October 27, 2005

Mr. Gordon Bischoff, Manager
Owners Group Program Management Office
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P.O. Box 355
Pittsburgh, PA 15230-0355

SUBJECT: RESPONSE TO WESTINGHOUSE OWNERS GROUP LETTER NO. WOG-05-287, DATED AUGUST 22, 2005, REGARDING WCAP-16406-P, "EVALUATION OF DOWNSTREAM SUMP DEBRIS EFFECTS IN SUPPORT OF GSI-191"

Dear Mr. Bischoff:

At the NRC staff's request, the Westinghouse Owners Group (WOG) Letter No. WOG-05-287, dated June 20, 2005, submitted a draft copy of WCAP-16406-P, "Evaluation of Downstream Sump Debris Effects in Support of GSI-191," for information only. No formal review by the NRC was requested nor desired by the WOG. The final version of WCAP-16406 was submitted via WOG Letter No. WOG-05-331, dated July 18, 2005, which was actually transmitted to the NRC on August 2, 2005, also for information only. Subsequently, WOG Letter No. WOG-05-378, dated August 22, 2005, was submitted requesting that the WOG be informed of the NRC findings regarding any potential flaws in the methodology described in WCAP-16406.

In response to the WOG's above request for staff comments, the Nuclear Regulatory Commission (NRC) staff has completed a review of WCAP-16406 and the NRC staff comments are provided in the enclosure to this letter. The NRC's review and comments on this WCAP do not constitute an approval for its use. The staff is willing to discuss and clarify these comments at a time convenient to the WOG in the near future. If you have any questions, please contact Mr. Girija Shukla at (301) 415-8439.

Sincerely,

/RA/
Herbert N. Berkow, Director
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Project No. 694

Enclosure: As stated

cc w/encl:
Mr. James A. Gresham, Manager
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COMMENTS BY THE OFFICE OF NUCLEAR REACTOR REGULATION

TOPICAL REPORT WCAP-16406-P, "EVALUATION OF DOWNSTREAM

SUMP DEBRIS EFFECTS IN SUPPORT OF GSI-191"

WESTINGHOUSE OWNERS GROUP

PROJECT NO. 694

WCAP-16406-P was not formally submitted for Nuclear Regulatory Commission (NRC) staff review and approval. Therefore, the staff has not performed a detailed review. The NRC staff may have additional comments if material in WCAP-16406-P is submitted or referenced formally in other submittals. The staff comments are provided below:

1. Pages xvii and xviii: Add the missing abbreviations such as Pz, CF, and RV (Page 4-3).

   Chapter 4: It is noted that Chapter 4 is general in nature and that licensees must specifically address their individual design and licensing bases. Licensees must also address applicability to their normal operating procedures (NOPs), abnormal operating procedures (AOPs), and (emergency operating procedures (EOPs).

2. Page 4-1: In the second paragraph of Section 4.1.1 the WCAP states that low-pressure injection (LPI) delivers flow to the cold legs. In the B&W-designed nuclear steam supply systems (NSSSs) the LPI delivers flow directly into the reactor vessel. This should be clarified.

3. Page 4-20: We note that Indian Point 2 has three high-pressure injection pumps that can feed into two paths via a coupled alignment - not two as stated in Section 4.1.3. This should be clarified.

4. Page 4-23: Containment spray system (CSS) Recirculation Alignment Summary for Combustion Engineering (CE) Plants - states, "There is no limiting scenario for CSS. In general, this system is built with complete redundancy and one train alone (of the two trains) is capable of supplying the total flowrate." Downstream effects is a common mode failure mechanism, therefore, there is only redundancy if there is only a single train in operation. Plant-specific procedures and accident assumptions may need to be revised.

5. Page 4-27, Section 4.2.2.1, CE Plants - Pumps, Second paragraph - similar to previous comments where operator actions are credited.

