April 3, 1997

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

SUBJECT: REQUESTS FOR ADDITIONAL INFORMATION (RAIs) ON THE NOTRUMP FINAL VALIDATION REPORT

Dear Mr. Liparulo:

In support of the AP600 design certification review, the Nuclear Regulatory Commission (NRC) staff is evaluating the use of the NOTRUMP small break loss-of-coolant-accident analysis computer code for assessing the performance of the AP600. Westinghouse letter NSD-NRC-96-4920, dated December 18, 1996, submitted the NOTRUMP Final Validation Report, WCAP-14807 (without the Oregon State University (OSU) validations). Westinghouse letter NSD-NRC-97-4960 dated January 31, 1997, provided the OSU validations needed to complete the report. Based on a review by the NRC staff and its contractor, additional information is needed for the review. These RAIs are provided as an enclosure to this letter.

If you have any questions regarding this matter, you can 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

cc w/encl: See next page

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Docket No. 52-003
AP600

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REQUEST FOR ADDITIONAL INFORMATION
NOTRUMP FINAL V&V REPORT, WCAP-14807

General Comments

440.599 The report needs to document the specific judgements made by the Westinghouse analysts of the validity of each modified code model. Additionally, even though Westinghouse is making an Appendix K submittal, they have based much of their final V&V report on high-ranked PIRT phenomena. Therefore, the report needs to document Westinghouse judgements of the ability of NOTRUMP to correctly represent all PIRT high-ranked phenomena. These judgements should be summarized at the end of each applicable report section and a summary of all of the assessments should appear in the conclusions of the report. These judgements should be made using the terms defined in Section 1.5. In cases where the judgement would be minimal or inadequate, analyses should be provided which show that the code results are conservative.

Specific Comments

440.600 Section 3.2.2 discusses the validity of the Yeh correlation used in the drift flux model for core flooding. It indicates that the validity of the model is shown in reference 3-4. Reference 3-4 was written in 1985. The Yeh correlation used in NOTRUMP was modified recently as documented in section 2.3. Please provide a validation that is applicable to the modified Yeh correlation that is currently found in NOTRUMP.

440.601 Section 3.2.5 states that "...CCFL is correctly predicted by NOTRUMP..." but then it continues to say that "... NOTRUMP will tend to predict more holdup of liquid... than indicated by data." Please make a specific judgement using the terms defined in Section 1.5.

440.602 Section 3.3.4 states that the flow reversal point predicted by NOTRUMP occurs at a lower vapor flow than indicated by the data. Does this considerable discrepancy indicate that the leveling drift flux model performance is reasonable or minimal? Is this behavior conservative?

440.603 There are two apparently inconsistent references to Figure 3.4-11 in Section 3.4. The first reference is at the bottom of page 3.4-2 and it appears to refer to a figure that has been omitted. The second reference to Figure 3.4-11 is at the top of page 3.4-3. This second reference does match the Figure 3.4-11 that is included. Please provide the omitted Figure and renumber the remaining figures.

440.604 Please add conclusions to Section 3.4.

Enclosure

440.605 Figure 5.4-18 shows a step change in the PE5W data which appears erroneous. This was not discussed in the text. Including this step change distorts the scale of the plot. Please redraw the plot with the scale adjusted so the top of the step change is not included but the remainder of the plot is shown larger. Please explain the step change in the text.

440.606 The Westinghouse response to RAI 440.440 states that, "thermal stratification effects in the CMT are not identified as a specific thermal-hydraulic phenomena on the final small break LOCA PIRT chart." However, thermal stratification effects in the CMT are included as high-ranked phenomena on both the Westinghouse and the NRC PIRT charts. Please explain this difference. The RAI also requested that Westinghouse provide plots of the fluid driving heads calculated by NOTRUMP for each side of the CMT loop. Westinghouse responded that the requested plots would be provided in the final V&V report. The requested plots were not provided in the final V&V report.

