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MFN-16-059, Supplement 1

Dockets 52-001 and 52-045
10 CFR 50.46(a)(3)(iii)

October 12, 2016

Francis M. Akstulewicz, Director
Division of New Reactor Licensing
Office of New Reactors
Document Control Desk
US Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: **Peak Cladding Temperature 2016 Annual Reporting Under 10 CFR 50.46 for the GE Hitachi Nuclear Energy Advanced Boiling Water Reactor (ABWR) Design Certification and the ABWR Design Certification Renewal Application**

References:

1. Letter, F. M. Akstulewicz (NRC) to J. G. Head (GEH), Peak Cladding Temperature for GE Hitachi Nuclear Energy Advanced Boiling Water Reactor Design Certification Rule Renewal Application (July 21, 2016)

2. Letter, J. G. Head (GEH) to Document Control Desk (NRC), MFN-16-059, Peak Cladding Temperature for GE Hitachi Nuclear Energy Advanced Boiling Water Reactor Design Certification Rule Renewal Application (August 19, 2016)

Dear Mr. Akstulewicz,

This letter submits information regarding the peak cladding temperature (PCT) and proposed changes to the Advanced Boiling Water Reactor (ABWR) renewal application currently under review by the NRC. The information is combined into a single submittal because of the relationship of the PCT reporting requirements applicable to both the ABWR certified design referenced by the South Texas, Units 3 and 4, Combined License Application, and the GEH ABWR design certification renewal application.

Reference 1 discussed the previous reports submitted under 10 CFR 50.46(a)(3)(iii) for the ABWR design certification. The information in Enclosure 1 updates the information in the previous reports and brings up-to-date the cumulative model changes or errors that could impact the temperature calculation for the original ABWR design certification.

DO50
D106
NRO

In Reference 2, GEH provided a response to the NRC letter (Reference 1), and indicated that we anticipated providing changes and required supporting information on a schedule commensurate with the planned December 2016 submittal of Revision 7 of the Design Certification Document (DCD) for the ABWR design certification renewal application. The information in Enclosure 2 describes the proposed changes that are shown on the DCD markups provided in Enclosure 3.

The markups shown in Enclosure 3 will be included in Revision 7 of the ABWR DCD.

Please contact me if you have any questions regarding this information.

Sincerely,

Jerald G. Head
Senior Vice President, Regulatory Affairs

Commitments: Submit DCD changes in DCD Revision 7, as scheduled.

Enclosures:

1. Advanced Boiling Water Reactor 2016 Annual Report Under 10 CFR 50.46(a)(3)(iii)
2. ABWR Design Certification Renewal Information on Peak Cladding Temperature
3. ABWR Design Certification Renewal Design Control Document Markups

cc: A. Muniz, NRC
S. Head, STP
DBR-0022784

Enclosure 1

MFN-16-059, Supplement 1

Advanced Boiling Water Reactor 2016 Annual Report Under 10 CFR 50.46(a)(3)(iii)

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Advanced Boiling Water Reactor 2016 Annual Report Under 10 CFR 50.46(a)(3)(iii)

LOCA Margin Summary Sheet

Plant Name:	Advanced Boiling Water Reactor (ABWR) Standard Plant Design Certification (52-001) and Renewal Application (Docket 52-045)			
Utility Name:	GE Hitachi (as applicant for ABWR Design Certification and Renewal Application)			
Reporting Year: 2016*				
	Evaluation Model: SAFER/GESTR (SAFER04A)			
	Limiting LOCA: Steam Line Outside Containment			
		LBPCT**	**Net PCT Effect**	**Absolute PCT Effect**
	Analysis of Record Licensing Basis PCT, with prior updates**	1149 °F		
A.	Prior 10 CFR 50.46 Changes or Error Corrections – Previous years	ΔPCT	+/- 200 °F	+ 220 °F
B.	Prior 10 CFR 50.46 Changes or Error Corrections – This year (itemized below)	ΔPCT	+/- 0 °F	+ 0 °F
	None to report			
C.	Absolute Sum of 10 CFR 50.46 Changes	ΔPCT		+ 220 °F
	Projected Licensing Basis PCT based on these changes	1349 °F		

*The reporting period is through 09/30/2016. Annual reporting will be adjusted accordingly for future reports. The sum of the PCT from the most recent analysis using an acceptable evaluation model and the estimates of PCT impact for changes and errors identified since this analysis is less than 2200 °F.