6. Page 4-30, Second paragraph: Credited operator actions must be addressed in EOPs or other appropriate licensing documents. Operation of the ECCS is not in "Severe Accident" space and therefore actions or mitigation strategies in accord with Severe Accident Guidelines do not apply. Cooling paths are only considered redundant if EOP or other system line-ups control them as such. Compliance with single failure criteria and other DB and LB bases must be verified.

If “operator actions” are credited to mitigate the consequences of an accident, then the actions must be incorporated into DB and LB, as appropriate, with the proper controls.

Could not verify the statement, "Assuming that the HHSI [high-head safety injection] pump is not operating, the LHSI [low-head safety injection] pump can still push flow through the HHSI pump." Reference calculation CN-SEE-05-13 dated June 2005 was not provided. It is expected that this assumption will be verified by licensees, if they chose to use the logic within the WCAP.

7. Page 4-34: Section 4.2.3.3 of the third paragraph, credits the reactor barrel - nozzle interfacial gap as a circulation path that contributes to there being no need for hot leg injection in B&W-designed NSSSs. Does this refer to what is commonly called the "hot leg nozzle gap?" If so, the NRC has not accepted the crediting of this flow path under these conditions because no licensee or vendor has established the presence of a viable flow path with consideration of potential plugging due to debris. (Credit for this flow path is specifically excluded in Section 9.1.)

8. Page 5-3, Section 5.5.2, Assumptions - What is meant by size of flow passage? Is it the largest opening dimension (i.e, diameter of the circle or the hypotenuse) if it's a rectangular opening? It should be clarified.

9. Page 5-4: Section 5.5, Assumptions, #6 states: Once in solution, size of the debris, both particulate and fibrous, remains constant. This assumption is conservative as it provides for a maximum debris size that may cause blockage in the emergency core cooling and containment spray system flow path. It also provides for a conservative wear and abrasion evaluation. This assumption is not valid for active screen designs, and may not be conservative. A justification or clarification should be provided for this assumption.

10. Page 5-7: Last sentence in 1st paragraph of Section 5.8 reads as follows, "If a review of plant-specific flow rates may indicate that debris settle may occur in other locations, the methods described in the following section may be applied to evaluate the rate of settle out." This sentence is poorly written and unclear.

11. Pages 5-8 and 5-9: Introduce the concept of the reactor vessel acting as a filter through debris settling. Information should be provided on how the factors were developed for developing this concept of "reactor vessel filter efficiency" ($C_{so}/C_{co}+C_{so}$ in the example) We would expect that this should be significantly different for hot-leg (HL) breaks versus cold-leg (CL) breaks.

12. Page 5-9: What is the basis of the term C^*_{CO} in equation 5.8-5?

13. Page 5-10, Section 5.9 - Note that settling rates are an un-validated assumption and must be verified applicable by each licensee

14. Page 5-11: Indicates that three cases were analyzed for effect on break location and flowrate, and refers to Figure 5.9-1. The three cases indicated are one cold-leg break and two hot-leg breaks with different ECCS trains operating. The legend in Figure 5.9-1

indicates three different ECCS operating modes (HL/CL recirc + number of trains) without reference to the location of the break. Please clarify the curve correlation to the accidents identified as the three cases.

15. Page 5-13, Figure 5.9-1: The three curves on this figure show similar shape and characteristics, with different curves provided for different ECCS operating configurations. No indication is given for break location in the figure legend. The phenomenology for debris removal from ECCS injection water would be different, for example, for a CLB with CL injection (low flow through the core, debris removed by settling/boiloff of water in the core region) than a HLB with CL injection (high flow through the core, debris removed by impingement/interaction with core/structural components). Can WOG explain why, in light of the differing phenomena (boiloff vs. mechanical filtration, for example) the curves appear similar for the different phenomena, and why not all of the 4 different combinations of break/injection location (CLB/CLI, CLB/HLI, HLB/CLI, & HLB/HLI) appear on the graph?

