52-803

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

January 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, Pennsylvania 15230

SUBJECT: COMMENTS ON THE REVISED AP600 PRHR HEAT EXCHANGER FINAL TEST REPORT

Dear Mr. Liparulo:

Westinghouse letter NSD-NRC-96-4868, dated November 5, 1996, submitted revision 2 to WCAP-12980, AP600 Passive Residual Heat Removal (PRHR) Heat Exchanger (HX) Test Final Report. The revision addresses previous Nuclear Regulatory Commission (NRC) staff comments and concerns documented in a January 23-24, 1996 meeting, summary dated February 21, 1996. The NRC staff has reviewed the revised PRHR HX test report WCAP and has additional questions and comments which are included as an enclosure to this letter.

The staff has also begun to review the draft safety evaluation report open item (DSER) response to open item 21.3.3-1 on the applicability of the straight tube PRHR HX test data to the "C"-tube configuration. This information was submitted by Westinghouse letter NSD-NRC-96-4660 dated March 6, 1996. The staff had previously informed Westinghouse that it would not review the open item response until it had received and reviewed the revised PRHR HX test report. Based on a preliminary assessment, the Westinghouse response to open item 21.3.3-1 does not appear to address the staff's major concern as to the performance margin available in the design if critical heat flux (CHF) in the horizontal tube bundle were exceeded. In numerous discussions with Westinghouse on this issue, the staff has suggested that a sensitivity study be provided demonstrating that even if a substantial portion of the PRHR Heat Exchanger (HX) was deactivated due to CHF, it could still perform its design basis function. During the December 18 and 19, 1996 ACRS, thermal-hydraulic subcommittee meeting on the AP600 test program, Westinghouse implied that such an analysis had been done but had not been submitted to the NRC for review.

If Westinghouse continues to use arguments that have their basis in single tube or single wire data that are of questionable utility when analyzing a bundle of tubes, the staff remains doubtful that the PRHR data can be proven applicable to the C-tube design, especially on the horizontal section.

The staff notes that when the response to open item 21.3.3-1 was prepared, Westinghouse was in the process of revising the PRHR test program report, including reanalysis of all of the data. The staff must conclude that any insights from the additional analysis or revisions to the heat transfer correlations that may have resulted from the reanalysis has no bearing on the open item response.

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To resolve this issue, Westinghouse should consider providing to the staff an appropriate set of sensitivity studies, using a conservative estimate of the heat transfer from the active portion of the HX and varying the deactivated portion (due to CHF) of the HX over a range of both forced and natural convection conditions. Acceptable results of such a sensitivity study, along with insights from ROSA and a commitment (in Chapter 14 of the SSAR) to perform testing in-plant (during power ascension) to verify the performance capability of the PRHR HX (or, alternatively, a Tier 1 commitment by Westinghouse to test a prototype heat exchanger before the first plant is built) would enable the staff to complete its safety evaluation of the PRHR test program.

Many of the enclosed questions and comments on the PRHR final test report do not merit the issuance of formal RAIs. To expedite the review process, Westinghouse is requested to provide brief written responses to each item in the enclosed material which can then be used to conduct detailed discussions during a subsequent telecon or meeting. The staff requests that Westinghouse provide the written responses to the enclosed items in advance of any further discussions (except requests for clarifications by Westinghouse). The staff expects that the enclosed questions and comments will be included in the open item tracking system so that the status and disposition of these items can be tracked.

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

cc w/enclosure: See next page

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DOCUMENT NAME: A: PRHR-COM.INL * See previous concurrence

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Mr. Nicholas J. Liparulo
Westinghouse Electric Corporation

Docket No. 52-003
AP600

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Staff Comments on PRHR Report

The revised report represents a significant improvement over the original version submitted to the NRC. In general, the data appear to have been analyzed appropriately; there are, however, some inconsistencies and errors that need to be corrected. The outstanding question of applicability to the current "C"-tube HX design is not addressed to any significant degree in the report. Additional comments include:

Technical

1. It would be helpful for the reader to know which orifice plate was used for each test, to better understand how flow data are computed.

