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TOKYO, JAPAN

August 31, 2009

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Attention: Dr. Jeffrey A. Ciocco

Docket No. 52-021
MHI Ref: UAP-HF-09433

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") and input decks for the LOCA Analyses documented in Chapter 15.6.5 of the US-APWR Design Control Document ("DCD") Revision 1. The report is provided to explain, in general, the description of these changes and their impacts to the peak cladding temperature ("PCT"). The impact of the corrections is negligible, and the results of re-analyses will be submitted to the NRC in the next revision of DCD in October 2009.

This report discusses the following two (2) corrections to the PCTs for the LOCA analyses:

1. Correction to the PCT Calculation for the Best-Estimate Large Break LOCA Evaluation
2. Correction to the PCT Calculation for the Appendix-K-based Small Break LOCA Evaluation

This letter includes the Optical Storage Medium ("OSM") containing input decks for US-APWR LOCA analysis (Enclosure 3), and the Affidavit of Yoshiki Ogata (Enclosure 1), which identifies the reasons MHI respectfully requests that all material designated as "Proprietary" in Enclosures 3 be withheld from disclosure pursuant to 10 C.F.R. § 2.390 (a)(4).

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,

Y. Ogata

Yoshiki Ogata,
General Manager - APWR Promoting Department
Mitsubishi Heavy Industries, LTD.

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NRO

Enclosures:

1. Affidavit of Yoshiki Ogata

2. Reporting of Modifications and Corrections in ECCS Evaluation Models for the US-APWR LOCA Analyses (Non-proprietary)

3. OSM: Corrected Input Decks for the US-APWR LOCA Analyses (Proprietary)
   The files contained in this OSM are listed in Attachment 1.

CC: J. A. Ciocco
C. K. Paulson

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ENCLOSURE 1

Docket No. 52-021
MHI Ref: UAP-HF-09433

MITSUBISHI HEAVY INDUSTRIES, LTD.

AFFIDAVIT

I, Yoshiki Ogata, being duly sworn according to law, depose and state as follows:

1. I am General Manager, APWR Promoting Department, of Mitsubishi Heavy Industries, Ltd. ("MHI"), and have been delegated the function of reviewing MHI's US-APWR documentation to determine whether it contains information that should be withheld from disclosure pursuant to 10 C.F.R. § 2.390 (a)(4) as trade secrets and commercial or financial information which is privileged or confidential.

2. In accordance with my responsibilities, I have reviewed the enclosed document entitled "Reporting of Modifications and Corrections in ECCS Evaluation Models for the US-APWR LOCA Analyses" and the enclosed Optical Storage Medium ("OSM") dated August 31, 2009, and have determined that all files contained in the OSM are proprietary information that should be withheld from public disclosure. The label on the OSM have been marked to indicate that the entire contents of the OSM should be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4).

3. The basis for holding the referenced information confidential is that it describes the unique design of the safety analysis, developed by MHI (the "MHI Information").

4. The MHI Information is not used in the exact form by any of MHI's competitors. This information was developed at significant cost to MHI, since it required the performance of research and development and detailed design for its software and hardware extending over several years. Therefore public disclosure of the materials would adversely affect MHI's competitive position.

5. The referenced information has in the past been, and will continue to be, held in confidence by MHI and is always subject to suitable measures to protect it from unauthorized use or disclosure.

6. The referenced information is not available in public sources and could not be gathered readily from other publicly available information.

7. The referenced information is being furnished to the Nuclear Regulatory Commission ("NRC") in confidence and solely for the purpose of supporting the NRC staff's review of MHI's application for certification of its US-APWR Standard Plant Design.

8. Public disclosure of the referenced information would assist competitors of MHI in their design of new nuclear power plants without the costs or risks associated with the design and testing of new systems and components. Disclosure of the information identified as proprietary would therefore have negative impacts on the competitive position of MHI in the U.S. nuclear plant market.

