December 31, 2007

Dr. Keith Paulson
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300 Oxford Drive, Suite 301
Monroeville, PA 15146

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION ON MASS AND ENERGY RELEASE ANALYSIS CODE APPLICABILITY FOR US-APWR TOPICAL REPORT MUAP-07012-P

Dear Dr. Paulson:

By letter dated July 20, 2007, Mitsubishi Heavy Industries, Inc. (MHI) submitted for Nuclear Regulatory Commission (NRC) staff review the "LOCA Mass and Energy Release Analysis Code Applicability Report for US-APWR." The NRC staff has reviewed the topical report MUAP-07012-P and has determined that additional information is needed for the NRC staff to complete its review.

Subsequently, the NRC staff has sent a draft request for additional information (RAI) electronically on November 15, 2007, followed by a conference call with MHI on December 14, 2007 to clarify the draft RAI. Furthermore, MHI has confirmed that the draft RAI does not contain any proprietary information

MHI is requested to provide a response to the NRC staff's RAI within 30 days of the date of this letter. MHI's responses to the NRC staff's RAI will be addressed in Chapter 21 of the NRC staff's safety evaluation report for the US-APWR design certification document. The RAI list is enclosed.

Sincerely,

/RA/

Jin W. Chung, Senior Project Manager
USAPWR Projects Branch
Division of New Reactor Licensing
Office of New Reactors

Project No. 0751

Enclosure: As stated

cc: See next page

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REQUEST FOR ADDITIONAL INFORMATION (RAI)
TOPICAL REPORT MUAP-07012-P
LOCA MASS AND ENERGY RELEASE ANALYSIS
CODE APPLICABILITY REPORT FOR US-APWR
PROJECT NUMBER 0751

1. Beginning on page 3-3, modeling of the advanced accumulator within the SATAN-IV and WREFLOOD computer codes is described.

   a. Please describe any differences between this modeling and the advanced accumulator model in WCOBRA/TRAC that will be used to show compliance with 10CFR50.46. If differences exist, justify that the effect will lead to conservative containment analyses. If there are no significant differences, the staff plans to perform only one review for the advanced accumulator model in all 3 computer codes.

   b. The description of the advanced accumulator flow model appears to be quasi-steady so as not to account for fluid inertia in the injection path. Please provide a discussion on the effect of not including injection path fluid inertia on the containment analysis.

2. On page 3-3 the advanced accumulator model that is built into SATAN-VI and WREFLOOD is described. On page 3-15 injection of accumulator water into a cold leg using the US-APWR GOTHIC model is discussed. Has GOTHIC also been modified to include a model of the advanced accumulator? If so please describe this model and justify that it is conservative for containment analysis.

3. On page 3-5 it is stated that the treatment of uncertainties in the accumulator initial conditions (pressure, water mass and the injection pipe resistance) will be established by sensitivity studies. When will these sensitivity studies, as they relate to containment analysis, be completed and submitted for NRC staff review?

4. The topical report states that the SATAN-VI(M1.0) computer code will be used to describe the blowdown portion of a loss-of-coolant accident (LOCA) and the WREFLOOD(M1.0) computer code will be used to describe the reflood portion. Please describe the transition between the SATAN-VI(M1.0) and WREFLOOD(M1.0) analyses in greater detail. For the sample calculation in MUAP-07012, provide the reactor system water mass and temperature, temperature of the fuel in the core, the neutron reflector, reactor vessel heavy metal, steam generator heavy metal and steam generator water mass and temperature at the time of transition.

5. The staff could not find a description of treatment for the refill period following a LOCA in the topical report. Please describe treatment of this period of analysis and justify that this treatment is conservative.

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6. The topical reports described modeling of the advanced accumulator in SATAN-VI and WREFLOOD to produce the (M1.0) versions of the code. Please describe all other changes in SATAN-VI and WREFLOOD and justify that they are conservative for containment analysis.

7. The topical report references NRC staff approved Westinghouse methodology described in WCAP-10325-P-A. The WCAP provides lists of modeling options that were utilized in tables 1 through 4. Please provide comparisons of the options in these tables to those selected for analysis of USA-PWR. If differences exist, justify that the selected options are conservative.

8. Steam flow to the containment using the WREFLOOD code will be dependant on the piping resistances assumed for the reactor system. Please quantify the degree of conservatism which will be used in selecting piping resistances for the containment analysis.

9. Figure 3-2 provides the SATAN-VI noding diagram for USA-PWR. Please identify the nodes by which flow from the accumulators and the HHIS enters the reactor system.

10. Starting on page 3-12 a brief description of the GOTHIC containment model is presented. When will the detailed containment model be provided for staff review?

