52-003

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

May 17, 1996

Mr. Nicholas J. Liparulo, Manager
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Nuclear and Advanced Technology Division
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P.O. Box 355
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SUBJECT: DISCUSSION ITEMS FOR AN AP600 MEETING ON WCOBRA/TRAC LARGE BREAK LOSS-OF-COOLANT ACCIDENT APPLICABILITY AND LONG TERM COOLING ANALYSES

Dear Mr. Liparulo:

As a result of its review of the June 1992, application for design certification of the AP600, the staff has determined that it needs additional information. The enclosed questions and comments have been developed by the staff and its contractor (INEL) based on review of previous request for additional information (RAI) responses from Westinghouse on WCOBRA/TTRAC code applicability for LBLOCAs. In addition, some additional questions concerning use of WCOBRA/TRAC for long term cooling analyses have been included.

We propose that the enclosed discussion items as well as the related AP600 SDSER open items on WCOBRA/TRAC LBLOCA and long term cooling serve as agenda items for a currently unscheduled meeting on AP600 WCOBRA/TRAC issues. The meeting will be scheduled when Westinghouse is prepared to provide detailed responses on these items. During the meeting, the staff will determine which of the enclosed discussion items need to be formally addressed by Westinghouse.

You have requested that portions of the information submitted in the June 1992, application for design certification be exempt from mandatory public disclosure. While the staff has not completed its review of your request in accordance with the requirements of 10 CFR 2.790, that portion of the submitted information is being withheld from public disclosure pending the staff's final determination. The staff concludes that these follow on questions do not contain those portions of the information for which exemption is sought. However, the staff will withhold this letter from public disclosure for 30 calendar days from the date of this letter to allow Westinghouse the opportunity to verify the staff's conclusions. If, after that time, you do not request that all or portions of the information in the enclosures be withheld from public disclosure in accordance with 10 CFR 2.790, this letter will be placed in the NRC Public Document Room.

These follow on questions affect nine or fewer respondents, and therefore is not subject to review by the Office of Management and Budget under P.L. 96 511.

If you have any questions regarding this matter, you may contact me at (301) 415-1141.

Sincerely,

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

Enclosure: As stated

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Docket No. 52-003
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1. Westinghouse response to question 440.343:

   (a) For part (a), Westinghouse stated that the broken loop hot leg (BLHL) steam flow was improved in the calculation presented in the response to question 440.348(c). However, comparison of BLHL flows in Figure 440.348-32 and Figure 3.1-47 from Reference 2 shows that the revised calculation in the response to question 440.348(c) overpredicts the BLHL steam flow worse than in the original calculation in Reference 2. Clarification of the improvement should be provided. Is the reason for the higher calculated steam flow in the BLHL the more rapid quench front advancement in the calculation? If yes, clarify the effect on AP600 LBLOCA analyses. If no, clarify the reason for the difference and the impact on AP600 LBLOCA analyses.

   (b) Westinghouse response to 440.343, part (b) referred to its response to part (a); therefore, closure on part (b) is dependent part (a) closure.

2. Westinghouse response to question 440.344:

   Westinghouse's response to question 440.344(a) is adequate except Westinghouse needs to clarify whether the reference to cold leg 3 for Run 274, Phase BII should be cold leg 2 (see Figure 440.348-59 and Figure 3.2-39, Reference 2).

3. Westinghouse response to 440.345 and 440.357:

   (a) Responses to questions 440.345 and 440.357 noted that the calculated peak cladding temperature (PCT) for Cylindrical Core Test Facility (CCTF) Run 58 (Reference 3) was approximately 30°F higher than the measured temperature at the 6 foot elevation, and this was within the range of PCT differences for other CCTF tests already included in the code uncertainty data base. However, the WCOBRA/TRAC code uncertainty in the Westinghouse Code Qualification Document (CQD) (Reference 4) is based on PCT comparisons at a number of elevations and not just the 6 foot elevation. Clarify the PCT differences (both the CQD CCTF PCT differences and the CCTF Run 58 PCT differences) at the other elevations and discuss the potential for their impact on the code uncertainty. Do the changes made to the operating plant code uncertainty calculation in Reference 5 (Superposition) impact the AP600 uncertainty calculation and the response to RAIs 440.345/357?

