REQUEST FOR ADDITIONAL INFORMATION MUAP-07011 REV 2

03/25/2009

US-APWR TOPICAL REPORT

Large Break LOCA Code Applicability [MUAP-07011-P(R0)]

Mitsubishi Heavy Industries, Inc.

Docket No. 52-021

SRSB Branch

The following RAIs are necessary to help determine if the requirements of 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Nuclear Power Reactors", and Appendix K of 10 CFR 50, "ECCS Evaluation Models" have been satisfied.

1. CSAU –Step- 4 clearly required identification of frozen code and where it is derived from. CSAU- Step-5 requires proper documentation with model described with references, and assessment of their range of applicability to US-APWR. There should be a clearly defined version of COBRA-TRAC that was approved by USNRC and is the basis of COBRA-TRAC (M1.0). A list of the changes, made from the last approved version, should be provided. How have these changes been validated?

2. Chapter 2.0 describes plant design and features. Here are questions for this section.

   2.1. Report indicates (Section 2.4.2) three ECCS systems: Advance Accumulator, High Head Injection System and Emergency Letdown System. However, there is no description of Emergency Letdown System. This needs explanation.

   2.2. Section 2.4.2 indicates role of ECCS in cooling the reactor for various events but the large break LOCA is not included. Please explain.

3. Section 3.0 briefly describes LBLOCA code and methodology. Based on the review of this section, request for additional information is formulated in the questions listed below.

   3.1. LBLOCA has been divided into three phases (Table 3.3-1) but is not clear what defines the boundaries of these phases. Refilling generally starts when accumulator flow comes in and ends when lower plenum is full. Provide a detail explanation of Table 3.3-1.

   3.2. [

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3.3. [

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3.9. [(Proprietary information withheld under 10 CFR 2.390)

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3.10. * [

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3.11. * General comment. The stored energy release should be important as it affects coolant conditions. How does total heat release from the reactor system (excluding fuel rods) structures compare to the decay heat? Why is the reactor system stored energy not considered in the PIRT?

3.12. Subsection 3.5.1, Advanced Accumulator, and Appendix B, Advanced Accumulator Model Built into WCOBRA/TRAC, describes the advanced accumulator. The advanced accumulator is a new component in the APWR and it requires implementation and review of new correlation in COBRA-TRAC (M1.0). Based on the review, the questions listed below were developed for the advanced accumulator.

3.12.1. Will there be any nitrogen flow into the cold leg of the primary section either through ingress in the stand pipe or from the dissolved nitrogen?

3.12.2. Model validation uses same data that was used to develop the correlation (Tests 1, 2, 3, 4, and 6, Page 5-1, MUAP 07001-P (R1)). This could be a check on implementation but not a validation. Please indicate how this correlation applies to smaller scale tests and how it will apply to plant (full scale) that will have different size vortex chamber?

3.12.3. [

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3.12.4. Explain the statement that the test was divided based on C_{vmi} and C_{fmi}.

3.12.5. [

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3.12.6. [(Proprietary information withheld under 10 CFR 2.390)

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3.12.7. On page 3-27, correct the reference to instrument uncertainties from Table 3.5-5 to Table 3.5-4.

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3.12.8. Are the values in Tables 3.5-4, 3.5-5 and 3.5-6 percentages?

3.12.9. On page 3-28, it is stated that the total uncertainty is treated as statistical parameter in ASTRUM. This statement needs to be expanded. How is this implemented in ASTRUM? Is the sampling done on both sides of the best estimate value? Does the range of parameters include 95% of values? How is bias in flow rate coefficient accounted for in the analysis?

3.12.10. How is switching level uncertainty implemented in ASTRUM?

3.12.11. Do same uncertainties apply to plant? Is there a scale effect? Section 4.3 (Ref MUAP 07001) only mentions Reynolds number as scaling parameter.

3.12.12. In Appendix B, page B-1; equation B-1 implies that the flow damper outlet pressure will always be greater than the vapor pressure. Provide a reference or documentation that supports this assumption.

3.12.13. [
(Proprietary information withheld under 10 CFR 2.390)
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3.12.14. [
(Proprietary information withheld under 10 CFR 2.390)
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3.12.15. Explain the basis of Eqs. B-9 and B-10. Please use definitions of friction factor and loss coefficient from WCAP-16009 and provide reference. There seems to be a factor of two differences when it is derived using expressions from COBRA-TRAC manual (Eq. 4-197 as definition for friction factor and 4-256 for loss coefficient). Are there differences in definitions?