I declare under penalty of perjury that the foregoing affidavit and the matters stated therein are true and correct to the best of my knowledge, information, and belief.

Executed on this 31st day of August, 2009.

Y. Ogata

Yoshiki Ogata

Enclosure 2

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

1. Correction to the PCT Calculation for the Best-Estimate Large Break LOCA Evaluation

1.1 BACKGROUND

MHI has utilized the WCOBRA/TRAC and HOTSPOT codes to perform the best-estimate large break loss-of-coolant accident (LBLOCA) analyses [2] reported in Chapter 15.6.5 of the Design Control Document (DCD) Revision 1 for the US-APWR [3].

MHI found that some minor corrections to the codes used for the US-APWR LBLOCA analysis were required. The corrections to be made are expected to give only insignificant impact to the previously reported analysis results. MHI has been performing the evaluation to determine the impact using the corrected codes. MHI also discovered that some minor corrections to the input data used for the US-APWR LBLOCA analysis were necessary. MHI reports the impacts of the corrections to the codes and to the input data in this report.

1.2 LBLOCA CODE AND INPUT CORRECTIONS

1.2.1 LBLOCA CODE CORRECTIONS

1.2.1.1 WCOBRA/TRAC Steam Table Minor Corrections

Corrections were made to the subroutines for the steam table in WCOBRA/TRAC. The WCOBRA/TRAC code was updated to incorporate the following changes to the steam table:

(i) Fix the coding for the power calculation, which is part of the density calculation in the subroutine; and
(ii) Correct a typo-error for the coefficient in the steam table subroutine.

Evaluation

The corrections slightly affect the calculation in the lower-temperature region in the steam table. Therefore, the resultant impact on PCT is small.

1.2.1.2 HOTSPOT Burst Temperature Logic Corrections

The HOTSPOT code was updated to incorporate the following corrections to the burst temperature calculation logic:

(i) Change the rod internal pressure used to calculate the cladding engineering hoop stress from the value in the previous time step to the value in the current time step;
(ii) Revise the average cladding heat up rate calculation to reset selected variables to zero at the beginning of each calculation and to use the instantaneous heat up rate when fewer than five values are available; and
(iii) Reflect the assumed saturation of ramp rate effects above 28°C/s for Zircaloy-4 cladding.

Evaluation

The difference caused by the correction of item (i) is very small. The corrections for items (ii) and (iii) give the impact only to the Zircaloy-4 cladding. However, the Zircaloy-4 cladding is not adopted in the US-APWR. Therefore, each correction is expected to cause negligible effect to the LBLOCA analysis.

1.2.2 LBLOCA INPUT CORRECTIONS

1.2.2.1 Fuel Temperature Data in WCOBRA/TRAC and HOTSPOT

It was found that the power density used in the fuel design analysis has not taken into account the change in fuel pellet density due to fuel relocation in the vertical direction. In the MHI LOCA analysis, several input data related to the fuel performance are set up based on the evaluation results of the fuel design analysis so that the LOCA codes reproduce the fuel temperature obtained by the fuel design code at the initial steady-state. The resultant parameters to be corrected in the LOCA analysis are listed up below:

(i) Initial fuel temperature at the hottest location;
(ii) Fuel burnup for the fuel pellet thermal conductivity;
(iii) Radial power profile in the fuel pellet;
(iv) Fuel-internal pressure;
(v) Initial mole fraction of FP gases released to the pellet-cladding gap; and
(vi) Initial thickness of the oxidized cladding film.

Evaluation

The power density change accounted in the fuel design analysis is 0.2%. Therefore, the difference between the previously evaluated and revised fuel temperature related data is very small and is expected to cause a negligible effect on LBLOCA analysis.

1.2.2.2 Temperature Range of Material Property Data in WCOBRA/TRAC

A value of 70°F was used as the lower bound in the temperature range for the material properties. In the statistical analysis, it has been found that there is a possibility that the resultant temperature would fall below the current lower bound value. The lower bound value is modified.