   (b) Also, the response to questions 440.345 and 440.357 referred to CQD Section 19 as providing the WCOBRA/TRAC code uncertainty calculations. However, the CQD Section 19 calculations are for the MOD7 code version while the NRC review is based on the MOD7A, Revision 1, code version. The code assessment for MOD7A, Revision 1, is based on the MOD7A code version because the Revision 1 changes had a negligible impact on the code assessment. Therefore, Westinghouse should provide responses to these questions in light of the MOD7A results provided in Reference 6, and clarify any differences that would result.

4. Westinghouse response to question 440.346:

The response noted there are not specific peculiarities associated with the 2x4 configuration used in the AP600 design that need special model nodalization attention. This is consistent with staff experience. In addition, Westinghouse noted the LOFT facility (Reference 7) and the UPTF Facility (Reference 8) provided separate assessments of the two hot legs and four cold legs configuration. However, some followup information is needed. The modeling of the vessel/loop connections was given careful consideration in the operating plant review, and this modeling is still important for the AP600. Therefore, clarify how the K factor for reverse flow through the cold leg nozzles is applied to the AP600, and how losses for forward flow are modeled. How is the uncertainty in this model input covered in the AP600 LBLOCA uncertainty analysis?

5. Westinghouse response to question 440.347:

The response stated that the G-1 (Reference 9) and G-2 (Reference 10) tests analyzed in the CQD provided the needed verification of the blowdown cooling calculated by WCOBRA/TRAC during the AP600 LBLOCA analysis. To support this assertion, clarify the following items.

(a) Westinghouse stated the G-1 and G-2 assembly liquid downflow mass fluxes were similar to that calculated for AP600. While the AP600 value was provided, the mass fluxes from the G-1 and G-2 tests were not provided. Therefore, provide the G-1 and G-2 test mass fluxes on the same basis as the AP600 value to verify the AP600 mass flux is bounded by the test conditions.

(b) Review of TRAC-PF1/MOD2 (Reference 11) analysis for the limiting AP600 LBLOCA (Reference 12) found that different results were calculated for the blowdown cooling period relative to the Westinghouse results. This was due to differences in core inlet flow and core steam generation that impeded core downflow from the upper plenum. Clarify how the G-1 and G-2 tests verified the WCOBRA/TRAC calculated flow split of the flow from the upper plenum to the core versus the upper plenum to the hot leg to feed the break. Are the G-1 and G-2 facility designs prototypical of the AP600 in the upper head/upper plenum/hot leg region? If the G-1 and G-2 tests do not verify the accuracy of the upper plenum flows, clarify which tests in the code assessment matrix do verify this flow split for AP600 conditions or provide additional assessment cases. Describe how the calculation of the core inlet flow during the accident is verified. Justify why the Westinghouse modeling- calculation of core inlet flow is correct for AP600 LBLOCA.

6. Westinghouse response to question 440.348:

(a) Part (a) asked Westinghouse to compare WCOBRA/TRAC calculated flooding curves for CCTF Run 58 and Upper Plenum Test Facility (UPTF) Test 21 (Reference 13) to those based on test data. Westinghouse's response implied that appropriate comparisons could not be made because CCTF Run 58 conditions did not include ECC bypass and the UPTF correlation (Reference 14) did not apply to downcomer injection tests. Is there sufficient test data from CCTF Run 58 and UPTF Test 21 to develop a flooding curve to compare to that calculated with WCOBRA/TRAC? If yes, provide the comparisons for review.

