAR Revision: NONE

Question 480.286

Re: (WGOTHIC MODELS AND PHENOMENA)WGOTHIC VELOCITIES AND FORCED CONVECTION
For the shell interior (and also the internal heat sinks), the forced convection correlation used by WGOTHIC is

NUx = 0.0296*(REx**(4/5))*(PR**(1/3)) (3)

Additional justification and documentation is needed on the treatment of the spatial dependence in Eq. (3) above, particularly on the selection of the zero-point.

Response:

Westinghouse has changed its approach to use a bounding evaluation model, which affects the applicability of the above question. The change in the evaluation model addressed the staff's previous concern.

Since the interior surfaces of the PCS are assumed to be only in free convection (Reference 480.286-1, Table 14-5), it is not necessary to select a zero-point for the interior forced convection correlation.

References

480.286-1 WCAP-14407, "WGOTHIC Application to AP600," September 10, 1996.

SSAR Revision: NONE

Question 480.289

Re: (WGOTHIC MODELS AND PHENOMENA)WGOTHIC VELOCITIES AND FORCED CONVECTION
For the shell interior (and also the internal heat sinks), the forced convection correlation used by WGOTHIC is

NUx = 0.0296*(REx**(4/5))*(PR**(1/3)) (3)

For each node, is Eq. (3) integrated over the range of x values represented by the node, or is a characteristic value of x defined to represent an entire range of nodes?

Response:

Westinghouse has changed its approach to use a bounding evaluation model, which affects the applicability of the above question. The change in the evaluation model addressed the staff's previous concern.

Since the interior surfaces of the PCS are assumed to be only in free convection (Reference 480.286-1, Table 14-5), it is not necessary to define characteristic values of x for the interior forced convection correlation.

References

480.286-1 WCAP-14407, "WGOTHIC Application to AP600," September 10, 1996.

SSAR Revision: NONE

Question 480.302

Re: (WGOTHIC MODELS AND PHENOMENA)SENSITIVITY TO NODALIZATION IN THE LUMPED PARAMETER MODE (LPM)

If the velocities in the AP600 model are functions of the nodalization scheme, how will those velocities be validated in the plant calculations?

Response:

Westinghouse has changed its approach to use a bounding evaluation model, which affects the applicability of the above question. The change in the evaluation model addressed the staff's previous concern.

The WGOTHIC evaluation model assumes only free convection internal to containment (Reference 480.302-1, Table 14-5), so that internal heat and mass transfer rates are independent of predicted velocities.

References:

480.302-1 NSD-NRC-96-4816, (WCAP-14407), "WGOTHIC Application to AP600, " September 1996.

SSAR Revision: NONE

Question 480.335

Re: (WGOTHIC MODELS AND PHENOMENA)DIFFERENCES BETWEEN FINITE DIFFERENCE (FD) AND LUMPED PARAMETER (LPM) MODES

In the November 1994 meeting, WEC stated that WGOTHIC captures momentum advection in the lumped parameter mode (LPM). Based on an examination of the WGOTHIC documentation, the code does not capture momentum advection terms in the LPM. Definitive clarification of this issue is required.

Response:

To clarify the lumped parameter momentum formulation used in WGOTHIC, convective momentum terms are not modelled through junctions connecting lumped parameter volumes (Reference 480.335-1, Section 5.1, and Reference 480.335-2, Sections 4.1 [junctions in lumped parameter mode]). The convective momentum terms, used in the WGOTHIC distributed parameter mode are described in Reference 480.335-2, Sections 11.3.3 and 11.3.4.

References

480.335-1 NSD-NRC-95-4489, (WCAP-14382), "WGOTHIC Code Description and Validation," June 20, 1995.

480.335-2 NTD-NRC-95-4563, "GOTHIC 4.0 Documentation," Enclosure 2: Technical Manual, September 21, 1995.

SSAR Revision: NONE

Question 480.336

Re: (WGOTHIC MODELS AND PHENOMENA)DIFFERENCES BETWEEN FINITE DIFFERENCE (FD) AND LUMPED PARAMETER (LPM) MODES

The WGOTHIC documentation states that in the LPM, the creation of the noding structure may also require an a-priori knowledge of the expected flow direction and magnitude; something which in general, is not known ahead of time. This does not appear to be consistent with WEC's attempt to calculate velocities along the inner shell surface for use in a mixed convective correlation, and needs to be addressed.

