April 5, 2002

Mr. Gordon Bischoff, Project Manager
Westinghouse Owners Group
Westinghouse Electric Company
Mail Stop ECE 5-16
P.O. Box 355
Pittsburgh, PA 15230-0355

SUBJECT: WESTINGHOUSE OWNERS GROUP TRANSMITTAL OF WCAP-15603-NP, REV. 0, "WOG 2000 REACTOR COOLANT PUMP SEAL LEAKAGE MODEL FOR WESTINGHOUSE PWRS" (MUHP-6074)

Dear Mr. Bischoff:

By letter dated December 20, 2000, the Westinghouse Owners Group (WOG) submitted for NRC staff review Topical Report WCAP-15603-NP, Rev. 0, "WOG 2000 Reactor Coolant Pump Seal Leakage Model for Westinghouse PWRs" (MUHP-6074). The staff has completed its preliminary review of WCAP-15603-NP and has identified a number of items for which additional information is needed to continue its review. On August 23, 2001, the NRC staff forwarded an informal set of the request for additional information (RAI) questions that had been discussed with the WOG during a conference call. The staff is now forwarding the enclosed RAI. You have indicated that a tentative response to the RAI can be expected by April 15, 2002. Partial submittals would be welcomed to minimize delays.

Pursuant to 10 CFR 2.790, we have determined that the enclosed RAI does not contain proprietary information. However, we will delay placing the RAI in the public document room for a period of ten (10) working days from the date of this letter to provide you with the opportunity to comment on the proprietary aspects only. If you believe that any information in the enclosure is proprietary, please identify such information line by line and define the basis pursuant to the criteria of 10 CFR 2.790.

If you have any questions, please call me at (301) 415-1436.

Sincerely,

/RA/

Drew Holland, Project Manager, Section 2
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Project No. 694

Enclosure: Request for Additional Information

cc w/encl: See next page

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cc:
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REQUEST FOR ADDITIONAL INFORMATION

WCAP-15603-NP, REV. 0, "WOG 2000 REACTOR COOLANT PUMP SEAL LEAKAGE MODEL FOR WESTINGHOUSE PWRS" (MUHP-6074)

PROJECT NO. 694

1. The topical report (TR) states in Section 1.0 (page 1-1) that the Brookhaven National Laboratory (BNL) model is the current regulatory model for reactor coolant pump (RCP) seal leakage, and it uses this model as the starting point for the development of the WOG 2000 model. However, the BNL model is not the current regulatory model. The staff committed in resolving Generic Issue 23 to use the Rhodes model until other acceptable RCP seal models were developed. The original intent of the BNL report was to interpret and clarify the other existing RCP seal models, including the Rhodes model. However, as part of their report, BNL developed their own best-estimate RCP seal model, which differed from the other seal models. In developing the BNL best-estimate model, BNL made assumptions regarding seal failure with which the NRC staff may not fully agree. For example, the BNL model uses a probability of 0.54 for the popping-and-binding failure mode for the third-stage seal, given that the second stage seal has failed, and the WOG 2000 model reduces this probability to 0.27 for the new O-rings. However, the Rhodes model assumed pop-open failure of the third-stage seal under these conditions (i.e., probability of one). The TR needs to address and justify the differences between the WOG 2000 model and the Rhodes model.

2. The TR defines the RCP seal leakage model for the condition of a sustained total loss of RCP seal cooling with timely stopping of the RCPs. However, the TR does not adequately define or justify the assumption of timely stopping. The TR implies in Section 2.2 (page 2-1) that if the RCPs are not stopped within a certain (but unspecified) time period, the RCP seals are assumed to fail catastrophically (i.e., result in a maximum leakage rate). Please state the time in which the RCPs must be stopped for the use of this leakage model and provide a justification for the use of this time. In addition, please state the assumed consequence associated with failing to meet this condition.

3. The leakage model does not address the potential for operations with pre-existing stage failures and/or random failures (e.g., associated with manufacturing defects or installation errors/damage). Please justify not explicitly including these specific failure contributions in the model or address them in the model.