(b) Westinghouse's response to part (b) noted the conservative WCOBRA/TRAC calculation of UPTF Test 21. Other Westinghouse responses also noted this conservatism (for example, see the response to question 440.357). One issue that Westinghouse did not address in applying these conservative results to AP600 is the difference in DVI location between UPTF (slightly above the cold leg elevation) and AP600 (approximately 3 feet below the cold leg centerline). Clarify the effect of this DVI location difference to justifying that WCOBRA/TRAC will result in a conservative calculation of DVI injection for AP600.

(c) For part (c), Westinghouse determined that WCOBRA/TRAC calculated the UPTF Test 6 (Reference 15) to Test 21 differences correctly. For CCTF Run 58 to Run 62 (Reference 16) differences, however, the WCOBRA/TRAC results differed from that observed in the experiments. In particular, the experimental Run 62 results showed no downcomer/core oscillations while the Run 58 results showed downcomer/core oscillations and a slower quench front progression. However, the WCOBRA/TRAC calculation for Run 62 calculated downcomer/core oscillations and a slower quench front progression relative to the WCOBRA/TRAC Run 58 calculation which did not show downcomer/core oscillations. Clarify how these results support WCOBRA/TRAC's ability to calculate DVI in AP600. Also, the recalculated results for CCTF Run 58 in the RAI response showed that: (a) the WCOBRA/TRAC results tended to overpredict and underpredict the steam and liquid mass flows, respectively, and (b) there were some differences in the downcomer and core differential pressure comparisons. Please explain these differences.

(d) In the part (e) response, Westinghouse provided two tables comparing UPTF Test 21 conditions to the AP600 worst case LBLOCA. Conditions for AP600 are similar to those for Run 274/Phase BII. However, WCOBRA/TRAC calculations for Run 274/Phase BII showed little or no lower plenum penetration by the ECC (Figure 440.348-52), whereas, the WCOBRA/TRAC calculation for the AP600 worst case LBLOCA showed the ECCS successfully penetrated the lower plenum (Reference 2, Figure 2.2-28) and mitigated the accident. Clarify the reasons for the difference in ECCS behavior between the UPTF analysis and the AP600 analysis given the similarity of test and plant conditions.

7. Westinghouse response to question 440.350:

   Response part (c) (and part of (d)) to 440.350 noted that the LOFT comparisons in the CQD verified the WCOBRA/TRAC AP600 model's capability to predict lower plenum filling behavior with the low resistance in the AP600 lower plenum. Clarify this response because the code/data comparisons in the CQD do not compare lower plenum filling rate/behavior. Provide additional data comparisons to verify the lower plenum filling behavior is correctly calculated for AP600. Also, while Westinghouse's response to part (c) discussed the AP600 calculated response to DVI, Westinghouse did not address the effect of the different AP600 lower plenum geometry on lower plenum sweep out and ECC bypass and how WCOBRA/TRAC was verified to correctly calculate those effects.

8. The Westinghouse phenomena identification and ranking table (PIRT) for AP600 submitted by Westinghouse letter dated April 4, 1996, provided numerical rankings for LBLOCA phenomena. Because of the operating plant review and the differences between the WCOBRA/TRAC and TRAC-PF1/MOD2 results, the following questions arose regarding the AP600 PIRT:

   (a) Westinghouse left the fuel rod gap conductance unranked in the AP600 and operating plants PIRTs. For the operating plants, however, the gap conductance was directly included in the uncertainty evaluation. Westinghouse indicated at a March 1996, meeting that the AP600 uncertainty evaluation would be based on that for operating plants; therefore, gap conductance would be directly included in the AP600 uncertainty evaluation. Is there anything from the operating plant uncertainty evaluation (such as parameter sensitivity studies or as indicated in the paper by E. Elias and G. Yadikaroglou in Nuclear Safety Volume 19, Number 2, (see page 163)) that would cause Westinghouse to reevaluate the PIRT gap conductance ranking for AP600? Additional information or justification on the AP600 PIRT ranking for gap conductance is needed. See also part (d) of this question.

