April 25, 1996

APPLICANT: Westinghouse Electric Corporation

PROJECT: AP600

SUBJECT: SUMMARY OF TELEPHONE CONFERENCE TO DISCUSS AP600 TESTING

The subject telephone conference was held on April 15, 1996, between representatives of Westinghouse Electric Corporation and the Nuclear Regulatory Commission (NRC) staff. The purpose of the teleconference was to address discussion items concerning the AP600 Oregon State University (OSU) test analysis report. These discussion items were provided to Westinghouse by an NRC letter dated March 11, 1996

Attachment 1 is the list of individual participating in the telephone conference. Attachment 2 is a summary of the discussion items and the Westinghouse responses. Based on some of the discussion item responses, the staff issued followon questions in a letter to Westinghouse dated April 23, 1996.

original signed by:

William C. Huffman, Project Manager
Standardization Project Directorate
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

Docket No. 52-003

Attachments: As stated

cc w/attachments:
See next page

<u>DISTRIBUTION w/attachment</u>:

Docket File
PUBLIC
JSebrosky
TKenyon
HScott, T-10 G6
PDST R/F
DCrutchfield
DJackson
TCollins, O-8 E23
TLee, T-10 G6
TQuay
RArchitzel
WHuffman
RJones, O-8 E23

<u>DISTRIBUTION: w/o attachment</u>:

ACRS (11)
AThadani, O-12 G18
WDean, EDO
WRussell/FMiraglia, O-12 G18
EJordan, T-4 D18
FEltawila, T-10 G6
RZimmerman, O-12 G18
JMoore, O-15 B18
ALevin, O-8 E23

DOCUMENT NAME: A:OSU-TLCN.496 (4D AP600 DISK)

To receive a copy of this document, indicate in the box: "C" = Copy without attachment/enclosure "E" = Copy with attachment/enclosure "N" = No copy

OFFICE	PM:PDST:DRPM		SC:PDST:DRPM							
NAME	WHuffman		RArchitzel							
DATE	04/25/96		04/25/96							

OFFICIAL RECORD COPY

DF03,1

NRC FILE CENTER COPY

9604300123 960425
PDR ADOCK 05200003
A PDR

Westinghouse Electric Corporation

Docket No. 52-003

cc: Mr. Nicholas J. Liparulo, Manager
Nuclear Safety and Regulatory Analysis
Nuclear and Advanced Technology Division
Westinghouse Electric Corporation
P.O. Box 355
Pittsburgh, PA 15230

Mr. B. A. McIntyre
Advanced Plant Safety & Licensing
Westinghouse Electric Corporation
Energy Systems Business Unit
Box 355
Pittsburgh, PA 15230

Mr. John C. Butler
Advanced Plant Safety & Licensing
Westinghouse Electric Corporation
Energy Systems Business Unit
Box 355
Pittsburgh, PA 15230

Mr. M. D. Beaumont
Nuclear and Advanced Technology Division
Westinghouse Electric Corporation
One Montrose Metro
11921 Rockville Pike
Suite 350
Rockville, MD 20852

Mr. Sterling Franks
U.S. Department of Energy
NE-50
19901 Germantown Road
Germantown, MD 20874

Mr. S. M. Modro
Nuclear Systems Analysis Technologies
Lockheed Idaho Technologies Company
Post Office Box 1625
Idaho Falls, ID 83415

Mr. Charles Thompson, Nuclear Engineer
AP600 Certification
NE-50
19901 Germantown Road
Germantown, MD 20874

Mr. Frank A. Ross
U.S. Department of Energy, NE-42
Office of LWR Safety and Technology
19901 Germantown Road
Germantown, MD 20874

Mr. Ronald Simard, Director
Advanced Reactor Program
Nuclear Energy Institute
1776 Eye Street, N.W.
Suite 300
Washington, DC 20006-3706

Ms. Lynn Connor
Doc-Search Associates
Post Office Box 34
Cabin John, MD 20818

Mr. James E. Quinn, Projects Manager
LMR and SBWR Programs
GE Nuclear Energy
175 Curtner Avenue, M/C 165
San Jose, CA 95125

Mr. John E. Leatherman, Manager
SBWR Design Certification
GE Nuclear Energy, M/C 781
San Jose, CA 95125

Barton Z. Cowan, Esq.
Eckert Seamans Cherin & Mellott
600 Grant Street 42nd Floor
Pittsburgh, PA 15219