4. The TR states in Section 3.1 (pages 3-1 and 3-2) that the binding failure mechanism is effectively eliminated by the use of qualified O-rings. Based on this assertion, it reduces the combined probability of popping-open or binding failure by a factor of two. RCP seal hydraulic instability (i.e., pop-open) and seal binding are two separate phenomena that occur as a result of different physical conditions. Popping-open can occur whenever net positive RCP seal face closing forces are lost due to a change in the thermodynamic fluid conditions. Popping open will occur at the time the conditions are favorable for the phenomenon and is therefore not time-dependent. Binding can occur after the extrusion

of the secondary seal (i.e., O-ring or channel seal). This usually occurs only after some time at elevated temperature and is therefore somewhat time-dependent. In the Rhodes and BNL models, the probabilities of these failure modes were combined because of the state of knowledge at that time. For example, the Rhodes and the BNL models both use a combined popping and binding probability of 0.025 for the first-stage seal. This assumption is made for seal assemblies using old O-rings and those using new and improved O-rings that are qualified for high temperature and the expected pressure differential without seal stage failure. The Rhodes model, as shown in Appendix A of NUREG/CR-5167, and the NUREG-1150 model both use a failure probability of 1.0 for the third-stage seal (i.e., the vapor seal) because it is not designed to withstand full system pressure. The NUREG-1150 model was also constructed with expert opinion input from Westinghouse. Therefore, reducing the combined probability of popping and binding by a factor of two does not appear to be justified based on the present state of knowledge. Please provide additional justification, including any supporting test results, analyses, and operational events, for eliminating the binding failure mechanism due to premature extrusion failures of the O-rings or channel seal elastomers and for reducing the combined probability of popping open or binding failure.

5. The TR assumes in Section 3.2 (pages 3-3 and 3-4) and Section 4.2 (page 4-2) that the onset of seal leakage occurs 30 minutes after the loss of RCP seal cooling. The correct time for onset of RCP seal leakage in the model should be at the end of the thermal transient leading from the fully cooled condition at the first stage of the seal assembly to the time when the fluid temperature at the entrance to the first-stage seal reaches full reactor coolant temperature. This is estimated in WCAP-10541, "RCP Seal Performance Following a Loss of All AC Power," to be approximately 10 to 13 minutes after loss of RCP seal cooling in the Westinghouse RCP seal design. Popping-open of the second-stage seal, if it occurs, will most likely occur at this time. Please provide additional justification, including any supporting test results, analyses, and operational events, for the delay in this timing to 30 minutes, instead of using a time of 10 to 15 minutes.

6. The TR assumes in Section 3.1 (page 3-2) a failure probability of 0.0 for new or improved O-rings that have been qualified for the conditions expected under a loss of RCP seal cooling, assuming that no seal stage failures have occurred. That is, these new or improved O-rings have been qualified for full reactor coolant temperature, gap differentials at the expected seal stage temperature, and the pressure differential that each O-ring would experience without any seal stage failure. Fully qualified O-rings could withstand full reactor temperature and pressure at the expected gaps. However, no information has been presented to support that any fully qualified O-rings exist and are in use in commercial nuclear power plants. Therefore, using a probability of 0.0 for failure of the new O-rings is only justified for those cases in which no seal stage failures occur. Further, the BNL model also recognized the potential for failure of the improved O-rings after 2 hours and stated that this assumption (i.e., failure after 2 hours) is more justifiable than the one made in the best-estimate model (i.e., the BNL model that assumed O-rings would not fail) because there is not clear proof that the new O-ring material would survive full system pressure. If the difference in risk between these two cases is judged significant, then further elastomer qualification testing would be necessary to resolve this issue. Please provide additional justification, including

additional test results, for using a zero probability of elastomer failure for the new O-rings, or provide the rationale (and comparison to the Rhodes model) for use of a non-zero probability.