440.607 None of the NOTRUMP calculations (CMT test, SPES, nor OSU) predict the CMT temperature distribution observed in the test data. In the integral facility simulations this has caused delays in the start of ADS-1 as well as overly warm fluid being injected from the CMTs. It might be easier to develop a thermal stratification model for the CMTs rather than explain the discrepancies. In any case, this difficulty needs to be discussed in greater depth.

440.608 It appears that the NOTRUMP model of the SPES facility may underestimate the ambient losses and overestimate the heat transfer between the primary and the secondary. This should be discussed in more detail.

440.609 The Westinghouse response to RAI 440.489 indicates that nodalization studies would be performed to assess ways of improving PRHR heat transfer and the results would be presented in the final V&V report. The final V&V report did not document the results of any such nodalization studies and the PRHR heat transfer is found to be persistently underestimated by NOTRUMP when compared to the data from the SPES and OSU test facilities. Can these problems be fixed merely with a different nodalization or do they indicate an intrinsic deficiency in the NOTRUMP code? The Westinghouse response to RAI 440.513 indicated that the additional PRHR modeling issues raised in that RAI would be resolved in the final V&V report. These issues remain unresolved.

440.610 The Westinghouse response to RAI 440.504 points out that using a check valve connected between the ADS 1-3 line and atmospheric pressure to represent the vacuum breaker was ineffective. A more accurate representation of the elevation changes in the ADS 1-3 line would have made the vacuum breaker model effective. Perhaps a more accurate representation would be useful to resolve other problems as well. The OSU and SPES models of the pressurizer and ADS 1-3 do not predict as much pressurizer refill during ADS 1-3 flow as is observed in the tests and the model of the OSU pressurizer drains too quickly once ADS4 begins to flow. These problems might be fixed by merely improving the NOTRUMP input

specification but may also require code modifications. Please analyze and document what nodalization changes have been considered to improve the ability of the NOTRUMP model to match the SPES and OSU data for pressurizer level beyond the time when ADS 1 opens.

440.611 RAI 440.510 asks for an explanation for why the NOTRUMP code overpredicts the IRWST injection flow rates during the early part of IRWST injection. The Westinghouse response indicates that this is caused by over prediction of ADS 4 flow. The final V&V report indicates that it is caused by a low pressure in the DVI line in the calculation. This behavior (overprediction of the initial IRWST injection) was observed in nearly all of the calculations of SPES and OSU even though the ADS4 flow is not always overpredicted. Please provide a more complete explanation.

440.612 The OSU model does not include ambient losses from the steam generator secondary. An explanation should be provided to justify why this is acceptable.

Report Details

The final V&V report does not address some known problems with the OSU tests. For example, in test SB12 a leaky check valve in the NRHR system caused unusual CMT recirculation flow. In the final V&V report, Westinghouse has removed the test data trace for the CMT injection flow rate from Figures 8.3.4-21 and 8.3.4-22. If these two figures had included the data traces, the effect of the leaky check valve would have been evident. In the earlier NOTRUMP preliminary Validation Report for OSU tests, Figure 5.4-16 included the test data trace for the CMT injection flow rate and the leaky check valve was detectable from the magnitude of the recirculation flow. In similar ways elsewhere in the report, Westinghouse did not address several other important problems with test performance, instrumentation, and calculation results. Some of these problems are briefly discussed but dismissed without detailed explanations. The following questions are examples of some of these occurrences.