   (b) The AP600 PIRT did not rank upper plenum countercurrent flow (CCF/fall back). Given the different response calculated with TRAC-PF1/MOD2 regarding blowdown cooling as a result of upper plenum CCF/fall back (which implies uncertainty in the calculated results), clarify the basis for this ranking. How will the Westinghouse AP600 uncertainty evaluation account for the uncertainty in this phenomenon? Justify uncertainty in upper plenum CCF/fallback is appropriately accounted for with this method. See also part (d) of this question.

(c) The upper head is an important source of water for the blowdown cooling calculated in AP600. The upper head temperature will influence when the upper head water flashes and significant draining of the upper head occurs. What is the expected uncertainty in the upper head temperature? How is this uncertainty accounted for in the uncertainty evaluation? Does the upper head temperature need to be ranked in the AP600 PIRT?

(d) The NRC AP600 PIRT developed by Los Alamos National Laboratory (LANL), Reference 12, was very detailed relative to previous PIRTs in the CSAU study (Reference 17) and the Westinghouse AP600 PIRT. Based in its review of the LANL PIRT, the staff notes the following items may be important to include and/or have a modified ranking in a revised Westinghouse AP600 PIRT: downcomer interfacial drag/entrainment/deentrainment in blowdown; accumulator discharge; degraded pump performance during blowdown; rod gap conductance; core entrainment/deentrainment (all three periods), core top down flow/CCF (all three periods), core level/oscillations (during reflood), core interfacial heat/mass transfer (during reflood), and core multidimensional behavior (during reflood); upper plenum multidimensional flow and flow distribution (Hot legs/core) during blowdown and reflood; upper plenum/core CCF (all three periods); and hot leg flow phenomena during reflood. Explain either why these items were not ranked, or explain the Westinghouse PIRT rank assigned to these items relative to the LANL PIRT.

(e) In its response to Volume 1, question 2 of Reference 18, Westinghouse provided PIRT comparisons for AP600 and three- and four-loop operating plants with the CSAU PIRT, Reference 17. That response was helpful because it provided the basis for the rankings assigned by Westinghouse; however, because of that review's focus on operating plants, AP600 specific information was minimal. An explanation of the basis for AP600 PIRT rankings and differences between AP600 PIRT rankings and the rankings in the CSAU and LANL PIRTs similar to the Volume 1, question 2 response described above would be useful.

(f) Clarify how the highly ranked items in the AP600 PIRT (ranked 7, 8, and 9) are accounted for in the AP600 uncertainty evaluation.

9. NRC AP600 audit calculations using TRAC-PF1/MOD2 (Reference 11) showed some differences in calculated behavior relative to the AP600 behavior described by Westinghouse in the response to Question 440.348. Clarify the reasons for the following differences:

(a) Differences in calculated degraded two-phase pump behavior that impact whether liquid reenters the bottom of the core and affects the blowdown cooling discussed in question 5.

(b) Westinghouse stated that core/downcomer oscillations were not likely in AP600 WCOBRA/TRAC calculations due to the location of the DVI line. The NRC calculation showed core/downcomer oscillations.

(c) Westinghouse stated the DVI nozzle would cover and likely remain covered in AP600 WCOBRA/TRAC calculations. NRC calculations showed the downcomer level does not recover to submerge the DVI nozzle.

10. Review of Reference 19 also indicated the following AP600 calculated responses that appear to be different from that calculated by Westinghouse in its WCOBRA/TRAC AP600 analyses:

(a) TRAC-PF1/MOD2 analyses show variations in core rewet and heat transfer that varies with the modeled rod radial/azimuthal location and position relative to the break. Westinghouse's WCOBRA/TRAC model does not represent the core in such a manner to allow this type of variation to be calculated. Is calculating this type of response important enough so that Westinghouse should consider making core model changes needed to calculate this type of response?