** The Licensing Basis PCT is the value of the limiting LOCA from Table 6.3-4 of the ABWR Design Control Document. The table below provides a detailed description of the bounding effects on the PCT reported in previous reports (see references). The bounding effects are used to provide an adjusted (bounding) PCT for the ABWR design certification renewal application in the Design Control Document (DCD) in Note 1 to Table 6.3-4.

References:

1. MFN-12-012, 10 CFR 50.46 Annual Report for the GE ABWR Standard Plant Design (February 13, 2012)
2. MFN-12-132, 10 CFR 50.46 Annual Report for the GE ABWR Standard Plant Design – 2012 (December 19, 2012)
3. MFN-13-095, 10 CFR 50.46 Annual Report for the GE ABWR Standard Plant Design - 2013 (December 13, 2013)
4. MFN-14-084, 10 CFR 50.46 Annual Report for the GE ABWR Standard Plant Design - 2014 (December 19, 2014)
5. MFN-15-096, 10 CFR 50.46 Annual Report for the GE ABWR Standard Plant Design 2015 (December 3, 2015)

Table of Evaluation Model Change Effects Applied to ABWR LOCA Analysis

Item	Description of the Evaluation Model/Method Alteration *	Bounding Change in PCT in °C (°F)
Original Analysis	SAFER03 to SAFER04 to SAFER04V – The computer code was revised and ported to an alternate computer platform, confirmed to cause no change in result.	+0 (0)
1996-01	Incorrect active fuel rods number – Input generation for the SAFER basedeck found to not accurately account for water rods and complete number of fuel rods in every bundle design.	+17 (30)
1999-02	Counter current flow limitation (CCFL) in upper tie plate, pre-GE11 bundles – CCFL in the upper tie plate included a constant to account for varying flow areas in different bundle designs. Methodology control left it uncertain that this was applied correctly for earlier bundle designs, so a compensating penalty is applied.	+14 (25)
2001-02	Time step change for convergence – Transient modeling was found to be sensitive to a time step which would hamper convergence of the solution; time step changes have been restrained based on observance, assuring converged solutions for each time step.	+14 (25)
2001-04	Steam condensed by ECCS injection – Steam flow from core exit was found to be inconsistently applied to steam mass when in contact with injected ECCS flow, affecting calculated vessel pressure.	+6 (10)
2002-02	SAFER vessel water level – Steam Dryer ΔP – Indicated level measured is level in the downcomer, not the level inside shroud or in core, due to the pressure difference across the steam dryer. Model input change accounts for the small suppression of core level.	+6 (10)
2002-03	GESTR input file interpolation –Fuel performance data input to the code was found to be interpolated poorly, based on format of the input file; the interpolation was corrected, though the effect was negligible.	+0 (0)
2002-04	SAFER04V to SAFER04A – Code ported to an improved computer platform, so it was confirmed to cause no change in results.	+0 (0)
2003-01	SAFER Level/Volume Table – Weights and volumes of vessel components were extracted from plant data and manipulated to reflect accurate level (filling) of the vessel. Some few dimensions were found in error as to volume occupied by related components. Adjustments were made.	+6 (10)
2003-03	Steam Separator Pressure Drop – Formulation of the loss coefficient across the steam separator was drawn from test data; small inaccuracies were noted.	+3 (5)

Item	Description of the Evaluation Model/Method Alteration *	Bounding Change in PCT in °C (°F)
2006-01	Top Peaked Power Shape – Historical analysis method was assumed mid-plane peaked, with cosine core power distribution. Investigation found some plants could produce a more limiting result with power skewed to the top, given earlier potentially uncovered core, with rod heatup, in that span.	+28 (50)
2012-01	PRIME Implementation – A more accurate calculation of fuel performance data was available from the PRIME code, which addresses NRC's concern with thermal conductivity degradation. This was incorporated as an NRC approved replacement for GESTR, serving the same purpose (providing fuel performance response) as the constituent code for the evaluation model.	+25 (45)
2014-01	Code changes of neutral effect – Series of software cleanup, principally in modules and nodes not impacting peak PCT for ECCS LOCA analysis or useful for other applications, including such items as non-physical prediction of certain quenched node temperatures, rare division by zero calculations that could occur on rate of pressure change, removal of discontinuity in rod gap conductance.	+0 (0)
2014-02	Mass Non-Conservation – Logic error found when upper plenum mass and core spray is low; mass from spray discarded from calculation, resulting in less total vessel water mass. Only certain plants/cases found to be affected.	+0 (0)
2014-03	Minimum Core ΔP Model – Due to non-physical ΔP calculated for droplet flow above two-phase level in core, a minimum ΔP was historically imposed; this was found to be non-conservative for cores with greater voiding and was subsequently removed.	-5 (-10)
2014-04	Lower Plenum Counter Current Flow Limitation (CCFL) restriction – Iteration scheme to define the coefficient for the CCFL at the bottom of the fuel bundle was found to take a pressure head output from the calculation and place it back as the pressure head (input) of the bundle at that location, rather than correctly retain the actual pressure head on account of mass (level) above that location for a next iteration.	+0 (0)