11. Starting on page 3-13 the GOTHIC model for predicting mass and energy release is described. Please describe the GOTHIC model in greater detail including the following considerations:

    a. Steam flow to the containment using the GOTHIC reactor system model will be dependant on the piping resistances assumed for the reactor system. Please quantify the degree of conservatism which will be used in selecting piping resistances for the containment analysis.

    b. The GOTHIC computer code provides very versatile methodology which gives many options to the users. Please identify all options selected that are relevant to mass and energy release calculations and justify that they are conservative.

    c. On page 3-14 it is stated that the fuel rods are modeled as a single WALL type conductor with a thickness specified to include the total mass of the fuel. Please describe how the fuel rods, including the cladding, are represented in the GOTHIC model in greater detail. Justify that it is conservative to model the cylindrical fuel rods with slab geometry and that the sensible heat in the fuel rods is released to the containment in a conservative manner.

    d. The FILM heat transfer option is stated to be used on all sides of the primary and secondary system conductors in contact with the fluid. Please describe this option in greater detail. What heat transfer correlations are used to calculate heat flow to liquid, steam and two-phase mixtures? Justify that these values are conservatively high for calculating the energy release.

    e. Core decay heat is stated to be calculated using the 1979 ANS model with two standard deviations of uncertainty added. NRC Information Notice 96-39 describes how users obtained differing results from the ANS standard depending

on the input options selected. Please provide the assumptions selected for actinide contribution, actinide production, neutron capture effect, fissions per initial fissile atom and power history that will be input into the standard for US-APWR containment analysis and justify that conservative values have been selected.

f. The GOTHIC model is stated to use two conductors to model the reactor system metal. Describe the components which are included within each to the conductors and justify that this treatment is conservative.

g. Describe and justify the treatment of the sensible heat within the primary system piping.

h. Treatment of the "primary loop metal located on the secondary side of the steam generators" is discussed. Please identify the components referred to. The initial temperature of this metal is said to be set equal to the secondary side fluid temperature. Justify that this assumption is conservative.

I. Please identify all code modifications made to GOTHIC for mass and energy release calculations.

j. On page 3-15 the discussion of the treatment of two-phase level by GOTHIC is not clear. Please describe this modeling in greater detail and justify that the treatment of the two-phase mixture leaving the core and calculated to enter the steam generators is conservative. Describe the assumptions made for relative velocity between steam and the liquid and justify that these assumptions are conservative. For the sample calculation in MUAP-07012-P, provide plots of the void fractions and mass flow rates of the fluid leaving the core and entering the steam generators as a function of time. It would be helpful if a comparison could be made of the steaming rate for the post reflood period between the methodology of WCAP-10325-P-A and that of the US-APWR topical.

k. In long term cooling analyses using RELAP5, the staff has found that the loop seals at the reactor coolant pump suctions close by being refilled with water. This water comes either from liquid carryover out of the core or from backflow of ECCS in the cold legs. During the blowdown period all the loop seals are calculated to open but during the post reflood period the loop seals begin to close until only one loop seal is left open. Flow through a single loop is adequate to remove the steam produced by the core and provide for core cooling. The staff's concern is that if following a double ended pump suction break, if all the steam flow is through the broken loop, the steam will not pass through any ECCS injection points and will enter the containment through the break without any steam quenching occurring. As a sensitivity study, please provide an analysis of the containment pressure if three coolant loops were blocked during the post-reflood period and only the broken loop were open to pass steam.

12. Section 5.1 of WCAP-10325-P-A describes model conservatisms which primarily involve code inputs. Please provide a comparison of the assumptions to be made for analysis of US-APWR with those of Section 5.1 of WCAP-10325-P-A and justify any differences.

13. Tables 6A and 7A of WCAP10325-P-A provide mass and energy balances for the sample case of a postulated double ended pump suction break. Please provide similar tables for the sample case in MUAP-07012-P and indicate the reference temperature upon which the energy balance is based.

14. Tables 13A, 14A, 14B, 15A and 15B of WCAP10325-P-A provide tabulations of the mass and energy release of steam and water from the reactor including ECCS spillage as a function of time for containment analysis. Please provide similar tables for the sample case of MUAP-07012-P.

15. On page 3-15 it is stated that steam condensation in the downcomer and the broken loop cold leg volume is prevented in the GOTHIC analysis of the post reflood period by setting the liquid/vapor interface areas in those regions to zero. Page 3-5 states that no mixing of steam and safety injection water in the downcomer is assumed for the reflood analysis. Please describe how this type of condensation is prevented during the reflood period when mass and energy release is being calculated by WREFLOOD.

16. The treatment of spilled accumulator water from the broken cold leg is not discussed for the blowdown period. Please provide the assumptions for containment analysis and justify that they are conservative.

17. The treatment of the spilled accumulator water from the broken cold leg is not discussed for the reflood calculation. Please provide these assumptions and justify that they are conservative. If the accumulators will still be discharging during the post-reflood period please describe and justify the assumptions for treatment of this water that will affect the containment analysis.

18. The equation for carryout rate fraction on page 3-8 contains a quench front level term Zq. Based on FLECHT data, the correlation was found to be valid until the quench front level neared but did not reach the top of the core. At that elevation the core was found to be quenched from the top so that water was no longer carried out the top of the core. The FLECHT data was obtained from a facility simulating a 12 foot reactor core. Please describe the assumptions used in modeling the 14 foot fuel of US-APWR with regard to termination of liquid carryout as the quench front level reaches the top of the core. Justify that this assumption is conservative for containment analysis.

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