(b) Choking at the DVI nozzle during accumulator injection was calculated in the TRAC-PF1/MOD2 audit calculation. Does Westinghouse calculate similar choking? If no, explain why not. Is calculating DVI nozzle choking important to the AP600 calculated response?

(c) The TRAC-PF1/MOD2 audit calculations calculated a three-dimensional flow pattern in the core and upper plenum during reflood. In the core, flow was from the low power peripheral assemblies to the hot channel. In the upper plenum, flow was from the location above the hot channel to the low power peripheral assemblies. Does Westinghouse calculate a similar response in its WCOBRA/TRAC calculations? If no, explain why not. Is calculating this three-dimensional behavior important to the AP600 calculated response?

(d) The audit calculation showed that liquid draining from the pressurizer flowed to the upper plenum and contributed to the liquid that entered the core during blowdown and provided top down cooling. In the AP600 standard safety analysis report (SSAR) (Reference 20), Westinghouse stated that the pressurizer was located on the unbroken loop hot leg based on past sensitivity studies completed for the upper plenum injection plants. Given the calculated core-wide blowdown rewet in the latest WCOBRA/TRAC AP600 analyses, does this sensitivity analysis need to be redone for AP600 to ensure the unbroken loop hot leg is the most conservative location for the pressurizer during AP600 LBLOCA analyses? This question relates to whether the pressurizer flow impacts significantly the blowdown cooling calculated in WCOBRA/TRAC AP600 analyses.

11. Do the responses to questions 9 and 10 indicate a need to modify the Westinghouse AP600 PIRT?

12. Question 5 above requested additional information on the range of conditions in APGOO analyses versus the assessment matrix. Because Westinghouse now intends to apply the uncertainty methodology developed for operating plants to AP600, it is also important to verify that the assessment range of conditions for operating plants plus the AP600 specific assessment bounds the range of conditions for AP600. This should be done for all items ranked high (7,8, or 9) in the Westinghouse AP600 PIRT and/or identified in Regulatory Guide 1.157 (Ref. 21). If the assessment range of conditions does not bound that expected in AP600, some additional assessments to cover the appropriate ranges should be provided.

13. Question 8 above requested additional information on the Westinghouse AP600 PIRT. The following information is also needed to clarify the latest Westinghouse PIRT (Ref. 22).

    (a) During the operating plant review, discussions with Westinghouse indicated that the PIRT rankings for AP600 core entrainment/deentrainment and AP600 three and four loop plants for upper plenum entrainment/deentrainment were more appropriately ranked as 8 rather than 6 as currently shown in the AP600 PIRT. Clarify why these changes have not been made to the latest AP600 PIRT rankings.

    (b) Clarify the basis for the difference in containment pressure ranking for AP600 relative to operating plants.

    (c) For AP600, explain the ranking given to reactivity - void during blowdown as this phenomenon is one which shuts down core reactivity.

14. In Reference 23, Westinghouse discussed its approach to the AP600 treatment of uncertainty. In its letter:

    (a) Westinghouse chose to treat a number of items in AP600 differently from the operating plant review. Provide justification for this different treatment.

    (b) Westinghouse did not discuss the uncertainty treatment for the code and model uncertainty. Describe and justify how this component of uncertainty will be treated in AP600 analysis.

    (c) Explain why grid deformation from seismic/LOCA loads was shown as not applicable to AP600. Is this based on NRC reviewed and approved analyses? If no, please clarify the status of the review process.

WCOBRA/TRAC LONG TERM COOLING QUESTIONS

The following questions refer to SSAR Section 15.6.5.4C and supplement the open items discussed in the SDSER on this subject.

1. In the three windows presented, boiling in the core takes place in subcooled water, thus, segments 4 and 5 bubbles collapse as they rise. If the sump (and the core) water were saturated would: (1) the pressure distributions (inside and out of the vessel) be the same? (2) the water head be the same? (3) the water level in the core be the same? (4) the two phase rising bubbles cover the core? and (5) the peak clad temperature be the same?