Mr. Ed Rodwell, Manager
PWR Design Certification
Electric Power Research Institute
3412 Hillview Avenue
Palo Alto, CA 94303

AP600
WESTINGHOUSE/NRC
TELECONFERENCE PARTICIPANTS
APRIL 15, 1996

NAME	ORGANIZATION
John Butler	WESTINGHOUSE
Tim Andreychek	WESTINGHOUSE
Gene Piplica	WESTINGHOUSE
Al Levin	NRC
Bill Huffman	NRC

Attachment 1

QUESTIONS, COMMENTS, AND DISCUSSION ITEMS

CONCERNING THE WESTINGHOUSE AP600 OSU TAR TEST SB09

Section 5.4: Test SB09

1. a. In Figure 5.4.1-1, the rate of depressurization changes sharply at about 380 seconds, well before the beginning of the ADS phase of the transient. Please explain the reason for the increased rate of depressurization between 380 seconds and ADS-1 actuation. Note: The text, on p. 4.4.1-2, appears to attribute this behavior to emptying of the steam generator tubes. If this is the case, please explain the rationale behind this assertion, since it appears that emptying of the SG tubes would allow steam to enter the tubes, which would then superheat due to heat transfer from the secondary side (primary pressure is lower than secondary pressure at this time). It is not clear why this sequence of events would lead to a higher depressurization rate.

   Response:

   The draining of the SG-1 tubes required that the CLBL break be fed from the liquid inventory in the downcomer. The downcomer fluid had a lower enthalpy than that being discharged from SG-1, and therefore resulted in a greater mass flow out the break (recall that the PRHR was operating at this time). The discharge of the lower enthalpy flow allowed for a larger mass discharge rate through the break, and a quicker depressurization.

   b. In addition, the end of the blowdown phase is said to occur when the primary and secondary pressures reach equilibrium, however, Figure 5.4.2-4 shows that from about 160 seconds to 380 seconds, the primary pressure oscillates at a value slightly above the secondary and then drops rapidly below the secondary pressure (as noted in number 1, above), without ever really reaching an equilibrium. Please discuss.

   Response:

   Reviewing the data plotted in the figure identified above, within the uncertainty of the measurements and for practical purposes, the measured pressures of the primary and secondary sides are equal from about 160 seconds to about 380 seconds.

2. Why is there an approximately 200-second difference between the times for initiation of IRWST injection for the two DVI lines? Is this related to the different times at which the CMTs empty?

   Response:

   The difference between time of initiation of IRWST injection through the two DVI lines is indeed related to the difference in drain-downs observed for the two CMTs and the resulting difference in heads associated with each CMT inventory. As noted from Figure 5.4.2-8, CMT-2 empties just after 1200 seconds, and IRWST-2 injection begins about 1150 seconds. Similarly, CMT-1 empties at about 1650 seconds, and IRWST-1 injection begins about 1350 seconds.

3. A plot of system pressure during the IRWST phase is absent in Figure 5.4.1-1. This would be especially of interest between 10,000 and 13,000 seconds, when system-wide oscillations in pressure were noted.

   Response:

   The data plot given in Figure 5.4.1-1 is consistent with other similar plots constructed for purpose of providing an introduction and overview of a specific test. The system-wide pressure oscillations referred to in the comment are addressed, in detail, in the Long Term Cooling discussion of test SB09, and are shown for the time period of interest in Figure 5.4.3-53.

4. The integrated CMT flow in Figure 5.4.2-9 differs from the two CMTs. Is this due to lack of recirculation in CMT-1 for a substantial period due to the balance line break? This plot is somewhat confusing. One would expect the integrated mass flow to equal the original mass in the CMT, assuming the CMT empties completely. This is not the case, because the flow coming back into the CMT during recirculation is not subtracted from the integrated outflow. So instead of an integrated mass flow of about 650 lb. [2000 cu. ft/192)*62.4], values in this test range from about 700 to 840 lb.

   Response:

   The explanation offered in the comment is correct. For the intact CMT, the total injected mass includes mass flow from the CMT during recirculation. For the purposes of the analyses performed by Westinghouse, the total flow from the CMT, including that observed during recirculation, was of interest and hence the reason for the plots of the two integrated CMT mass flows taking on the values they do.

