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Document Control Desk
U.S. Nuclear Regulatory Commission
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Attention: Dr. Jeffrey A. Ciocco

Docket No. 52-021
MHI Ref: UAP-HF-08120

Subject: Reporting of Modifications and Corrections in ECCS Evaluation Models for the US-APWR LOCA Analyses

In compliance with 10CFR50.46, Mitsubishi Heavy Industries, Ltd. ("MHI") is submitting the attached preliminary report on the modifications and corrections implemented in the US-APWR ECCS Evaluation Models ("EM") for the LOCA Analyses documented in Chapter 15.6.5 of the US-APWR Design Control Document ("DCD"). The report is provided to explain, in general, the description of these changes and their impacts to the peak cladding temperature ("PCT"). Since the impact of the corrections is not significant, results of re-analyses will be submitted to the NRC in the next revision of DCD in August 2008.

This preliminary report discusses two (2) corrections to the EMs for the LOCA analyses as follows:

1. The correction to the PCT calculation using the HOTSPOT code for the Best-Estimate Large Break LOCA Evaluation Model
2. The correction to the PCT calculation using the M-RELAP5 code for the Conservative Small Break LOCA Appendix-K Evaluation Model

Questions or requests for additional information related to this preliminary report should be directed to Dr. Keith Paulson. Thank you for your attention.

Sincerely yours,

Yoshiki Ogata,
General Manager - APWR Promoting Department
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Enclosures:

1. Reporting Modifications and Corrections to the ECCS Evaluation Models for the US-APWR LOCA Analyses

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Enclosure1

Reporting Modifications and Corrections to the ECCS Evaluation Models for the US-APWR LOCA Analyses [1]

1. Correction to the PCT calculation using the HOTSPOT code for the Best-Estimate Large Break LOCA Evaluation Model

1.1 Background

MHI has utilized the WCOBRA/TRAC code to perform the best-estimate large-break LOCA analyses reported in Chapter 15.6.5 of the Design Control Document (DCD) for the US-APWR. For the purpose of large-break LOCA analyses, the HOTSPOT code is appplied to perform the detailed fuel rod model analysis [2,3]. The code calculates the effect of uncertainties at axial locations of the fuel rod. The code uses a transient heat conduction model identical to that of WCOBRA/TRAC. The code also simulates cladding-burst, metal-water reaction and fuel relocation following burst phenomenon.

The code initially contained an error when calculating fuel relocation. MHI acquired the information from 10 CFR 50.46 reports published in the US-NRC ADAMS [4]. MHI confirmed that the same error was included in the HOTSPOT code used for US-APWR large break LOCA analysis reported in the DCD.

The HOTSPOT code contains a fuel relocation model to evaluate the possibility that additional pellets fragments above the axial node where the burst is predicted to occur may settle into the burst region. The effect of fuel relocation on local linear heat rate was initially calculated. However, it was inadvertently omitted later in the coding. The necessary corrections have since been implemented to the code [4].

1.2 Margin to Safety Limit

Table-1 Summary of updated PCT Margin for US-APWR Best-Estimate Large-Break LOCA

	Cladding Temperature (°F)
Analysis Of Record PCT	1763
PCT Assessments	
HOTSPOT Fuel Relocation Error	0
Analysis Of Record PCT + PCT Assessments	1763

For the limiting Best-Estimate Large Break LOCA, the correction of the HOTSPOT Fuel Relocation error has resulted in a peak cladding temperature (PCT) of 1763°F, which is the same as the result in the DCD. Therefore, the correction does not result in any change to the PCT calculation. Furthermore, it is significantly below the 10 CFR 50.46(b)(1) acceptance criterion of 2200°F [5]. Re-analysis will be performed to confirm that the calculated total oxidation of the cladding will not exceed 0.17 times the total cladding thickness before oxidation as required by other 10 CFR 50.46 acceptance criteria [5].

1.3 Justification that the Error is insignificant

The PCT limiting case does not cause any impact from the fuel relocation on the local linear heat rate. The correction does not result in any change to PCT. The best-estimate analysis of the large break LOCA still demonstrates that the acceptance criteria set forth in 10 CFR 50.46 are satisfied.

1.4 Schedule of Re-analysis

MHI is performing re-analysis of the US-APWR Large Break LOCA using the HOTSPOT code in which the coding or modeling error has been corrected. Re-analysis results will be reported

to the NRC in the next revision of DCD in August 2008.

