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

March 7, 1994

Docket No. 52-003

Mr. Nicholas J. Liparulo
Nuclear Safety and Regulatory Activities
Westinghouse Electric Corporation
P.O. Box 355
Pittsburgh, Pennsylvania 15230

Dear Mr. Liparulo:

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION ON THE AP600

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 in order to complete its review. The additional information is needed regarding the scaling report for the core makeup tank test (Q440.52).* Enclosed is the staff's question. Please respond to this request within 90 days of the date of receipt of this letter.

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 this request for additional information does 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's Public Document Room.

*The number in parentheses designates the tracking number assigned to the question.

This request for additional information affects 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 can contact me at (301) 504-1120.

Sincerely,

Original Signed By:

Thomas J. Kenyon, Project Manager
Standardization Project Directorate
Associate Director for Advanced Reactors
and License Renewal
Office of Nuclear Reactor Regulation

Enclosure:
As stated

cc w/enclosure:
See next page

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Mr. Nicholas J. Liparulo
Westinghouse Electric Corporation

Docket No. 52-003
AP600

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REQUEST FOR ADDITIONAL INFORMATION
ON THE WESTINGHOUSE AP600 DESIGN

440.52 The staff has determined that the scaling report on the core makeup tank (CMT) does not provide sufficient information to demonstrate that the CMT separate-effects test will represent the processes occurring in the AP600 plant during operation of the CMTs. In addition, there appear to be inconsistencies in the report. Address the following concerns:

a. The description of the operation of the CMT described in Section 1-2 of the report appears to be inconsistent with Figure 1-1. On page 4, it states that "the discharge line isolation valves are normally open." This is inconsistent with the drawing referenced in the discussion (Fig. 1-1), which shows the valves closed. In addition, this description appears to be incorrect, since with the CMT at reactor coolant system (RCS) pressure, leaving the discharge valves open would establish a circulation path from the reactor vessel through the pressurizer to the CMTs, and the tanks would drain slowly. From the AP600 SSAR, it has been understood that all CMT isolation valves are normally closed (but fail open), and open on the various CMT actuation signals. Clarify this inconsistency.

b. Clarify the nomenclature in Chapter 2 of the report (from page 141) used for the conservation equations for the CMT. Specifically, in the momentum equation, as shown in Equations 2.2 and 2.7, and in the dimensionless parameters derived therefrom, the terms a_c and ℓ appear, which are defined as core area and subchannel length, respectively. While the equation *per se* is appropriate, insofar as consistency with the stated assumptions (1-D steady-state momentum) is concerned, the reference to core parameters in the CMT equation does not appear appropriate. The symbology or the nomenclature should be corrected.

c. In Section 2-2 of the report, in the discussion of convective heat transfer during the recirculation mode of CMT operation, it is stated (on page 30) that the Reynolds numbers for both the plant's CMT and the test article are about 6000-7000, and that this is a "turbulent flow regime such that a turbulent heat transfer convective correlation such as Dittus-Boelter...is applicable." The staff concludes that a Re value of 6000-7000 places the system in the laminar-to-turbulent transition regime, not a fully turbulent one. There are very few heat transfer correlations developed for this regime, and this situation is further complicated by the fact that the flow is natural convection, in which the velocity/temperature profiles can be considerably distorted from those which would exist in turbulent forced convection. In addition, for Dittus-Boelter specifically--and all other similar heat transfer correlations (Colburn, McAdams, Seider-Tate)--the applicable range given is Re>10,000 (and, it

Enclosure

should be noted, the aspect ratio range is L/D>60 for Dittus-Boelter, which is also much larger than exists in either the plant or the test article), so that the use of this correlation for the comparison/scaling of convective heat transfer appears to be incorrect. As a practical matter, however, this effect may be second order in many cases, and errors in its scaling may be of low importance overall. However, it is important that correlations with appropriate thermal-hydraulic and geometric ranges be employed in this study, because there may in fact be instances where the effects are not second-order. Address these concerns.

d. The approach taken in the scaling analyses presented in Chapters 2 and 3 of the report mirrors that used by Oregon State University (OSU) in the scaling of the APEX facility. However, there do not seem to be any real conclusions drawn about the applicability of the test facility results to plant behavior, and, further, there is little or no discussion about what has been left out of the analyses at the start. For example, the scaling of both recirculatory and draining behavior is based on a one-dimensional momentum equation. This is certainly applicable for the test facility, since multi-dimensional effects are suppressed by the small diameter of the test article. However, it may not be the case for the full-size CMT, where the diameter is large both in absolute terms and as compared to the tank length. The report does not address distortions due to suppression of multi-dimensional behavior in the test facility, nor is there an order-of-magnitude analysis showing the relative importance (or lack thereof) of multi-dimensional effects. In addition, for many of those aspects of CMT operation not specifically analyzed, qualitative or intuitive arguments are used, with no supporting justification. An example is found on page 32, in the discussion of liquid mixing and flashing effects during recirculation. The fact that things "seem like" they should behave similarly is not a substitute for a quantitative scaling study. Distortions and the uncertainties that they introduce into the scaling analysis should be dealt with in a quantitative manner, where possible. Address these concerns.

e. The scaling analysis for draining behavior presented in Chapter 3 of the report does not provide an order-of-magnitude analysis to separate the important phenomena/scaling parameters from the unimportant ones. In addition, the scaling parameters derived for this mode of operation appear to vary over a very wide range (factors of 6 or more) during a given experiment, but the significance of such a variation is not addressed. Also, the scaling of steam jet behavior should be updated to address the incorporation of the steam "distributor" at the CMT inlet. Dependence of the mixing length on steam diffuser design, scaling of the mixing length between the test facility and the CMT, behavior of steam when the diffuser is uncovered, and the means and impact of "scaling up" the diffuser should be addressed. The potential effects of non-condensible gases on condensation behavior and the resultant impact on CMT behavior should be addressed in a quantitative fashion. Furthermore, it appears that the mass conservation equation employed in Chapter 3 includes the assumption that all steam that enters the CMT condenses. Were this to be the case indefinitely, the CMT would not drain, because some vapor (steam or non-condensible gas) will fill the space vacated by the water as the tank empties. As the top layer of water in the CMT is heated, condensation will slow, and some steam (or other gas) will remain at the top of the tank, accumulating as the CMT drains. The equations used to assess draining behavior should explicitly reflect the physical processes that occur during that period of CMT operation; this includes not only condensation, but also the development, growth, and subsequent behavior of a thermally stratified layer of liquid as draining continues, including the possible flashing of the hot fluid as the system is depressurized. The proper scaling of these effects on CMT draining behavior should be addressed.

f. Provide a discussion of the significance of the plots of predicted plant and model behavior, and dimensionless parameters and their ratios, that are presented in Chapter 3 of the report. It appears that for certain conditions at certain points in a given type of experiment, the model will represent approximately the behavior expected in the plant, but it is not clear that such a conclusion can be extended to the range of conditions under which the CMTs are expected to operate, that the assumptions made (e.g., mixing depth) are realistic, nor that the idealized test conditions used for the analyses adequately represent the conditions that would exist during periods when CMT operation is most important. Address these concerns, and provide justification for these assumptions and for the selection of the test conditions.

g. Discuss how the CMT test results will be related to CMT operation in other integral test facilities, and how the overall results will be implemented in the codes.