Response:

Westinghouse has changed its approach, to use a bounding evaluation model, which affects the applicability of the above question. The change in the evaluation model addressed the Staff's previous concern.

Based on a review of AP600 physics and circulation patterns expected based on an international containment test database, the WGOTHIC lumped parameter model of AP600 has been used to assess the effect of various postulated circulation patterns on pressure predictions (Reference 480.336-1, Section 9). As described in the reference, based on code validation (Reference 480.336-2, Section 8) with the LST, the postulated flow patterns were obtained using WGOTHIC lumped parameter by varying the assumed break locations, giving a range of steam concentration distributions. The results were used to select a limiting scenario for use in PCS DBA calculations. A bounding scenario has been defined for use in PCS DBA calculations.

The limiting LOCA scenario has been shown to be a break postulated in the steam generator compartment away from the heat sinks associated with the pressurizer compartment. Such a location, combined with dissipation of break momentum in the steam generator compartment, is shown to limit access to internal heat sinks during the peak pressure period, while internal heat sinks are important.

The limiting MSLB scenario is an elevated break in the steamline above the operating deck. The lumped parameter evaluation model with an elevated break biases the steam distribution away from internal heat sinks which are the dominant means of pressure reduction for an MSLB.

References

480.336-1 NSD-NRC-96-4816, (WCAP-14407), "WGOTHIC Application to AP600," September 10, 1996.

480.336-2 NTD-NRC-95-4489, (WCAP-14382), "WGOTHIC Code Description and Validation," June 20, 1995.

SSAR Revision: NONE

Question 480.353

Re: (PCS-GSR-001)AP600 ANALYSES

The reasons for differences between the Version 1.2 and SAR results need to be identified, and the dominant effects need to be highlighted and discussed. What is the relative influence of the various modeling changes made in WGOTHIC on the pressure predictions?

Response:

The report, PCS-GSR-001(Reference 480.353-1), was documentation of work in progress, and was written to provide a status of WGOTHIC code development and a comparison of results between code versions. Please see response to RAI 480.346 for clarification of the report purpose and results with respect to the reasons for differences between code versions.

The dominant effects for determining the AP600 PCS DBA pressure response have been identified and discussed (Reference 480.353-2, Section 2). The relative influence of various modeling parameters in the evaluation model is shown by the results of sensitivities in the various sections of (Reference 480.353-2).

References

480.353-1 NTD-NRC-94-4174 (PCS-GSR-001), "AP600 PCS Design Basis Analysis (DBA) and Margin Assessment," June 30, 1994.

480.353-2 NSD-NRC-96-4816, (WCAP-14407), "WGOTHIC Application to AP600," September 10, 1996.

SSAR Revision: NONE

Question 480.354

Re: (PCS-GSR-001)AP600 ANALYSES

Has WEC performed any sensitivity studies that demonstrate the importance of various modeling changes?

Response:

The report, PCS-GSR-001(Reference 480.354-1), was documentation of work in progress, and was written to provide a status of WGOTHIC code development and a comparison of results between code versions. Please see response to RAI 480.346 for clarification of the report purpose and results.

Sensitivity studies for the dominant effects for determining the AP600 PCS DBA pressure response have been provided (Reference 480.354-2, Sections 5-11, 13).

References

480.354-1 NTD-NRC-94-4174 (PCS-GSR-001), "AP600 PCS Design Basis Analysis (DBA) and Margin Assessment," June 30, 1994.

480.354-2 NSD-NRC-96-4816, (WCAP-14407), "WGOTHIC Application to AP600," September 10, 1996.

SSAR Revision: NONE

Question 480.355

Re: (PCS-GSR-001)AP600 ANALYSES

The plots of the MSLB results should be clarified.

Response:

The report, PCS-GSR-001(Reference 480.355-1), was documentation of work in progress, and provides a status of WGOTHIC code development and a comparison of results between code versions. Please see response to RAI 480.346 for clarification of the report purpose.

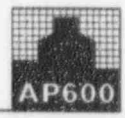
Figures 11 and 12 in the subject report show the MSLB pressure and temperature responses, respectively, for WGOTHIC 1.2 and WGOTHIC 1.0 for both the 102% and 30% initial power cases. The line type is the same for the WGOTHIC 1.2 30% and WGOTHIC 1.0 102% cases. The distinction can be made by noting that the WGOTHIC 1.2 results are in phase with the WGOTHIC 1.0 results on the abscissa (as may be expected since the M&E releases between cases run by different code versions is unchanged). That is, the time of peak pressure or temperature is unchanged by the change in code version. Similarity of time phase, together with the values of peak pressure and temperature given in Table 5, is believed to provide sufficient clarification to allow the reader to assess the results.