5. It appears as if the way in which the average void fraction is estimated assumes an average void distribution along the entire length of the heated rods. This could be non-conservative, if boiling begins above the bottom of the rods; i.e., the actual average void fraction along those portions of the rod where boiling exists would be higher. This could affect assumptions about the effectiveness of heat transfer along the rods, especially in the highest void-fraction region near the top.

   Response:

   The two methods employed to evaluate core exit void fraction are described within Sections 4.11.2.1 and 4.11.2.2. Neither approach assumes a void fraction distribution along the heated length of the heater rods. Rather, using two different approaches, both methods determine the saturation line in the core and then calculate steam production by considering the core power above the saturation line.

Power below the saturation line is assumed to heat water to its saturation temperature, while that above the saturation line is assumed to generate steam. No average void distribution along the length of the heater rods is assumed for these calculations.

6. In Figures 5.4.2-48 to -51, as the upper plenum and head are recovering, there is one final sharp down-spike in level at about 2000 seconds. This does not appear to be reflected in the core level/mass plots in Figures 5.4.2-44 and -45. What causes the dip in the upper plenum and upper head?

   Response:

   The integrated liquid mass flow for the two ADS 4 lines shown in Figure 5.4.2-64 indicates that the decrease in liquid mass in the upper plenum and the head is the result of upper plenum and head inventory being exhausted out ADS 4. Therefor, the core level plots are not affected by the noted draining of the upper plenum and head.

7. Figure 5.4.2-33, curve "C" shows integrated PRHR heat removal. The curve peaks at around 600-800 seconds, after which it begins to decrease. If this is truly an integrated curve, a decrease would seem to indicated heat transfer <u>from</u> the IRWST <u>to</u> the primary system, which does not seem to be logical. Please explain what this curve shows and the reason for its shape.

   Response:

   The parameter plotted on this figure will be reviewed further prior to responding to this comment. --------------------- **Staff to issue RAI on this question.**

8. There appears to be a slight zero offset in time on Figure 5.4.2-67; the break flow begins to rise before time "zero." Please explain.

   Response:

   This figure will be reviewed further with respect to the definition of time "zero" prior to responding to this comment. ----------**Staff to issue RAI on this question.**

9. Why does the curve in Figure 5.4.2-67 have a "multiple hump" shape? What is driving the increases and decreases in steam flow?

   Response:

   The second "hump" is approximately coincident with the draining of SG-1 short tubes. This second peak in steam flow out the break is interpreted as being driven by the venting of steam generated as the water in the steam generator short tube becomes steam, causing the short tube to drain. Once drained, the break becomes a path of least resistance and steam is vented to the break, causing the "hump" or peak in measured steam mass flow rate.

10. Why is the indicated liquid break flow in Figure 5.4.2-68 negative between about 100 and 200 seconds? Is flow really going back through the break, or is this an anomaly of the configuration of the BAMS?

    Response:

    As described in Section 4.8, Break Separator, the break flow is calculated accounting for measured liquid and vapor flows, and the change in liquid and vapor inventory in the break separator. Recall that, although the magnetic flow meters can indicate reverse flow, they do not provide a meaningful measure of the magnitude of the reverse flow. Thus, the apparent negative break flow is attributed to the dynamic affects of the inventory in the break separator and separator drain pipe attempting to find an equilibrium level to accommodate the break flow.

11. The description of the break flow behavior in the first paragraph of "Energy Transport via the Break and Automatic Depressurization System" on p. 5.4.2-3 hardly captures the behavior of the curves. The liquid break flow, for example, peaks well above the stated 4 lbm/sec., oscillates, goes sharply negative, recovers, goes negative again, then drops to near zero. The text should more clearly describe and explain the behavior of the curves.

    Response:

    The purpose of the text in the paragraph in question was to briefly summarize the calculated break flow behavior, and to provide the reader an overview of the calculated results. Reflecting upon the detail contained in the comment, this purpose appears to have been accomplished.

    As a point of clarification, however, it is noted that the text in question states that "break flow rose of a maximum value of over [4]^{a,b,c} lbm/sec. of water," but does not indicate how much over the value given. Furthermore, for the purpose of the analyses documented in the Test Analysis Report, integrated break flow was the parameter of interest; an instantaneous peak or spike in observed break flow behavior did not significantly impact the overall analysis.

    ------------------------ **Staff to issue RAI on this question.**

NOTE: There was no " Item 12" in the March 11, 1996, NRC discussion item letter to Westinghouse.