Evaluation

For cases that require material property data with the lower bound value of 70°F is expected not to produce a limiting PCT. It is clear that the limiting PCT case do not need the lower temperature material property. Therefore, the estimated effect to the limiting PCT will be zero.

1.2.2.3 ACC Tank Geometry, ECCS Actuation Setpoint and SG Secondary Mass Data in WCOBRA/TRAC

Minor corrections were given to the following input data:

(i) Inner diameter of the advanced accumulator tank;
(ii) Pressure value associated with the ECCS actuation setpoint; and
(iii) Liquid mass of SG secondary side to determine the target steady-state.

Evaluation

The differences between the previously used and corrected (i) ACC tank geometry related data, (ii) ECCS actuation pressure setpoint and (iii) SG secondary mass for steady-state confirmation are very small. Each correction is expected to cause negligible effect to LBLOCA analysis.

1.2.2.4 DVI Line Injection Flow Area in WCOBRA/TRAC

Flow area and hydraulic diameter of the DVI nozzle were corrected to maintain consistency with those of the injection line.

Evaluation

The injection of coolant through the DVI lines into the reactor vessel takes place after the reflood-PCT has occurred. Hence, it causes no impact on the limiting PCT.

1.2.2.5 Thermal Connection with Unheated Conductors in WCOBRA/TRAC

The following input data relevant to the unheated conductors are corrected:

(i) Thermal connection between the unheated conductor and hydraulic cell; and
(ii) Mass of the unheated conductors.

Evaluation

The differences between the previously used and corrected data in each unheated conductor connected to hydraulic calls are small enough and cause a negligible effect to the analysis result.

1.3 MARGIN TO SAFETY LIMIT

For the best-estimate LBLOCA analysis, the limiting PCT is determined by ASTRUM, a statistical methodology to calculate the PCT, maximum local oxidation and core-wide oxidation with the 95/95 confidence level through 124 runs of the random sampling [2]. As described in the previous section, it can be estimated that the PCT impact due to the code and input data corrections are either small or negligible. Therefore, the inputs providing PCTs within 100°F from the limiting case in the US-APWR DCD revision 1 [3] are used to evaluate the impact on PCT. It is noted that the impact due to the code and input data corrections is simultaneously evaluated.

Consequently, the corrections to the code and input errors have resulted in a new PCT of 1750°F, which is only a -13°F change from the value reported in the DCD revision 1. The value is still significantly below the 10 CFR 50.46(b)(1) acceptance criterion of 2200°F [4].

Table-1 Updated PCT for US-APWR Best-Estimate LBLOCA

	Cladding Temperature (°F)
Analysis of Record PCT	1763
Updated Analysis of Record PCT + PCT Assessments	1750

1.4 JUSTIFICATION THAT THE ERROR IS INSIGNIFICANT

The corrections to the codes do not result in any significant impact on the cladding temperature. In the case of limiting PCT, the best-estimate analysis of the LBLOCA demonstrates that the acceptance criteria set forth in 10 CFR 50.46 are satisfied.

1.5 SCHEDULE OF RE-ANALYSIS

MHI has been performing the re-analysis for the US-APWR LBLOCA using the WCOBRA/TRAC and HOTSPOT codes, in which all the code and input errors have been corrected. Re-analysis results are to be reported to the NRC in the next revision of DCD in October 2009.

2. Correction to the PCT Calculation for the Appendix-K-based Small Break LOCA Evaluation

2.1 BACKGROUND

MHI has utilized the M-RELAP5 code to perform the small break loss-of-coolant accident (SBLOCA) analyses [5], which conforms to the Appendix K to 10CFR50 [6]. The analysis results are reported in Chapter 15.6.5 of the Design Control Document (DCD) Revision 1 for the US-APWR [3].

MHI found that some minor corrections to the code used for the US-APWR SBLOCA analysis were required. The corrections to be made are expected to give only insignificant impact to the previously reported analysis results. MHI has been performing the evaluation to determine the impact using the corrected code. MHI also discovered that some minor corrections to the input data used for the US-APWR SBLOCA analysis were necessary. MHI reports the impacts of the corrections to the code and to the input data in this report.