Results in Figures 15 and 16 are similarly in phase and, together with the values of peak pressure and temperature in Table 6, provides sufficient clarification.

References

480.355-1 NTD-NRC-94-4174 (PCS-GSR-001), "AP600 PCS Design Basis Analysis (DBA) and Margin Assessment," June 30, 1994.

SSAR Revision: NONE



Question 480.356

Re: (PCS-GSR-004)

The following questions relate to "Experimental Basis for the Heat Transfer Correlations Selected for Modeling Heat transfer from the AP600 Containment Vessel," PCS-GSR-004, Westinghouse Electric Corp., August 31, 1994.

How is the characteristic length defined?

Response:

PCS-GSR-004 was superseded by Reference 480.356-1. The characteristic length for the both the Grashof and Reynolds number calculations is the channel hydraulic diameter, as described on pages 2-2 and 2-3 of Reference 480.356-1.

References

480.356-1 NTD-NRC-95-4428, (WCAP-14326), "Experimental Basis for the AP600 Containment Vessel Heat and Mass Transfer Correlations," April 13, 1995.

SSAR Revision: NONE

Question 480.357

Re: (PCS-GSR-004)

The following questions relate to "Experimental Basis for the Heat Transfer Correlations Selected for Modeling Heat transfer from the AP600 Containment Vessel," PCS-GSR-004, Westinghouse Electric Corp., August 31, 1994.

The predicted local Nu is considerably too high for the smallest x/d values. Does this suggest that the entrance effect treatment is inappropriate for the experimental configuration?

Response:

PCS-GSR-004 was superseded by Reference 480.357-1. The method for calculating the entrance effect multiplier as a function of distance in the channel is described in the both reports. This method was found to yield inaccurate results for the very first volume in the channel, as stated on page 3-2 of both reports. However, if the entrance effect multipliers had not been used to increase the heat transfer to the subsequent volumes within the channel, the predicted Nusselt numbers for those volumes would have been significantly lower than the measured values. Entrance effect multipliers are not being used in the AP600 containment evaluation model.

References

480.357-1 NTD-NRC-95-4428, (WCAP-14326), "Experimental Basis for the AP600 Containment Vessel Heat and Mass Transfer Correlations," April 13, 1995.

SSAR Revision: NONE

Question 480.358

Re: (PCS-GSR-004)ECKERT AND DIAGUILA TESTS

What is the potential significance of the "dense screens"?

Response:

PCS-GSR-004 was superseded by Reference 480.358-1. It is assumed that the dense screens were installed to breakup the velocity profile at the entrance of the heated channel. In this way, both the temperature and velocity profiles would develop simultaneously.

References

480.358-1 NTD-NRC-95-4428, (WCAP-14326), "Experimental Basis for the AP600 Containment Vessel Heat and Mass Transfer Correlations," April 13, 1995.

SSAR Revision: NONE

Question 480.372

Re: (PCS-GSR-006)WESTINGHOUSE STC FLAT PLATE EVAPORATION TESTS

Is the Reynolds number range calculated based on the channel hydraulic diameter? If not, how were the Reynolds numbers obtained?

Response:

PCS-GSR-006 was superseded by Reference 480.372-1. The Reynolds number was calculated based on the channel hydraulic diameter, as described on page 2-3 of Reference 480.372-1.

References

480.372-1 NTD-NRC-95-4428, (WCAP-14326), "Experimental Basis for the AP600 Containment Vessel Heat and Mass Transfer Correlations," April 13, 1995.

SSAR Revision: NONE

Question 480.395

Re: On page 9-1 of Ref. 3, the text refers to Section 9.4. This should be Section 9.6. Figure 9-1 on page 9-10 is cut off and the x-axis is missing. Provided the full figure.

Reference:

3. "WGOTHIC Code Description and Validation," WCAP-14382, May 1995.

Response:

Westinghouse has changed its approach to use a bounding evaluation model, which affects the applicability of the above question. Section 9 of Reference 480.395-1 is excluded from the AP600 PCS DBA licensing basis.

References

480.395-1 NSD-NRC-95-4489, (WCAP-14382), "WGOTHIC Code Description and Validation," June 20, 1995.