13. There appears to be a slight inflection and increase in the slope of the break flow curves in Figures 5.4.2-62 and -63, around 250 seconds. Why does this occur?

    Response:

    As noted in the first paragraph under the section titled, "Energy Transport via the Break and Automatic Depressurization System," of page 5.4.2-3, the increase in break flow is attributed to a decrease in enthalpy of the fluid leaving the break. This would suggest that the break flow would consist of more water than steam, and result in an increased mass flow rate.

14. Figure 5.4.2-70 shows "total mass." However, the system components contributing to this total are not described. It is not clear, therefore, how the "total mass" can rise immediately after the start of the transient, when it would not seem that mass is being added to the system; if anything, with inventory going out the break, "total mass" would appear to decrease. In addition, if the "total mass" includes components that can inject mass to the system, then it is not clear why the "total mass" should increase at all. Please clarify what this plot represents, and discuss its behavior as a function of time.

    Response:

    The apparent system inventory increase is the result of the following;

    1. The response of levels instruments to the initiation of the event. As portions of the system are pressurized, some levels transducers show a small apparent increase in level. This increase is noted as an increase in stored mass in the system.

    2. The effect of initial inventory in liquid measurement loop seals. The initial inventory in the system did not account for mass in the loop seal of the break separator and ADS 1-3 piping. Actuating flow through these lines results in an apparent "increase" of liquid inventory.

    3. Measurement errors and instrument uncertainty. The uncertainty in and errors associated with the instruments accounts for variability in the calculated parameters that are used to calculate the "total mass" parameter.

       The manner in which the total mass parameter, TOTMASS, is calculated is described in Section 4.21.1, Total System Mass Inventory. The parameter plotted in Figure 5.4.2-70 is M^*_{PRIM} as defined in Equation 4.21.5.

15. Please describe in detail the system response immediately upon opening the sump injection valves. Specific items of interest include the sharp spike in sump flow and the reversal of DVI injection flow.

    Response:

    The layout of the test facility piping and hydraulic heads was such that, for test SB09, upon initiation of sump injection, injection flow from the sump was diverted, in part, to the IRWST through flow meter FMM-701. This is noted in Figure 5.4.3-6, where the IRWST flow to DVI line 1 goes negative. Contrary to the suggestion advanced in the comment, Figure 5.4.3-6 shows that the total flow through DVI line 1, however, does not go negative. Similarly, Figure 5.4.3-7 shows that the IRWST injection flow remains positive at a rate of about 3 lbm/sec. throughout the period of sump injection. This is taken as an indication that the sump feeds the IRWST through FMM-701 and the IRWST, in turn, continues to inject into the reactor vessel via DVI line 2.

As noted in both the FDR and TAR, the magnetic flow meters, while indicating reverse flow, do not provide a reliable measure of the reverse flow.

16. Figure 5.4.3-36 shows two spikes in steam flow shortly after the end of the second set of large-amplitude oscillations. What is responsible for these spikes? Similar features are noted in several other figures, e.g., 5.4.3-34, -35, and -37.

Response:

The noted steam flow spikes are the release of steam inventory from the reactor vessel that had driven the large amplitude oscillations. Water levels in the reactor vessel and hot legs allowed the steam to be vented, bringing the oscillations to an end.

17. On p. 5.4.3-2, the upper plenum collapsed liquid level is described as staying "between the hot leg and DVI elevations throughout the transient." The level did not drop to this point until after the inception of sump injection.

Response:

The description of the data of Figure 5.4.3-2 should read that, prior to sump injection, the collapsed liquid level in the downcomer region remained between the mid-level of the hot and cold legs. After initiation, the collapsed liquid level in the downcomer region remained between the mid-level of the DVI lines and the hot legs. The amended description will be included as an errata to the TAR.

18. At the end of Section 5.4.3.1 (p. 5.4.3-3), the ADS-4 liquid flow is said to increase after about 13,100 seconds. This is not clear from the figure referenced (Figure 5.4.3-44), where average values are difficult to discern due to oscillations and/or noise. If the ADS-4 flow does increase for a brief time, it appears to decrease beginning around 14,000 seconds. Please elaborate on this behavior and explain how the description of events is represented by the plots.

Response:

To properly respond to this comment, the description of ADS-4 behavior will be further reviewed to and an amended description will be included as an errata to the TAR, as determined appropriate by the review.