2. In the LTC following the 2 inch small break LOCA the containment pressure was assumed to be 8 psi. However, the saturation temperature is reported as 260 °F, which corresponds to a higher pressure. Please explain this discrepancy. Please discuss the expected pressure variations in the containment and the vessel throughout the transient and explain why the analysis assumptions are conservative.

3. The two windows chosen for the LTC following a large break LOCA, are not convincing regarding the effectiveness of the passive cooling system. This is partly due to lack of information regarding: (1) pressure variation during LTC (2) variation of the available sump head during LTC and (3) the effect of saturation temperature in the sump on: flows, temperature distributions, pressure distributions, and available injection head. Please provide additional information in these areas for the LTC analyses.

REFERENCES

1. B. A. McIntyre, Westinghouse letter to USNRC Document Control Desk, "Westinghouse Responses to NRC Requests for Additional Information on the AP600," NTD-NRC-95-4598, Docket No. STN-52-003, November 17, 1995.

2. Westinghouse Electric Corporation, WCOBRA/TRAC Applicability to AP600 Large-Break Loss-of-Coolant Accident, WCAP-14171-P, September 1994.

3. J. Sugimotgo, et al., Data Report on Large Scale Reflood Test -78, CCTF Core-II Test C2-AA2 (Run 58), JAERI-memo 59-446, February 1985.

4. Westinghouse Electric Corporation, Code Qualification Document for Best Estimate LOCA Analysis, Volumes 1 (Revision 1) to 5, WCAP-12945-P, June 1992 to June 1993.

5. N. J. Liparulo, Westinghouse, letter to USNRC Document Control Desk, "Confirmatory Items Related to the Review of WCAP-12945-P," NSA-SAI-96-019, January 24, 1996.

6. S. M. Bajorek, Westinghouse, letter to C. P. Fineman, INEL, NTD-NSA-MYY-94-65, November 11, 1994 (Submittal U).

7. D. L. Reeder, LOFT System and Test Description (5.5-ft Nuclear Core 1 LOCEs), NUREG/CR-0247, TREE-1208, July 1978.

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14. H. Glaeser, "Downcomer and Tie Plate Counter-current Flow in The Upper Plenum Test Facility (UPTF)," Nuclear Eng. and Des., 133, 1992, pp. 259-283.

15. 2D/3D Program UPTF Experimental Data Report, Test No. 6, Downcomer Counter current Flow Test, U9 316/89/2, KWU, 1989.

16. T. Okubo, et al., Data Report on Large Scale Reflood Test -- 82 --- CCTF CORE-II TEST C2-4 (RUN 62)---, JAERI-memo 59-540, 1984.

17. R. A. Shaw, et al., Development of a Phenomena Identification and Ranking Table (PIRT) for Thermal-Hydraulic Phenomena During a Large-Break LOCA, NUREG/CR-5074, EGG-2527, November 1988.

18. S. M. Bajorek, Westinghouse, letter to C. P. Fineman, INEL, NTD-NSA-MYY-95-12, April 21, 1995.

19. J. F. Lime and B. E. Boyack, Updated TRAC Analysis of 80 percent Double-Ended Cold-Leg Break for the AP600, LA-UR-95-4431.

20. Westinghouse Electric Corporation, Simplified Passive Advance Light Water Reactor Plant Program, AP600 Standard Safety Analysis Report, DE-AC03-90SF18945, Revision 5, February 29, 1996.

21. US Nuclear Regulatory Commission, Regulatory Guide 1.157: Best-Estimate Calculations of Emergency Core Cooling System Performance, May 1989.

22. B. A. McIntyre, Westinghouse letter to NRC, "AP600 Large Break LOCA Phenomena Identification and Ranking Table," NSD-NRC-96-4685, April 4, 1996.

23 B. A. McIntyre, Westinghouse letter to NRC, "AP600 Large Break LOCA Methodology (Treatment of Uncertainty)," NSD-NRC-96-4684, April 4, 1996.