440.613 On page 7.3.1-3, Westinghouse states that the NOTRUMP calculation relies excessively on steam generator heat transfer because of low PRHR heat transfer. On page 7.3.1-7 in the discussion of Figures 7.3.1-37 through 7.3.1-39, Westinghouse states that the initial secondary pressure was set higher than in the test in order to match the primary conditions. This implies that when the NOTRUMP secondary pressure was set at the experimental value, the primary temperature was too low. In order to raise the primary temperature the secondary pressure was raised. This is an indication that the heat transfer from the primary to the secondary is too high. Thus, the excess reliance on the steam generators in the NOTRUMP calculation may be due largely to the excessive primary to secondary heat transfer and only partially to the low PRHR heat transfer. Please explain the root cause for the overprediction of the heat transfer through the steam generators. Is it due to an inadequacy in the NOTRUMP code itself or only in the SPES input? How does this impact the AP600? (Note: this problem is persistent for all of the SPES test analyses.)

440.614 At the bottom of page 7.3.1-5 and for each of the SPES test analyses, Westinghouse says that the upper head does not drain properly in the NOTRUMP model because of differences in the initial upper head temperature, flow rates, and ambient losses. All of these things could have and should have been corrected in the SPES NOTRUMP input. Why weren't these errors corrected?

440.615 All of the SPES and OSU NOTRUMP calculations have a problem that whenever any water enters the cold legs it passes up the balance lines. This is not physically accurate. Is this due to deficiencies in the horizontal stratification model or a horizontal stratification entrainment model?

440.616 Figures 7.3.3-27 and 28 show that NOTRUMP considerably underpredicts the ADS flow but on page 7.3.3-6 the text says that the agreement is reasonable. Please reevaluate this judgement.

440.617 On page 7.3.3-7 the discussion of Figure 7.3.3-39 says that the secondary level for steam generator B in the test is not available. However, the steam generator B level does appear on the plot. Please revise the text and explain the steam generator B level.

440.618 On page 7.3.4-2 Westinghouse merely says that the cold leg temperature is underpredicted. There is no discussion of why. Please provide the reason why.

440.619 On page 7.3.4-4 Westinghouse states that the performance of accumulator B is unimportant. However, it appears that an overprediction of the accumulator B flow causes CMT B flow to be unduly reduced. This delays the predicted draining of CMT B and delays ADS. That makes the performance of accumulator B important. The flow resistance should be modeled correctly. Please revise this section to acknowledge the importance of the accumulator B flow or provide enough information to justify the Westinghouse position.

440.620 On page 7.3.4-4 Westinghouse states that the downcomer level is overpredicted without explanation. Then it is stated that the predictions are adequate. The agreement to data appears to be minimal. NOTRUMP predicts a higher core level at the time of the minimum core level in the test. Additionally, the core level prediction is not well matched to the data at the start of IRWST injection. Please reevaluate the discussion of these issues.

440.621 On page 7.3.4-5, in the discussion of Figure 7.3.4-21, Westinghouse points out some considerable problems with the agreement of the NOTRUMP prediction and the test data but does not discuss the cause of the discrepancies. Please provide an explanation of the discrepancies.

440.622 In Figure 7.3.4-24, the agreement between the NOTRUMP prediction and the test data appears to be minimal. Please provide an explanation and/or a new calculation.

440.623 At the top of page 7.3.4-6, Westinghouse says that NOTRUMP underpredicts the downcomer voiding. This is only true for the tubular part of the downcomer. Voiding in the annular part of the downcomer is overpredicted by NOTRUMP. Please provide an explanation.

440.624 On page 7.3.4-6, Westinghouse says that Figure 7.3.4-32 compares the PRHR heat transfer but provides no discussion. Please discuss the results shown in this figure.

440.625 The results shown in Figure 7.3.5-11 are quite different from other tests. Please provide an explanation of these results.

440.626 In all of the NOTRUMP calculations for OSU the distribution of fluid in the vessel is skewed when compared to the test data. The calculated core level is consistently low and the downcomer level is consistently high. Is it possible that NOTRUMP is failing to represent an important phenomenon?

440.627 In Figure 8.3.1-22, NOTRUMP underpredicts the CMT 2 recirculating flow rate. This could be an effect of the leaky check valve in the NRHR system. Please comment.