3.12.16. * [
(Proprietary information withheld under 10 CFR 2.390)
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3.12.17. Page B-5, how are QLTMIN and VDMIN estimated for input?

3.13. In Section 3.5.3, Neutron Reflector, the report describes modeling of a new component of APWR.

3.13.1. There is no description of cooling holes and stored energy in the neutron reflector. Provide a reference or description of the cooling holes including the number and size of these holes.

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3.13.2. * COBRA-TRAC (M1.0) has been modified to model the flow field in the unheated flow channel, hot wall flow regime, for the flow channels in NR. Provide a reference or explanation for the following questions. Are the flow regimes described for hot wall and normal flow regimes applicable to flow channels in the neutron reflector? Does the model switch to normal wall flow regime when wall cools below T_{CHF}? Is the limit used for T_{CHF} valid for channel flow of neutron reflector, if so why?

3.13.3. The expression for $\alpha_{critical}$ for flow regime is described in COBRA-TRAC manual, Equation 3-39, but no reference provided. The section states that it is derived in Chapter 4 but it is not shown in that chapter in the version of the manual provided. Provide a reference or explanation to resolve the above issue.

3.13.4. * Provide a reference or explanation to the following questions. How much stored energy is in NR and how does the heat transfer to fluid compare to decay heat?

3.14. The plant model is described in Section 3.6, Sample Plant Analysis.

3.14.1. Nodes communicate with other nodes in the radial, azimuthal and axial directions. Provide a reference or explanation on how the friction terms (wall, turbulent, etc.) are specified or computed through the gaps (interface between nodes)?

3.14.2. Provide a reference or explanation for the following questions. How are the fuel rods nodalized for conduction calculation? How does this nodalization compare to the previously approved 4-loop Westinghouse PWR representation?

3.14.3. In Subsection 3.6.1.3, Loop Model, DVI injects coolant through downward pointing nozzle in the vessel. Provide a reference or description on how it is specified in COBRA part of the code?

3.14.4. [

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3.14.5. * In Subsection 3.6.3.2, Homologous Pump Curves for the US-APWR RCP, the report describes the pump model. Figures 3.6-11 and 3.6-12 are shown as for US-APWR. Specific speed indicates similarity of pump performance in single phase flow. However, in case of two phase flow there are other length scales (bubble size) that are independent of pump size. It has been found that smaller pump degrades more than larger pumps with

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same pump specific speed (NUREG/CR-5249, App L). Provide a reference or discussion to why the 1/3 scale data will represent US-APWR for two phase degradation?

3.15. Section 3.6.5, Analysis Results, discusses the results from the analyses.

3.15.1. In Subsection 3.6.5.1, the blowdown phase shows hot channel flow rate in Figure 3.61-5. Provide a reference or discussion on why does flow increase around 5 seconds?

3.15.2. The description of refill phase indicates that this phase ends when the downcomer is full. Figure 3.6-18 indicates that the downcomer level is less than the level at the beginning of the transient when the downcomer is filled with liquid. Provide a reference or explanation of the ending of refill phase.

3.16. In Section 3.7, ASTRUM Methodology Applied to US-APWR, the report describes ASTRUM methodology as related to the US-APWR design. It is based on non-parametric approach described by Wilks and later on by Guba et al. This step is consistent with CSAU step 13 but differs from CSAU demonstration where response surface method was used. In non parametric approach, the plant and model parameters are randomly sampled and a set of 124 calculations are performed to achieve 95%/95% values of the three parameters of the acceptance criteria.

3.16.1. How is it assured that the values of any parameter obtained by random sampling of the distribution, is obtained from the full range of the distribution and is not selected from only one part of the distribution?

3.16.2. The description of matrix, first paragraph on page 3-90, below Equation 3.7-2, states that it has N rows and 3 columns which are incorrect. Correct it by changing N rows and 3 columns to 3 rows and N columns.

3.16.3. In Subsection 3.7.2, the report describes the parameters used for uncertainty analyses. There is no mention of uncertainty in global phenomena such as pump, condensation/flashing etc. as were identified in the PIRT. What are the important global parameters and how are they accounted for in the uncertainty analyses?

3.16.4. Tables 3.7-1 and 3.7-2 do not provide any information on type of distribution, range and basis of this information. Provide the reference or document that has this information for the US-APWR?

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