16. Page 5-17, Figure 5.11-1: Shows a debris curve for various screen filtration efficiencies. These appear to trend to zero, which does not seem appropriate for a clean screen. Wouldn't we expect these to trend to a theoretical minimum that would be based on screen design/hole size (i.e., the amount of debris that would be too small to ever be filtered out by the screen)? In the draft document, this Figure had labels indicating screen open area, why were these labels removed?

17. Section 6, Pumps - The complete test reports referenced in 6.2.6 and 6.4.1 were not provided for review.

18. Page 7-1, Section 7.2.1 - There is no Reference 8.11 which develops the depletion rate coefficients. Also, while the depletion rate decreases, this may have no effect on the wear of rotating equipment since erosion may not be the limiting factor. Initial debris loading on the internal components will provide the damage mechanism unless a flushing effect can be shown as the working fluid changes its characteristics.

19. Chapter 8, General - The WCAP often evaluates performance at runout conditions only. This may not be conservative as some recovery strategies throttle flow. At throttled flow Dp across stages may be higher. The resultant internal wear and vibrations levels would also be expected to increase, changing the set of conditions requiring evaluation.

20. Page 8-1: Contains information that vertical single stage pumps may have seals that depend on process water for cooling. The discussion and illustrative Figure 8.1-1 addresses one configuration (with or without a cyclone separator). There are other configurations that may also be susceptible to debris interaction (example - the residual heat removal (RHR) pump configuration that uses a ring on the drive shaft to provide a driving force to circulate water through a heat exchanger and thus provide seal cooling). The report should recognize that there may be other susceptible configurations as well.

21. Page 8-2: Uses the statement "smaller than the screen grid size" as an assumption regarding particle size that can pass through a screen. This wording is inconsistent with instructions in Appendix J and Section 5.5. Similar statements are contained in other report sections as well.

22. Page 8-3: Figures 8.1-2(a) and (b) show the expected debris concentration entering the ECCS pump suction. No report number is given for this reference, and no information is provided on how this report could be obtained. It might also be noted that this may be specific to a certain screen design, and other screen designs may have significantly different characteristics (i.e., active strainers, in particular).

23. Page 8-3, Debris concentrations in Figure 8.1-2 are not readable. Therefore, the statement on Page 8-6, third paragraph, last sentence could not be verified.

24. Page 8-4, first sentence: In regard to debris, states "without a significant short-term impact (up to 12 hours)." What is the justification for this statement as applicable to the many pump and seal designs in ECCSs? (To our knowledge, some of the configurations have not been tested with debris-laden water.)

25. Page 8-4: Under "2. Mechanical Shaft Seal Assembly Evaluation" near the bottom of the page, states that shaft seals on pumps in the ECCS for Westinghouse plants are designed with a backup seal. Confirmation or clarification for this statement should be provided. For example, is this correct for all RHR pumps from all vendors?

26. Page 8-5, paragraph 4: If a seal is expected to leak and operator action is credited to occur within 30 minutes, this action must become part of EOPs, AOPs, operator training and other DB and LB documents as appropriate.

27. Page 8-5: Fifth paragraph states, "The seal package for all ECCS and CSS pumps are of similar design." Please provide a basis and reference for this statement.

28. Page 8.5: Last paragraph, fourth sentence, "3. Pump Mechanical Evaluations (Vibration)" states, "For most pumps of this type, there is sufficient damping ..., see references 8.1.7 and 8.1.8". The quoted statement was not a conclusion of Reference 8.1.7. Reference 8.1.8. should be provided for review.

29. Page 8-6, Section 8.1.2, paragraph 2, sixth sentence - There is no validated confirmation of a 1 percent solution and a clearance bypass must be considered. Therefore, the statement, "...one can conclude that the effect of debris on the hydraulic efficiency of the ECCS pumps is insignificant," is not accurate.

30. Page 8-8: Section 8.1.3, first paragraph, last sentence states that, "Should the water cooling be lost, due to clogging of the piping or the heat exchanger that might be possible with high debris loading in the pumped fluid, the additional risk for seal failure due to loss of seal cooling is small for the required mission time for these pumps." It should be clarified.