7. The TR assumes in Section 4.1 (page 4-2) that old O-rings for the first and second seal stages have a failure probability for extrusion failure of 0.5 for times greater than three hours and that the old O-ring for the third-stage seal has a probability of extrusion failure of 0.5 for times greater than two hours after failure of the first or second O-ring. The old O-ring material was tested, per NUREG/CR-4077, at temperatures, gaps, and pressure differentials predicted by Westinghouse for a loss of RCP seal cooling event. Most O-rings tested failed in two hours or less when subjected to these conditions. Therefore, the use of a failure probability of 0.5 for old O-rings for times greater than three hours is not consistent with these results, and neither is the BNL model estimate of a probability of 1.0 of failure of all stages of O-rings in the third to fifth hours. Because of the modeling complexity created by the proposed change in failure probabilities from those in the BNL model, the TR model reverts to the BNL model failure probabilities. Given that the ultimate result is no change as compared to the BNL model, either eliminate this discussion or provide additional justification to support the statements that the failure probability could be reduced from the BNL probabilities for the elastomer failure of old O-rings after two hours of exposure. Also, please justify the modeling and associated failure probabilities that are used in the WOG 2000 model for extrusion failure of the old O-rings (including any based on the BNL model) against the modeling conditions and failure probabilities established by the Rhodes model.

8. The Chapter 4 discussion and results are not fully consistent with the RCP seal leakage event tree model presented in Figure 2.2-1. To be consistent with the Chapter 4 tables, there should be branch points in Figure 2.2-1 under the B3+P3 branch for each scenario path. Specifically, Scenarios 1 and 13 should be split to represent success or failure of the B3+P3 branch. This condition is reflected in the WOG 2000 model tables for the period, t, greater than or equal to 0.5 hours, but less than 2 hours. Likewise, Scenario 12 should be split to reflect t greater than or equal to 2 hours, but less than 4 hours. For t greater than or equal to 4 hours, Scenario 12 should be split further, for the B3 + P3 success branch previously split, under the O3 branch. Further, the associated scenario leakage rates need to be established for each of these additional scenarios. The leakage rates for Scenarios 1b and 13b (failure of B3 +P3) need to be established or justified as remaining at the rate for the success path. Likewise, the leakage rates for Scenarios 12a (success of B3 + P3) and 12b (failure of B3 + P3) need to be established or justified. This justification is needed because these branches come from Scenarios 5 and 7, respectively, which have different leakage rates of 57 gpm and 182 gpm, respectively. Finally, the leakage rate for Scenario 12aa (success of B3 + P3 and O3) needs to be established. Should the rate be 251 gpm (similar to Scenario 14 conditions) or 300 gpm?

9. Extrusion failure of old O-rings is assumed to occur during the third to fifth hour period. The third hour starts at time, t, equal to 2 hours. Thus, the probabilities related to this time for the first two stages should be stated as $t \geq 2$ hours (not 3 hours). For the third stage, which is assumed to fail two hours after the failure of either of the first two stages, it should be stated as $t \geq 4$ hours (not 5 hours). Please correct the information in Chapter 4 to be consistent with this condition.

10. Chapter 5 of the TR recommends using a simplified model. However, the basis for the simplification is not provided. In particular, for the new O-rings, the simplification only eliminates one scenario. Because the WOG 2000 model provides scenarios of different leakages, binning should be related to the leakage rates. Thus, for the new O-rings, the five scenarios should not be reduced in number unless plant-specific success criteria result in no difference in the leakage rates among selected scenarios. For example, after 2 hours, Scenario 2 has a per-pump leakage rate of about 57 gpm (228 gpm for a four-loop plant), and Scenario 4 shows a rate of 76 gpm (304 gpm for four-loop plant). If the plant-specific analysis indicates that these rates do not result in any differences in system success criteria, these scenarios could be combined. However, this is a condition of the plant-specific analysis and is not appropriate for the generic-type WOG 2000 model to address. Likewise, the old O-ring model should only be reduced generically to five scenarios to reflect the five different leakage rates identified in Chapter 4 (assuming the changes identified in Item 8 above do not affect the resulting simplifications), with the scenario combinations based on the leakage rate (i.e., from Chapter 4 Table 4.4-1 combining Scenarios 1 and 2 and combining Scenarios 5 and 6). Please revise the Chapter 5 discussion accordingly or provide additional justification for the proposed combination simplifications.