*These are reported conservatively as potentially applicable to ABWR based on information since the original LOCA analysis. Explicit confirmation of the estimated effects has not been calculated for the LOCA analysis and the specific evaluation effects are based on non-ABWR plant analyses, but are identified to assure a bounding net effect for purpose of demonstrating continued compliance to regulatory acceptance limits for the ABWR certified design.

Enclosure 2

MFN-16-059, Supplement 1

ABWR Design Certification Renewal Information on Peak Cladding Temperature

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ABWR Design Certification Renewal Information on Peak Cladding Temperature

The models and methods used for performing the ABWR design certification LOCA analysis represented the state of the NRC-approved evaluation model at the time the original analysis was performed, as described in the ABWR Design Control Document (DCD) Section 6.3. From the time of performance of a LOCA analysis, a series of changes or errors to the model may be identified which may or may not affect the analysis results. Identification, reporting and resolution of such changes or errors may be applied to a model to incorporate improved understanding of phenomena, calculation schemes, or errata in programming. Although the original ABWR LOCA analysis has not been revised, GEH evaluated changes or errors identified for operating BWRs and determined if the ABWR LOCA analysis could potentially be affected. These changes or errors have been treated as if they had been found in the ABWR LOCA analysis model and reported conservatively for the ABWR under 10 CFR 50.46(a)(3)(iii).

For these changes or errors identified in the ABWR design certification model, conservative estimates are developed as to potential effect of each change or error, as reported in the 10 CFR 50.46 reports, to ensure that the peak cladding temperature (PCT) regulatory acceptance limit of 2200 °F is met. As part of the original design certification, to ensure that any significant cumulative effects are addressed, a COL applicant must provide, in the COL application, results for the limiting break for each fuel bundle of the fuel design selected by the applicant (which may be the standard design fuel or a newer fuel), as required in DCD Section 6.3.6.3, "Limiting Break Results." This COL Information Item would incorporate resolution of changes or errors in the previous model, or any more current NRC-approved evaluation model, at the time of the COL application, and the results would be reviewed by the NRC as part of the COLA proceeding. This requirement remains in the DCD under the ABWR design certification renewal application. For changes that become "significant" by regulatory standard, the COL application analysis is viewed as the schedule for re-analysis as required by 10 CFR 50.46(a)(3)(ii).

The LOCA PCT results presented in DCD Table 6.3-4 reflect the calculated results of the original LOCA analysis, which (for the applicable break size) used bounding worst-case values for key plant parameters, including an arbitrary 20% increase in the break flow rate. A footnote is added to the table (Note 1) to account for the conservative estimates of changes or errors in the model (as described in the annual reports and discussed above), and provide a bounding value PCT for including the changes or errors in the model. Reference 6.3-2 is added to DCD Section 6.3.7, as shown in Enclosure 3 (below), which describes the changes or errors to the model. As shown on the DCD markups in Enclosure 3, the PCT could increase by as much as 114 °C (200 °F*), for an effective change for the limiting break from 621 °C (1149 °F*) to 735 °C (1349 °F*). These conservative results remain below the regulatory acceptance limit of 1204 °C (2200 °F). In a COLA proceeding, the COL applicant will present the results of a plant-specific analysis and adjust the values in Table 6.3-4, as appropriate. GEH has utilized this process in a non-domestic ABWR project.

* Temperature conversion rounded up on individual items reported, then summed.

Enclosure 3

MFN-16-059, Supplement 1

ABWR Design Certification Renewal Design Control Document Markups

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All instrumentation required for automatic and manual initiation of the HPCF, RCIC, RHR and ADS Systems is discussed in Subsection 7.3.1, and is designed to meet the requirements of IEEE-279 and other applicable regulatory requirements. The HPCF, RCIC, RHR and ADS Systems can be manually initiated from the control room.

