August 22, 2008

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

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION RE: PRESSURIZED WATER REACTOR OWNERS GROUP (PWROG) TOPICAL REPORT (TR) WCAP-16793-NP, REVISION 0, “EVALUATION OF LONG-TERM COOLING CONSIDERING PARTICULATE, FIBROUS AND CHEMICAL DEBRIS IN THE RECIRCULATING FLUID” (TAC NO. MD5891)

Dear Mr. Gresham:

By letter dated June 4, 2007, as supplemented by letter dated January 17, 2008 (Agencywide Documents Access and Management System Accession No. ML080220258), the PWROG submitted for U.S. Nuclear Regulatory Commission (NRC) staff review TR WCAP-16793-NP, Revision 0, “Evaluation of Long-Term Cooling Considering Particulate, Fibrous and Chemical Debris in the Recirculating Fluid.” As a result of the Advisory Committee on Reactor Safeguards review of March 19, 2008, the NRC staff has determined that additional information is needed to complete the review. Upon receipt of this letter, the NRC staff requests the PWROG provide an anticipated date to provide responses to the enclosed Request for Additional Information (RAI). If you have any questions regarding the enclosed RAI questions, please contact me at 301-415-1053.

Sincerely,

/RA/

Holly D. Cruz, Project Manager
Special Projects Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Project No. 694

Enclosure: RAI questions

cc w/encl: Mr. James A. Gresham, Manager
Regulatory Compliance and Plant Licensing
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ADAMS ACCESSION NO.: ML082260049 **NRR-106**

OFFICE	PSPB/PM	PSPB/LA	PSPB/BC
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DATE	8/13/08	8/18/08	8/ 22/08

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REQUEST FOR ADDITIONAL INFORMATION

BY THE OFFICE OF NUCLEAR REACTOR REGULATION

TOPICAL REPORT (TR) WCAP-16793-NP, REVISION 0

"EVALUATION OF LONG-TERM COOLING CONSIDERING PARTICULATE,

FIBROUS AND CHEMICAL DEBRIS IN THE RECIRCULATING FLUID

PRESSURIZED WATER REACTOR OWNERS GROUP (PWROG)

PROJECT NO. 694

1. TR WCAP-16793-NP, Revision 0, Appendix B, presents analyses of the effect of core inlet blockage using the WCOBRA/TRAC analysis code. Since the TR was prepared, additional analyses have been performed to determine the blockage level that would reduce core flow below that necessary to match coolant boil-off. Please provide documentation of the additional analyses that have been performed, including figures, for the integrated core inlet and exit flow, peak cladding temperature (PCT), core collapsed liquid level, core exit void fraction, and core pressure drop for the bounding conditions. The results should be presented for each case analyzed up to and including the blockage level for which boil-off is no longer satisfied.

2. Please clarify the assumptions of the TR regarding local blockage due to debris buildup. First, when a debris buildup of 110 mils or 50 mils is assumed at a spacer grid, please describe the assumed circumferential or azimuthal coverage of that debris layer. Given recent test observations, please justify any assumptions of less than full coverage. If the debris buildup bridges fuel rods, state whether the two rod heat sources are simultaneously applied in the analysis. Second, please discuss the same considerations regarding the layer of oxide, crud, and precipitate debris build-up on the fuel rods between spacer grids. Third, tests observed by the NRC staff indicate that fiber, particulate, and chemical precipitates can completely fill the grid space between adjacent rods in the first fuel assembly spacer grid. Please describe the effect of this debris build-up on local heating of pins and confirm that this affect is addressed in the TR local effects analysis.

3. For each of the following items, please discuss how the evaluation methods presented in TR WCAP-16793-NP, Revision 0, will ensure that each plant that uses the methods will not incur unacceptable blockage at the core inlet or within the core (at grid spacers), considering the following:

    a. The potential for filtering debris beds on horizontal downward facing surfaces at typical core inlet flow rates that have been observed during strainer and fuel inlet blockage testing,
    b. Impacts of debris loading (fibrous, particulate, chemical),
    c. Impacts of fuel inlet nozzle, protective filter, and spacer grid designs,

ENCLOSURE

d. The potential impact of less than the maximum amount of postulated debris arriving at the core (thin bed). The NRC staff believes that the potential for a fuel inlet thin bed is dependent on the protective filter above the inlet nozzle and the fuel inlet nozzle design, but has no test data to evaluate some of the designs. Filtering debris beds of less than 1/8 inch that have been observed during strainer testing,
e. Impacts of plant-specific flow rates and available head for postulated cold and hot leg breaks,
f. Justification for crediting settling in the lower plenum (if such credit is sought) based on lower plenum geometry, flow rates, and turbulence, and
g. Please include a discussion of how each plant is bounded by the TR analyses or how the prescribed methods in the TR will ensure that the plants have adequate guidance to perform a plant-specific evaluation of core inlet blockage. To the extent the TR attempts to extrapolate test results from one fuel assembly design to others, please provide the minimum and maximum fuel assembly inlet nozzle opening sizes including obstructions, such as due to spacer grids, for the fuel assembly designs involved. Please also include a description of the geometry of each fuel assembly inlet nozzle design in use, with dimensions, and identify the combinations of first fuel spacer-grid/inlet nozzle designs in use.

4. Please provide information on potential flow paths that could bypass the fuel inlet to provide cooling in the event the core inlet becomes fully blocked with debris. Specifically, discuss the potential alternate flow paths (e.g., location, number, and sizes) for coolant to reach the core in the event that a complete blockage at the core inlet occurred. If these flow paths are credited for passing water to the core, please justify that they will not become blocked with debris and that they will pass adequate flow to the core to maintain cooling. Please also justify that these bypass flows will not result in problematic debris build up in the core.