31. Page 8-8, Section 8.1.3: What is the justification for the conclusion that the additional risk of seal failure due to loss of seal cooling is small?

32. Page 8-12: Fifth paragraph, first sentence - Assumptions for non-tested configurations or the use of different models must be validated.

33. Page 8-28: Section 8.3 - First paragraph, last sentence states, "These chemical issues will be handled elsewhere, as they do not affect the functionality of the heat exchanger itself." Chemical issues may affect the functionality of a heat exchanger. It is acceptable that it will be handled outside of this WCAP.

34. Page 8-31: Section 8.4 - Second paragraph, second line states that, "Based on a review of plant data (Appendix B, C, and D), the majority of orifices have a bore of 5/16 inch or greater." Note that Appendices B, C, and D contains orifices related to spray nozzles only. They do not include any other orifices in the piping systems and equipment.

35. References 8.1-1 thru 8.1-4 should be provided for review.

36. Page 9-1, General for Section 9: The boiling process would concentrate a mixture of particulate, fibers and boric acid. Guidance should be given as to what the physical nature of the sludge is that might be moving through the core in a long-term cooling process involving core boiling. (What would be its chemical nature? What would be its heat transfer properties? Would it react with the fuel cladding at elevated temperatures? Any estimation of the sensitivity of these issues? Any test results available in this area?)

37. Page 9-5: Equation 9.2-1 suggests that a force balance of debris that accounts for hydraulic drag, gravity, and hydrostatic forces be utilized to evaluate the potential for transport of debris into the fuel region. The hydrostatic forces will depend on the density of the debris material which would be plant specific. The hydrostatic forces will depend on the shape of the debris particles. One method of calculating hydraulic drag would be to use Stoke's law. Stoke's law provides a relationship for calculating hydraulic drag for spheres. Should guidance be provided to predict hydraulic drag for other possible debris shapes?

38. Page 9-6: In Section 9.2.2, Item 5, the statement is made that if the particulate dimension is smaller than the limiting flow dimension, blockage will not occur. This statement may not be true for cold-leg breaks where all coolant entering the core boils and particulate or fibrous material entering the vessel will remain there regardless of its size and may thus produce core blockage, or where small particulates may be captured by trapped fibrous debris.

39. Page 9-8: Item 6.b.iv.2.d of Section 9.2.2 states that the peak cladding temperature (PCT) should be calculated and compared to the PCT limits for conditions of partial core flow blockage. Meeting the PCT limit of Section 50.46 of Title 10 of the *Code of Federal Regulation* (10 CFR) may not be sufficient for partial blockage of a core during long-term cooling since excessive cladding oxidation may occur for long-term exposure to lower temperatures. More complete guidance should be given (i.e., all criteria from 10 CFR 50.46 must be met).

40. Page 9-13: General for Section 9 - The presentation provided includes a reasonable list of "what" should be evaluated for Reactor Internals and Fuel blockage, but doesn't seem to provide enough details on "how" this evaluation should be performed. Example: Page 9-4, Section 9.2.2, item 3, is titled "Consider the debris that may be

injected into the ECCS through the Sump Screen." This step contains two substeps for evaluating particulate characteristics, but does not contain any guidance for how this information would be used for the sump screen design, or how this information would lead to a determination of the amount of debris injected into the ECCS through the sump screen (the ultimate goal of the step).

41. Page 10-10: Section 10.5.1 - Second paragraph, second sentence states that, "The minimum acceptable performance data are developed by the plant IST Program." This is an incorrect statement. The licensee engineering staff determines the minimum acceptable performance data after a thorough review of the DB and LB.

42. Section 10.5.2, third sentence - The use of "Verbal information from Davis-Besse testing" is not appropriate.

43. It is assumed that the information contained in Appendices B, C, and D will be validated by licensees prior to its use.