The RCIC, HPCF, and RHR Systems are automatically initiated on low reactor water level or high drywell pressure. The ADS is automatically actuated by sensed variables for reactor vessel low water level and drywell high pressure plus indication that at least one RHR or HPCF pump is operating. The HPCF, RCIC, and RHR Systems automatically return from system flow test modes to the emergency core cooling mode of operation following receipt of an automatic initiation signal. The RHR LPFL mode injection into the RPV begins when reactor pressure decreases to the RHR's pump discharge shutoff pressure.

HPCF injection begins as soon as the HPCF pump is up to speed and the injection valve is open, since the HPCF System is capable of injection water into the RPV over a pressure range from 8.12 to 0.69 MPaD or pressure difference between the vessel and drywell.

6.3.6 COL License Information

6.3.6.1 ECCS Performance Results

The exposure-dependent MAPLHGR, peak cladding temperature, and oxidation fraction for each fuel bundle design based on the limiting break size will be provided by the COL applicant to the USNRC for information (Subsection 6.3.3).

6.3.6.2 ECCS Testing Requirements

In accordance with the Technical Specifications, the COL applicant will perform a test every refueling in which each ECCS subsystem is actuated through the emergency operating sequence (Subsection 6.3.4.1).

6.3.6.3 Limiting Break Results

Results for the limiting break for each bundle design will be provided to the USNRC by the COL applicant (Subsection 6.3.3.7.3).

6.3.7 Reference

6.3-1 "General Electric Company Analytical Model for Loss-of-Coolant Analysis in Accordance with 10CFR50, Appendix K", (NEDE-20566-P-A), September 1986.

Add: 6.3-2 MFN-16-059, Supplement 1, "Peak Cladding Temperature 2016 Annual Reporting Under 10 CFR 50.46 for the GE Hitachi Nuclear Energy Advanced Boiling Water Reactor (ABWR) Design Certification and the ABWR Design Certification Renewal Application" (October 12, 2016), Enclosure 1, "Advanced Boiling Water Reactor 2016 Annual Report Under 10 CFR 50.46(a)(3)(iii)."

Table 6.3-4 Summary of Results of LOCA Analysis

Break Location	Break Size* (cm^2)	Systems Available	PCT (°C)	Maximum Local Oxidation
Based on Appendix K evaluation models:				
Steamline Inside Containment	985	1HPCF + RCIC +2 RHR/LPFL + 8 ADS	552	0.03%
Feedwater Line	839	1 HPCF + 2 RHR/LPFL + 8 ADS	542	0.03%
RHR Shutdown Cooling Suction Line	792	1 HPCF + RCIC + 2 RHR/LPFL+ 8 ADS	542	0.03%
RHR/LPFL Injection Line	205	1 HPCF + RCIC + 1RHR/LPFL + 8 ADS	542	0.03%
High Pressure Core Flooder	92	RCIC+2RHR/ LPFL + 8 ADS	542	0.03%
Bottom Head Drain Line	20.3	1HPCF + RCIC + 2 RHR/LPFL + 8 ADS	542	0.03%
Steamline Outside Containment	3939	1 HPCF + RCIC + 2 RHR/LPFL + 8 ADS	621	0.03%
Based on bounding values:				
Steamline Outside Containment	3939	1 HPCF + RCIC + 2 RHR/LPFL + 8 ADS	619	0.03%

(1)

(2)

* The most severe ABWR design basis LOCA calculations (Subsection 6.3.3.7.8) involve use of bounding worst-case values for key plant parameters - including an arbitrary 20% increase in the break flow rate. Even with these bounding assumptions, the LOCA analyses demonstrate that the ABWR design still retains large margins between predicted peak fuel clad temperatures and the criteria of 10 CFR 50, Appendix K.

Tolerances associated with fabrication and installation may result as-built break areas that could be 5% greater than these values. Based on the above conservatisms in the LOCA analyses, these as-built variations would not invalidate the plant safety analysis presented in Chapter 6 and Chapter 15.

2

NOTE: The core-wide metal-water reaction for this analysis has been calculated using method 1 described in Reference 6.3-1. This results in a core-wide metal-water reaction of 0.03%.

Insert Note 1 here.

NOTE 1: The estimated adjustment of the PCT based on reporting under 10 CFR 50.46 is a potential increase of 114 °C, or a total of 735 °C. This result demonstrates continued compliance to the 1204 °C (2200 °F) regulatory acceptance criteria limit with ample margin. See Reference 6.3-2.