2.2 SBLOCA CODE AND INPUT CORRECTIONS

2.2.1 SBLOCA CODE CORRECTIONS

2.2.1.1 Reactor Kinetics

It was found that the point reactor kinetics routine requires one correction and one modification. The first was a corrective modification in programming for the six delayed neutron groups which had been previously reported by MHI to the NRC [7]. The second was related to the logic on when to apply a quasi-steady form of the point kinetics equation rather than the fully transient form for numerical computations. The threshold to switch from the quasi-steady form to the transient form was reduced to obtain a more precise neutron response.

Evaluation

The present corrections are related to the neutron reactivity calculation, which becomes significant only for the reactivity insertion incident and accident analyses. Therefore, the present corrections are negligible for the US-APWR SBLOCA analysis and its impact on PCT is expected to be small.

2.2.1.2 Steam Property for the Film Boiling Heat Transfer Coefficient

The vapor steam properties used for the Bromley film boiling heat transfer coefficient had been determined based on the vapor temperature. From the viewpoint of the conservatism for the safety analysis, the temperature should be replaced by film temperature, which is the average of the wall and vapor temperatures.

Evaluation

This correction becomes significant when the cladding temperature rises higher during a film boiling condition. Referring to the US-APWR DCD [3], heat up in cladding temperature is suppressed sufficiently lower than the safety limit, therefore, it is expected that the present correction results in small impact on PCT.

2.2.1.3 Heat Capacity used in Surface/Edge Mesh of Heat Structures

The program was revised to compute the material heat capacity with the correct conductor cell volume. It is noted that this correction is necessary only for the outer surface mesh of heat structures.

Evaluation

Temperature change due to this correction is limited, and its impact on PCT is expected to be insignificant.

2.2.1.4 Modifications for Code Update

The following modifications were made to prevent from potential impact on PCT when M-RELAP5 is used in the different computational environment:

(i) Access to the back-up data;
(ii) Initialization for the fluid properties of non-condensable gases;
(iii) Input data procedure for the CHF reduction option; and
(iv) Structure of several variables in coding.

Evaluation

The above modifications are relevant to programming change for the code update. Therefore, the impact on PCT due to the modifications is either negligible or none.

2.2.1.5 Modifications for Output Edits

The following data are newly edited on the output file and/or restart plot file:

(i) Data related to the advanced accumulator;
(ii) Data related to the fuel/cladding model; and
(iii) Neutron reactivity decomposed to Doppler, coolant density, and control rod.

Evaluation

The above modifications are relevant to programming change for the code update. Therefore, the impact on PCT due to the modifications is either negligible or none.

2.2.2 SBLOCA INPUT CORRECTIONS

2.2.2.1 Fuel Temperature Data

As described in Section 1.2.2.1, the power density used for the fuel design analysis has been corrected, and thus the following data used for the SBLOCA analysis shall be updated:

(i) Initial fuel temperature at the hottest location;
(ii) Fuel pellet thermal conductivity (dependent on burnup);
(iii) Radial power profile in the fuel pellet;
(iv) Fuel-internal pressure;
(v) Initial volumes of FP gases released to the pellet-cladding gap; and
(vi) Initial thickness of the oxidized cladding film.

In addition, the initial thermal power of the hottest rod was corrected and multiplied by the factor of 1.002 which accounts for the effect of the fuel relocation.

Evaluation

Power density change is limited to 0.2%, therefore, its impact to the both fuel design and SBLOCA analyses is small.

2.2.2.2 RCP Input Data

The following small and minor corrections were made to the input data related to the reactor coolant pump (RCP):

(i) Reference coolant density; and
(ii) RCP two-phase degradation data.

Evaluation

The above corrections are not due to systematic error, and changes in the input data are quite small. Therefore, its impact on PCT is small.