2. Uncertainties in actual data are appropriate and useful. However, given the importance of the information derived from the raw data, estimates of the uncertainties in derived quantities, such as flow rates, heat transfer rates, and heat transfer coefficients should be provided.

3. The discussion in Section 8 is somewhat misleading and rather difficult to follow, in some cases, due to errors in the figures (see below). The data do seem to support a conclusion that the tank is well-mixed radially (e.g. Fig. 8-25). Vertical mixing, however, is not as efficient, and the discussion on p. 8-5 seems to focus on long-term behavior ($\geq$9500 sec). Comparing the top and bottom tank elevations overlooks, for instance, the behavior shown in Table 8-8, before the top of the tank saturates. Here (column "D"), while there is only 42°F gradient between the 23.917 and 1.917 ft elevation (the reference in the text to the 4.917 elevation as the lowest is not clear), there is almost 95°F between the 1.917 and tube-top (19.917 ft) elevations.

4. The staff understands that the report is limited, for the most part, to a discussion of the test program without any specific consideration of applicability to the current AP600 PRHR HX design (which has been addressed by Westinghouse in RAI responses). Nevertheless, some of the discussion in Section 8 is also misleading in this regard. For instance, in discussing the plume tests, Section 8-2 (p. 8-3) states, "...there should be no interactions between rows of HX tubes exist (*sic*) when the distance between the rows is 2 feet or more." While this may have been a pertinent observation for the 1989 HX design, it has no relevance whatsoever to the current design. Similarly, when discussing "zones of influence" of the plume, the report indicates that there is a minimum of tube-to-tube interaction. Since the tube spacing (center-to- center) is 1.5" within rows of the current HX design and 3" between rows, and the plume measurements show an influence, in some cases, more than 1.5" from the tube centerline, it seems reasonable to believe that there will, in fact, be some degree of tube-to-tube interaction in the current design. Note, too, that the measurements presented in Figs. 8-7 and 8-8 represent plumes between the tank wall and a tube; no data are shown that would correspond to a plume (or interacting plumes) between tubes.

Enclosure

Editorial

5. Figure 9-18 does not appear to be a plot of PRHR boiling data as stated, but rather a copy of Fig. 9-3, the single-phase (inside tube) heat transfer data.

6. Figure 8-24 is mislabeled and there are other data problems in Section 8. Looking at Table 8-7 and comparing the data to Fig. 8-24 (column "D") at about 5000 seconds, location "G" is not the hottest, as plotted in the figure; "C" (19.917 ft) is hottest. Also, in column "J" of the tables, the 4.917' elevation is markedly colder than the 1.917' elevation (see Tables 8-8 and 8-9, for instance); it appears that the thermocouple may have a significant bias, which should be noted in the figures or in the text. Even if the curve is relabeled, though, there appears to be a general discrepancy between the tables and the curves.

7. Section 4.4.1, p. 4-4, first sentence--the tube length should be 18.16 "feet," not "inches."

8. Section 9: Why is Eq. 9-10 different from the "PRHR Data" equation shown in Fig. 9-3?

9. In Fig. 9-1, what is the distinction (if any) between the "triangle," "square," and "diamond" data? There is no legend to distinguish between them.

10. In Fig. 9-3, the "dashed line" in the legend for the Dittus-Boelter and Petukhov-Popov correlations look identical; they also cannot be differentiated in the figure itself.

11. Figures 9-21 and 9-22 do not appear to be labeled properly; the relevance of the curves cannot be determined.

12. Page 9-7, eqn 9-20, liquid thermal diffusivity isn't used in the equation and should not be listed in the nomenclature.

13. Page 9-11, eqn 9-25, right hand side, denominator under the radical, rho sub r should be rho sub v.

14. Page 9-14, second to last paragraph, "Figures 9-22 and 9-23" should be 9-21 and 9-22, both times it appears.