SSAR Revision: NONE

Question 480.412

Re: On page 2-2 of WCAP-14382, it is states that two stacked sets of Climes are used in the PCS model. One is always considered to be dry and the other is called the "wet" stack. No other information is provided in the WCAP on how these stacks are modeled. Since this WCAP is a description of WGOTHIC, it should include a description of input needed and any other guidance for the used, such as the need to verify that modeling assumptions are consistent with the analyses. This should include the guidance on how to calculate the area for each region, what data are needed to perform this calculation and what is needed to verify that these assumptions are consistent with the completed WGOTHIC calculations.

Response:

A description of how input related to the WGOTHIC Climes models is developed for the PCS DBA evaluation model is provided in Reference 480.412-1, Section 4.4. The water coverage model, used to determine wet and dry coverage areas for each region, is discussed in Reference 480.412-1, Section 7.

Reference

480.412-1 NSD-NRC-96-4816, (WCAP-14407), "WGOTHIC Application to AP600," September 10, 1996.

SSAR Revision: NONE

Question 480.415

Re: In the attachment to letter NTD-NRC-95-4595, dated November 13, 1995, in Table 1, it is inferred that the error in routine condin.f is negligible because AP600 analyses are done in English units. Verify that (1) the error only effects printed output from the code (eg, the conversion is not performed on an English value to be used in a model that is coded as a metric formulation), and that (2) no conclusions as to GOTHIC's or WGOTHIC's abilities were based on the wrong value (eg, comparison of a metric test data base to GOTHIC metric output).

Response:

Westinghouse has incorporated coding changes in the WGOTHIC code (References 480.415-1, Section 3.2) to be consistent with GOTHIC 4.0 (Reference 480.415-2) which corrected deficiencies noted as a result of the EPRI-sponsored review by industry experts (Reference 480.415-3). The noted error in routine condin.f has been corrected in WGOTHIC 4.0.

References

480.415-1 NSD-NRC-96-4816, (WCAP-14407), "WGOTHIC Application to AP600," September 10, 1996.

480.415-2 NTD-NRC-95-4563, "GOTHIC Version 4.0 Documentation," September 21, 995.

480.415-3 NTD-NRC-95-4462, "EPRI Report RA-93-10, GOTHIC Design Review, Final Report," May 15, 1995.

SSAR Revision: NONE

Revision 1

AP600

Question 410.115 R1

Describe how AP600 SWS is designed to minimize the potential for water hammer.

Response:

Prior to system startup, the service water system (SWS) is filled with water and vented ~~as described in SSAR Subsection 9.2.1.3.1~~. During normal operation, the SWS pumps water from the basin at the SWS cooling tower, through piping and equipment, to a high point located at the SWS cooling tower riser; the cooling water is then discharged to atmosphere in a spray fashion above the cooling tower basin. The system arrangement is such that there are no high points in the system piping that can lead to formation of vapor pressure voids upon loss of system pumping.

When the pumps are stopped, check valves located at the discharge of each pump minimize reverse flow of system fluid through the pumps and into the basin; also, ~~cooling tower blowdown is isolated when the pumps are stopped.~~ if both pumps stop due to loss of normal ac power, cooling tower blowdown is isolated. Therefore, drain down of system fluid is minimized when the system is shut down. Drainage of system fluid that might occur, ~~such as through the small SWS motor cooling lines,~~ is replaced by air. No vapor cavities will form. Therefore, the potential for water hammer due to water column rejoining upon pump re-start is minimized.

Motor operated valves at the discharge of each SWS pump are interlocked to close prior to pump start. These valves then open at a controlled rate following pump start to slowly admit water to the system. This feature results in reduced fluid velocities during system start and minimizes transient effects that may occur as the system sweeps out ~~any~~ air and obtains a water solid condition. Temperatures in the system are moderate and the pressure of the SWS fluid is kept above its saturation pressure at all locations. Therefore, the potential for water hammer due to thermodynamic voiding and subsequent vapor collapse is minimized. There are no fast acting power-operated valves in the system, and the only check valves in the normal process flow path are in a standard configuration at the discharge of each SWS pump. Therefore, the design of the system minimizes water hammer potential due to rapid valve actuation.

SSAR Revision:

Section 9.2.1.2.1, General Description, add new fifth paragraph:

... heat exchanger to discharge to either cooling tower cell.

Temperatures in the system are moderate and the pressure of the service water system fluid is kept above saturation at all locations. This along with other design features of the system arrangement and control of valves minimizes the potential for thermodynamic or transient water hammer.

Service water materials ...