2. Correction to the PCT calculation using the M-RELAP5 code for the conservative Small Break LOCA Appendix-K Evaluation Model

2.1 Background

The M-RELAP5 code is utilized to analyze thermal hydraulic behaviours and safety performance of the MHI US-APWR during a postulated small break LOCA, in compliance with the requirements specified in 10 CFR 50.46, "Acceptance Criteria for ECCS for Light-Water Nuclear Power Reactors" [5], and in 10 CFR 50 Appendix K, "ECCS Evaluation Models" [6]. The analysis results are reported in Chapter 15.6.5 of the US-APWR DCD and its accompanying technical report [3,7,8].

A legacy FORTRAN code error in the point kinetic model of RELAP5 was reported and has recently been fixed [9]. MHI became aware that this code error was also in the M-RELAP5, the computer code used by MHI for the conservative small-break LOCA analyses, based on the Appendix-K. A correction to the point kinetics subroutine was performed. The code modifications that were made are several "do-loops" that evaluate the impact of delayed neutron groups. There was an incorrect indexing in the four summations that compute terms for the delayed neutron fractions for each group, which contributes to total power. The error adds an additional term to each of the summations. MHI has incorporated the corrections to the M-RELAP5 code and has re-run the limiting small-break LOCA cases (7.5 inch and 1-ft^2 breaks) to estimate the impact on the SBLOCA PCT.

2.2 Margin to Safety Limit

Table-2 Summary of updated PCT Margin for US-APWR Appendix-K Small-Break LOCA

	Cladding Temperature (°F)	
	7.5 inch break	1-ft^2 break
Analysis of Record PCT	775	1297
PCT Assessments		
Point Kinetics Coding Error	-1.0	+20
Analysis of Record PCT + PCT Assessments	774	1317

The table shows that for the 7.5 inch break, the PCT is 774°F, which is a -1°F change from the value reported in the DCD. For the 1-ft^2 break, the PCT is 1317°F, which is a +20°F change from the value in the DCD.

2.3 Justification that the Error is Insignificant

Section C.5.c of Appendix K defines a significant error as one that exceeds 50°F. The corrected results displayed in Table 2 show that the correction to the Point Kinetics model has resulted in a maximum PCT change of only 20°F. The conservative small break LOCA analysis, using the Appendix-K based M-RELAP5 model, demonstrates that the acceptance criteria set forth in 10 CFR 50.46 are met. Although the result is still acceptable, a re-analysis is being performed to assure that the acceptance criteria of 10 CFR 50.46 are satisfied.

2.4 Schedule of Reanalysis

MHI is performing a re-analysis of the US-APWR Small Break LOCA using the M-RELAP5 code in which the coding or modeling error has been corrected. The results of the re-analysis will be reported to the NRC in the next revision of DCD in August 2008.

3. References

1. NRC Information Notice 97-15, Supplement 1: Reporting of Errors and Changes in Large-Break/Small-Break Loss-of-Coolant Evaluation Models of Fuel Vendors and Compliance with 10 CFR 50.46(a)(3), April 23, 1999.
2. Large Break LOCA Code Applicability Report for US-APWR, MUAP-07011-P (Proprietary) and MUAP-07011-NP (Non-Proprietary), July 2007
3. US-APWR DCD Chapter 15, Transient and Accident Analyses, MUAP-DC015, Rev. 0, December 2007
4. Letter from Westinghouse to the U.S. NRC on "10 CFR 50.46 Report for the AP1000 Standard Plant Design", ADAMS accession number: ML080510189
5. 10 CFR 50.46, Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Nuclear Power Reactors, November 1997.
6. 10 CFR 50, Appendix K, ECCS Evaluation Model
7. Small Break LOCA Methodology for US-APWR, MUAP-07013-P (Proprietary) and MUAP-07013-NP (Non-Proprietary), July 2007
8. Small Break LOCA Sensitivity Analyses for US-APWR, MUAP-07025-P (Proprietary) and MUAP-07025-NP (Non-Proprietary), December 2007
9. Letter from AREVA to the U.S. NRC on the "2007 – Annual Reporting of Changes and Errors in ECCS Evaluation Models", ADAMS accession number: ML080860210