5. Please provide data that show the basis for the assumption that fibrous strainer bypass of 1 ft^3/1000 ft^2 of strainer area provides a reasonable estimation of fiber bypass and that use of this number will not affect plant evaluations non-conservatively. Note that some protective fuel filters may be challenged by lower amounts of fiber (i.e., a thin bed) while some may be challenged by higher amounts. Please verify that these data were correlated with the area of the test strainer and that the results were not confounded by extrapolation to strainer areas less than the total of all strainers that may be in service during the event (i.e., strainer bypass estimates should assume all available strainer area is available for bypass).

6. Please provide the following information for all fuel/core blockage tests that have been sponsored by the PWROG:

   a. flow rates and bases including any variation in the flow rate during testing,
   b. debris types and size distribution for all debris added,
   c. amounts of each type of debris added to each test or subtest,
   d. bases for amounts and sizes of debris added to each test or subtest,
   e. scaling information for debris amounts and test flow rates,

f. information regarding the prototypicality or conservatism of test facility flow pattern and settlement,
g. head loss value experienced for each test or subtest including time dependent plots if available,
h. observations of debris transport and accumulation including any settling with differences noted at different flow rates,
i. behavior of debris during testing (agglomeration),
j. test methodology and setup,
k. details of debris preparation and introduction,
l. order and rate of debris addition,
m. dimensions of fuel inlet test mock-up,
n. design of fuel protective filter modeled in the test,
o. photographs as available to assist in understanding the tests, and
p. theoretical debris bed thickness based on as-manufactured fiber density.

7. For hot-leg and cold-leg breaks, some debris may bypass the fuel inlet because it flows to the containment spray system instead of the emergency core cooling system (ECCS). Also, for cold-leg breaks, some flow bypasses the core by flowing out the break. If bypass is credited for a reduction of debris at the core inlet, please provide the basis for the magnitude of the reduction of debris entering the core.

8. Following a loss-of-coolant accident (LOCA), thermal energy stored in the thick reactor vessel shell and the reactor vessel baffle/barrel can influence the coolant temperature at the core inlet. For both a hot-leg break and a cold-leg break, please provide an estimate of the core inlet temperature as a function of time, starting at the onset of ECCS recirculation and ending when an equilibrium reactor vessel metal temperature has been reached. Please discuss how this temperature would affect:
   a) the solubility of aluminum-based precipitates,
   b) the solubility of calcium-based precipitates, and
   c) the potential for chemical precipitates to form in the vessel as a result of these phenomena.

9. The TR does not provide specific guidance to licensees concerning the evaluation of potential chemical effects on a debris bed formed at the core inlet. Various factors can affect potential chemical precipitate interaction with a debris bed on the core inlet. For example, plant-specific amounts of LOCA debris and sump strainer surface area will determine the amount and type of debris materials that bypass the sump strainer. Bypass particulate such as microporous insulation and calcium silicate will influence the filtering properties of a debris bed differently than latent dirt particulate. Elevated temperature can either increase the solubility of precipitates or decrease the solubility of certain precipitates. Please discuss how pressure drop at the core inlet could result from chemical precipitate interaction with a debris bed. Also, please discuss your plans for providing guidance in the TR for licensees to evaluate this potential phenomenon.

10. In addressing the effects of core inlet blockage on the availability of the lower-plenum mixing volume to delay the onset of boron precipitation, the TR states, “In the extreme, core inlet blockage could inhibit mixing between the core region and the lower plenum

and would effectively reduce the credited mixing volume contribution of the lower plenum and core baffle region in the analysis of record." The report also states, "Only total or severe core inlet blockage would effectively isolate the lower plenum from the core region." Please provide an analysis of the degree of core isolation and reduction in mixing capability expected for the degree of core blockage created by the quantity of bypassed debris evaluated in the TR to be acceptable. Also, please address the effect the density gradients between the liquid in the core and the liquid in the lower plenum may have on localized fluid velocities and the transport of debris to and/or into the core.

11. The TR does not include a discussion on boron precipitation associated with a hot-leg break. To address the effect of localized blockage on localized boron precipitation for hot-leg break scenarios, please address the following:

    a. In the event of localized debris accumulation at the core inlet, has it been demonstrated that adequate flow would travel through or around the debris such that excessive boron build up is prevented? What quantity of boron would be expected to precipitate downstream of the local blockage?
    b. Discuss, in terms of boron precipitation, the effects of local blockage on first grid structure above the fuel inlet nozzle.
    c. Describe how boric acid control measures would be effective at controlling the potential localized precipitate buildups, as well as controlling general boron precipitation.
    d. If localized boron precipitation were to occur due to local debris accumulation or lack of mixing between the core and the lower plenum, please state and justify the conclusion regarding whether the 800 °F PCT acceptance criterion would be met.

12. Emergency Operating Procedures typically specify use of hot leg injection at some point in the LOCA recovery period to reverse the core flow and control boron concentration and precipitation. Please identify the time into the accident at which each PWR class of design will employ hot leg injection. Also, discuss the effect of the change in flow distribution on the debris bed that has formed at the core inlet and fuel spacer grids.

13. Part of the LOCADM Model validation involved benchmarking against an experiment in which calcium sulfate solution entered an electrically heated tube and formed deposits on the heat transfer surface, Brahim et al. The heat fluxes were high enough to cause boiling within the deposits, according to the author's calculations. The LOCADM-predicted deposition rate was calculated to be higher than the deposition rate determined experimentally. Please discuss any additional LOCADM validation that has been performed, or will be performed, involving experimentally determined deposition rates to confirm that the amount of deposit predicted by LOCADM is conservative.

14. For each plant type and configuration, please provide the driving head available for hot-leg and cold-leg break scenarios to push flow into the core across the core inlet.