2.2.2.3 Loop Pressure Drop Data

In the process of SBLOCA analyses, the pressure drop through the primary loop except for the RCP head is adjusted to balance with the RCP head under the steady-state condition prior to the transient calculation. As mentioned in Section 2.2.2.2, the RCP head was slightly changed due to the input data correction.

Evaluation

Because the input data correction related to the RCP is quite small, its impact to the RCP head is negligible.

2.2.2.4 Dummy Spray Component Connection to Pressurizer

In order to obtain the targeting steady-state, pressurizer liquid volume is controlled by using the dummy spray component which is connected to the lower portion (a cell filled with liquid) of the pressurizer. The junction of the flow path, however, had been miss-connected to the upper portion (a cell filled with steam) of the pressurizer, which might result in divergence during the steady-state calculation. Therefore, the junction was appropriately modified to prevent any potential error.

Evaluation

The above modification gives no change in the converged solution for the initial steady-state, neither in the transient calculation following the obtained steady-state.

2.3 MARGIN TO SAFETY LIMIT

For the limiting SBLOCA case, the corrections to the code and input errors have resulted in a new PCT of 1286°F, which is only a -31°F change from the value reported in the DCD revision 1. The value is still significantly below the 10 CFR 50.46(b)(1) acceptance criterion of 2200°F [4]. 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 the other 10 CFR 50.46 acceptance criteria [4].

Table-2 Summary of Updated PCT for US-APWR Appendix-K-based SBLOCA

	Cladding Temperature (°F)	
	7.5-inch break	1-ft^2 break
Analysis of Record PCT	774	1317
PCT Assessments		
Code Modifications	-2	-1
Input Modifications	±0	-30
Analysis of Record PCT + PCT Assessments	772	1286

2.4 JUSTIFICATION THAT THE ERROR IS INSIGNIFICANT

The corrections to the code do not result in any significant impact on the cladding temperature.

In case the limiting PCT, the Appendix-K-based analysis of the SBLOCA demonstrates that the acceptance criteria set forth in 10 CFR 50.46 are satisfied.

2.5 SCHEDULE OF RE-ANALYSIS

MHI has been performing the re-analysis for the US-APWR SBLOCA using the M-RELAP5 code, in which all the code and input errors have been corrected. Re-analysis results are to be reported to the NRC in the next revision of DCD in October 2009.

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. 1, August 2008.
4. 10 CFR 50.46, Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Nuclear Power Reactors, November 1997.
5. Small Break LOCA Methodology for US-APWR, MUAP-07013-P (Proprietary) and MUAP-07013-NP (Non-Proprietary), July 2007.
6. 10 CFR 50, Appendix K, ECCS Evaluation Model
7. Letter from Mitsubishi Heavy Industry to U. S. NRC, "Reporting of Modifications and Corrections in ECCS Evaluations Models for the US-APWR LOCA Analyses", UAP-HF-08120, July 4 2008.

ATTACHMENT 1
FILES Contained in OSM

OSM: Corrected Input Decks for the US-APWR LOCA Analyses
- Proprietary Information -

Contents of OSM

File Name	Size	Sensitivity Level
- Readme.pdf	36KB	Proprietary
• Reference_Case_Corrected_Input		
- u05_ss*	203KB	Proprietary
- u05_tr*	34KB	Proprietary
• Limiting_Case_Corrected_Input		
- u05_ss*	207KB	Proprietary
- u05_tr*	34KB	Proprietary
- hs00.inp	1KB	Proprietary
- u19	5651KB	Proprietary
- u29	1KB	Proprietary
• M-RELAP5_Corrected_Input		
- dcd_ss301_input_er09.i	334KB	Proprietary
- dcd_ss301_input_er09-r1.i	14KB	Proprietary
- dcd_tr-1ft2-302b_pctmod_input_er09.i	20KB	Proprietary
- dcd_tr-7.5in-302b_pctmod_input_er09.i	20KB	Proprietary