March 10, 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: FOLLOWON QUESTIONS REGARDING EXTERNAL REACTOR VESSEL COOLING FOR THE AP600

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. Specifically, the enclosure to tnis letter contains requests for additional information concerning external reactor vessel cooling for the AP600.

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 followon 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 Nuclear Regulatory Commission Public Document Room.

If you have any questions regarding this matter, you may contact me at (301) 415-1132.

Sincerely,

original signed by:
Joseph M. Sebrosky, 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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See next page

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Mr. Nicholas J. Liparulo
Westinghouse Electric Corporation

Docket No. 52-003
AP600

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Enclosure to be distributed to the following addressees after the result of the proprietary evaluation is received from Westinghouse:

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Containment Systems and Severe Accident Branch
Request for Additional Information Regarding
AP600 External Reactor Vessel Cooling (DOE/ID-10460)

480.956 For cases where the metallic layer is contained within the hemisphere, Equation 6.9 appears to be in error (the cosine terms become zero for cases where angle theta equals zero). A more appropriate form of the equation is:

$$\sin^2\Theta_p A_{l,i}(T_{l,i}-T_b)^{4/3} = \sin^2\Theta_l A_{l,o}(T_b-T_{l,o})^{4/3} + (H_l/R)A_{l,m}(\sin\Theta_p + \sin\Theta_l)(T_b-T_{l,m})^{4/3}$$

Please clarify what equation is used in the full solution.

480.957 Figures 7.4 and 7.6 indicate that the oxide layer height will be 1.5 to 1.6m and the metal layer height will be 0.88 to 1.0m. This would result in the top of the metallic layer being above the hemispherical portion of the vessel. Please justify that the full solution adequately addresses this situation, and provide an estimate of the error introduced by the modelling assumption that metal layer is contained within the hemisphere.

480.958 Please clarify the nomenclature related to T_s and $T_{s,i}$. In Equation 6.10 and in the discussion on page 6-4, it appears that T_s should be replaced with $T_{s,i}$. If not, please justify why T_s is used as a sink temperature in Equation 6.10 and $T_{s,i}$ is used as a sink temperature in Equation 6.12. Also, please show the equation used to relate T_s to $T_{s,i}$ and $T_{s,o}$.

480.959 Please clarify the nomenclature and assumptions in the third term of Equation 6.12. In this term, it appears that the molten metal layer emissivity, ϵ, should be replaced with the radiative sink emissivity, ϵ_s. Please describe and justify the view factors and area relationships invoked to omit any terms with the vessel emissivity, ϵ_v and surface area ratio (S_s/S_v). It appears that the upper internal structure's heat was assumed to be entirely radiated to the vessel inner wall and that the upper internal structure surface area was assumed to be much smaller than the vessel inner surface area ($S_s << S_v$). However, the latter assumption contradicts nomenclature shown in Figure 5.1 (S_s pointing to both the upper internal structure inner surface and the vessel inner surface implies that these areas are equal).

480.960 It appears that the coefficient of the fourth term in Equation E.3 should be 1.35x10-2. Is this a typographical error?

480.961 Please clarify why the ratio $(H/R)^{0.25}$ is discussed on page 6-3. The equations used for predicting upward and downward heat transfer coefficients (Equations 5.12 and 5.28) don't have an (H/R) term.

Enclosure

480.962 Please describe and justify the assumptions used to obtain Equation 5.41 from Equation 5.35.

480.963 Please indicate the equation used to estimate A in the full model (Information on page 6-4 suggests that a Prandtl number function, rather than Equation 5-47, was used to evaluate the term, $A_{i,j}$).

480.964 Please indicate what properties were varied with temperature in Equation 6.11 (the equation suggests that all the thermophysical properties were evaluated at the appropriate film temperature except the thermal conductivity, k). Please specify the values used to obtain a single value for A (2764 W/m^2K) that is applicable to all directions (see captions for Figures 6.3 and 6.4).

480.965 For the following variables, please: (1) clarify if single values were used, (2) state the values or range of values assumed, and (3) provide the basis for these values:

- Upper internal structure surface area, S_s
- Vessel internal surface area, S_s (Figure 5.1 nomenclature)
- Upper internal structure thickness, δ_s
- Vessel thickness, δ_o
- Upper internal structure emissivity, ϵ_s
- Upper internal structure thermal conductivity, k_s

480.966 In the response to RAI 480.459, it is noted that: (1) the initial core barrel thickness (2 inches) is assumed for the upper internal structure thickness, (2) the initial vessel thickness (8 inches) was assumed for the vessel thickness, and (3) the vessel side wall surface area above the melt (57.4 m^2) was assumed for the vessel internal surface area. Please demonstrate that results aren't sensitive to values assumed for these parameters. Also, clarify if the area of the upper internal structure surface area and the vessel internal surface area were assumed equal as suggested by Figure 5.1 nomenclature.

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