440.628 In the discussion of Figure 8.3.1 27, Westinghouse says that no conclusions can be drawn. ADS1-3 flow is a highly-ranked PIRT item for which the ability of NOTRUMP must be assessed. Westinghouse points out that the fluid conditions were different. Please explain why the fluid conditions were different. Discuss the implications to AP600 calculations, possible causes, and possible solutions to the problem.

440.629 In Figure 8.3.1-29, the predicted break flow is quite inaccurate. Westinghouse explains that this is because accumulator water reaches the break. Please make a judgement of the NOTRUMP ability to properly model the break flow. Why does the accumulator water reach the break in the calculation and not in the test? How can this be fixed? How will this affect AP600 calculations? Is this conservative?

440.630 Please explain the sudden drops in the calculated secondary temperatures in Figure 8.3.1-38.

440.631 Please draw some conclusions from Figures 8.3.1-42 and 43. Why is the calculated temperature high? Could this cause the low core level?

440.632 For OSU test SB23 the break area was not the area of the installed orifice. How did this happen? What was the break area? Is this related to the problem with the break area in the performance of test SB05.

440.633 In the discussion of OSU test SB23 on page 8.3.2-3, Westinghouse mentions that the test data appears to have found a source of vapor that drains the tubes in steam generator 1. Is this real? Could this be an instrument problem? Please explain where the vapor came from and why it only exhibited its presence in the draining of the steam generator 1 tubes.

440.634 There is some confusion either in the text or in the Figure labels for Figures 8.3.2-6 through 9. Steam generator 1 and steam generator 2 may be switched.

440.635 There are many problems with OSU test SB23 (both the test itself and the calculation). Credibility of the final V&V is diminished by the Westinghouse claim that there is reasonable agreement between NOTRUMP and the test data considering all the test uncertainties and the calculation adjustments. Westinghouse should reassess this conclusion.

440.636 Please provide an explanation of the poor agreement in Figure 8.3.3- 40.

440.637 In Figure 8.3.4-5 the flow from accumulator 2 affects the flow from CMT2 far more in the NOTRUMP calculation than in the test. Please explain.

440.638 On page 8.3.4-6 at the end of paragraph 1 and the beginning of paragraph 2, no conclusions were drawn regarding ADS 1-3 flow. Please document what causes the discrepancies in ADS 1-3 flow, break flow, and pressurizer level.

440.639 There is a persistent problem in both SPES and OSU NOTRUMP calculations caused by water entering the cold legs when there is no water there in the tests. Why does this happen? Can you present comparison figures showing the cold leg levels in the test and the calculation? Many of the NOTRUMP inaccuracies are blamed on problems with the cold leg levels. Please provide more documentation on what the cold leg levels are. Please evaluate how these level problems can be eliminated.

440.640 On page 8.3.5-4 Westinghouse discusses Figures 8.3.5-10 and 11 and points out that the calculated behavior of the balance line level is wrong beyond 1500 s. Yet Westinghouse states that NOTRUMP predicts well the PIRT items related to the balance line. This is confusing and requires more explanation. Please reassess this judgement and revise the section to clearly explain that the refill is caused by nonphysical refill of the cold legs.

440.641 On page 8.3.6-2 in the second paragraph, the calculated behavior of CMT1 is very different from the test data. Why? What does this say about NOTRUMP?

440.642 In the last paragraph on page 8.3.6-3, 55 seconds is wrong. Perhaps it should be 5.5 seconds.

440.643 The comments contained in RAIs 440.613 through 440.642 are examples of areas in the final V&V where discussions do not appear to be adequate. Please re-examine the analyses presented in the final V&V report for areas which need additional discussion or explanation.

Quench Model

440.644 For each case where the quench model was used, a mixture level plot should be included that shows the calculation results with and without the quench model. Please specify the guidelines that should be followed in order to decide whether the quench model needs to be used. Clearly state that, because of these guidelines, no AP600 analysis would ever use the quench model.