Section 9.2.1.2.3.6, Loss of Normal AC Power Operation, revise as follows:

Question 410.255r1

Section 10.4.1.2.1 of the SSAR states "refer to Table 10.3.5-1 for permissible cooling water inleakage and time of operation for maintaining the required condensate/feedwater quality." Describe how the information in this table provides the above information. Where is the permissible cooling water leakage? Where is the information of length of time that the condenser may operate with degraded conditions without affecting the condensate/feedwater quality for safe operation? What are the definition of the action levels (1, 2, and 3) listed in Table 10.3.5-1? Also, provide information in the SSAR regarding the procedure to repair condensate leaks in accordance with Section 10.4.1 of RG 1.70.

Response:

SSAR subsection 10.4.1.2.1 is intended to convey that there is no absolute value of cooling water inleakage nor specific time of operation for maintaining the required condensate or feedwater quality. The measured parameters that affect plant performance and operator actions are the water quality values in SSAR Table 10.3.5-1. As a basis for design of the condensate polishing system, cooling water inleakage of .001 gpm "continuous" and .1 gpm "faulted" are used. These values are identified in SSAR subsection 10.4.6.1.2. Note that the circulating water system described in the SSAR is for reference only. Circulating water source and type is site specific. As a result, the effect of .001 gpm inleakage of cooling water on condensate or feedwater will vary from plant to plant. Thus the limit on inleakage is based on the resultant quality of condensate and feedwater and not on the amount of time of cooling water inleakage. Once condensate or feedwater quality are degraded to outside the limits contained in Table 10.3.5-1, the operator should take actions consistent with the EPRI NP-2701, PWR Secondary Water Chemistry Guidelines. This EPRI document defines action levels 1, 2 and 3 and the actions required for each. SSAR subsection 10.4.1, Revision 6, provides a description of the procedure for repairing condensate tube leaks.

SSAR Revision: None

In the event of loss of normal ac power, the service water pumps and cooling tower fans, along with the associated motor operated valves are automatically loaded onto their associated diesel bus. This includes isolation of cooling tower blowdown, which minimizes drain down of the system while both pumps are off. What drainage of system fluid that does occur is replaced by air without vapor cavities. The potential for water hammer on pump restart is minimized. Both pumps and both cooling tower cells automatically start after power from the diesel generator is available. Following automatic start, the operator may return the system to the appropriate configuration.

Question 410.296

Re: NRC Letter dated August 15, 1996

Some SSAR figures are not legible, for example: Figures 9.4.1-1, 9.4.2-1, 9.4.3-1, 9.4.6-1, 10.3.2-1, and 11.4-1. Westinghouse is requested to revise the SSAR figures to be legible.

Response:

Enlarged copies of the cited SSAR figures were provided to the NRC in response to the above request.

SSAR Revision: NONE

Question 440.579

Re: RELAP Modeling

The staff requires accurate information about pipe sizes and schedules for code modeling purposes. In RAI 440.247, the staff requested that Westinghouse identify all Schedule 140 piping in the AP600. The response to that RAI indicated that only the 20-inch NRHR inlet line was Schedule 140. However, AP600 drawings appear to indicate substantially more piping is Schedule 140, including:

a. Drawings PXS-PLW-010 through -028, Rev. 0 (dated 2/28/95) show most of the DVI lines as being pipe class BTA, which has been described as Sched. 140 (the NRHR line identified in the original response is class BTA).

b. Drawings PXS-PLW-035 and -036, Rev. 0 (dated 2/28/95) show the PRHR and ADS-4 inlet lines as both class BTA and Sched. 140. The PRHR outlet lines are shown as the same pipe class and schedule on drawings PXS-PLW-043 and -044, Rev. 0 (2/16/95).

c. Drawings PXS-PLW-054, -064, and -065, Rev. 0 (2/27/95) show the pressure balance lines as Sched. 140.

d. SSAR Fig. 5.1-5 (in Rev. 4 to the SSAR) shows the pressurizer surge line, pressurizer spray line, and ADS 1-3 inlet lines as pipe class BTA.

Please review the response to RAI 440.247 and the indicated drawings, and identify the AP600 piping that is currently designated as Schedule 140. If the above-noted drawing have been superseded, and the pipe classes and/or schedule have been changed, please provide copies of the current revisions that show correct pipe classes and schedules.

Response:

Revised drawings were provided in response to RAI 440.258. These drawing identify the pipe classes and schedules.

SSAR Revision: NONE