19. Please clarify what is meant by the last sentence in Section 5.4.3.1. What does "no effect on downcomer level" mean in this context?

Response:

The context of the statement is intended to note that, once sump injection was established, downcomer inventory became stable at about the mid-elevation of the hot legs.

20. The second paragraph of Section 5.4.3.2 (p. 5.4.3-3), states that reverse flow through the break was indicated after 6000 seconds. The way in which the BAMS is configured for this break appears to make actual reverse flow through the break difficult to achieve. Is there an alternate explanation for indicated negative break flow, which does not actually result in backflow through the break? Would such an alternate explanation affect the conclusions reached in this section?

Response:

The BAMS was designed to allow reverse flow through the break simulation late in the transient. Based on an evaluation of the elevation of liquid levels in the primary sump, break separator and the location of break simulation in the CLBL, it is concluded that not only is reverse flow through the break possible, but did occur in test SB09.

EDITORIAL COMMENTS RELATED TO SB09

1. The text on p. 5.4.1-1 indicates that Figure 5.4.1-2 shows the total DVI line flow and each of the components of that flow. However, the figure shows only the components (CMT, ACC, IRWST, sump), and not the total flow. A plot with the total flow would be quite useful.

   Response:

   The text identified on page 5.4.1-1 may be misleading as it does suggest that the total DVI line flow is shown on Figure 5.4.1-2. However, the data plot given in Figure 5.4.1-2 is consistent with other similar plots constructed for purpose of providing an introduction and overview of a specific test. Total flow for DVI lines 1 and 2 are provided in Figures 5.4.2-5 and -6, respectively, for the short term portion of the transient and in Figures 5.4.3-6 and -7, respectively, for the long term portion of the transient.

2. There is an inconsistency in the text, which puts the end of the blowdown phase at 160 seconds, and Figure 5.4.1-1, where it is shown as 120 seconds.

   Response:

   The inconsistency between the text and figure is noted and will be addressed as an errata item.

3. The reference to Figures 5.4.2-6 and -7 in the first paragraph of Section 5.4.2.1 should be figures 5.4.2-5 and -6. The staff also notes that these figures are sometimes difficult to interpret because of the subtle variations in shades of gray. Color plots are much easier to decipher.

   Response:

   The incorrect reference to Figure numbers in the text is noted and will be addressed as an errata item.

   The selection of a gray-scale format to present data is based, in part, on standard practice. Almost all multi-plot graphs might be made easier to decipher if made in color. However, the generation and replication of the number of such figures included in the TAR quickly becomes prohibitive in terms of both cost and production time.

4. The reference to CMT-2 in the third line from the bottom of p. 5.4.2-1 should be CMT-1.

   Response:

   The incorrect reference to CMT-2 instead of CMT-1 in the third line from the bottom of p. 5.4.2-1 is noted and will be addressed as an errata item.

5. On p. 5.4.2-2, it would be helpful (first paragraph) to indicate the time at which the core outlet temperature became subcooled after reaching

saturation at 24 seconds. This time appears to be about 55 seconds. It then remained subcooled from 55 to about 180 seconds before returning to saturation.

Response:

The purpose of the text of this section is to introduce the topic and supporting plot of the parameters of interest so as to set the stage for the reader to study the details. The comment suggest that this purpose was accomplished. No additional descriptive text is considered necessary to accomplish this purpose.

6. In the next-to-last paragraph on p. 5.4.3-2, it is stated that the equilibrium mass of water in the reactor vessel is about 375 lbm. It would be useful to state when this value was reached (it appears to be about 2000 seconds after the start of sump injection).

Response:

Equilibrium water mass in the reactor vessel is achieved at about 15,500 to 16,000 seconds. This is about 500 to 1,000 seconds after initiation of sump injection. The text of this section is consistent with comparable sections for other tests and no additional text is considered necessary.

7. In Drawing LKL 920200, the reference to Cold Leg 1 at the bottom of the PBL originating at the top of CMT-1 appear to be wrong. This should be Cold Leg 3.

Response:

It appears that, in Drawing LKL 920200, Rev 10, Sheet 3 of 6, the reference to Cold Leg 1 at the bottom of the PBL originating at the top of CMT-1 should indeed be Cold Leg 3. This drawing will be updated with the correction and the updated drawing incorporated as an errata item.