



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

May 29, 2019

MEMORANDUM TO: Jennivine Rankin, Acting Branch Chief
Licensing Branch 3
Division of Licensing, Siting, and Environmental Analysis
Office of New Reactors

FROM: James Shea, Project Manager */RA/*
Licensing Branch 3
Division of Licensing, Siting, and Environmental Analysis
Office of New Reactors

SUBJECT: REGULATORY AUDIT RESULTS SUMMARY REPORT FOR THE
ADVANCED BOILING-WATER REACTOR DESIGN CERTIFICATION
RENEWAL PEAK CLADDING TEMPERATURE INCREASE

Enclosed is the U.S. Nuclear Regulatory Commission (NRC) staff's Peak Cladding Temperature (PCT) Increase Audit report regarding the GE Hitachi (GEH) Advanced Boiling-Water Reactor (ABWR) design certification (DC) renewal application (Docket No. 52-045). The staff performed an on-site and off-site audit of the reported emergency core cooling system evaluation model changes or errors that resulted in increased PCT for the ABWR standard plant design that was certified by rule in Title 10 of the *Code of Regulations* Part 52, "License, Certifications, and Approvals for Nuclear Power Plants," Appendix A, as part of their application to renew the ABWR design certification.

The audit was conducted for about a month, starting on August 6, 2018, and concluding with an exit meeting on August 31, 2018. The ABWR DC renewal PCT audit was completed remotely using the GEH Electronic Reading Room (eRR) as well as during an on-site visit from August 13 through August 17, 2018. The staff reviewed several of the applicant's engineering change reports and conducted phone conferences with the applicant for clarification information as part of the staff audit activities. In addition, as the audit proceeded the staff requested additional documents to review in the eRR, which were provided by GEH.

CONTACT: James Shea, NRO/DLSE
(301) 415-1388

Docket No. 52-045

Enclosure:
As stated

cc w/encl: See next page

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ADAMS Accession Nos.: ML19136A281 (Summary) ML19136A257 (Pkg.) *via email NRO-002

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NAME	JShea	SGreen	Rkaras	JRankin	JShea
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U.S. NUCLEAR REGULATORY COMMISSION REGULATORY AUDIT SUMMARY REPORT:
GE HITACHI U.S. ADVANCED BOILING-WATER REACTOR DESIGN CERTIFICATION
RENEWAL: TITLE 10 OF THE CODE OF FEDERAL REGULATIONS - SECTION 50.46,
“ACCEPTANCE CRITERIA FOR EMERGENCY CORE COOLING SYSTEMS FOR LIGHT-
WATER NUCLEAR POWER REACTORS”, ANNUAL ECCS EVALUATION MODEL CHANGE
AND ERROR REPORTS

(Docket No. 52-045)

APPLICANT: General Electric Hitachi (GEH)

LOCATION(s): Phase 1: U.S. Nuclear Regulatory Commission (NRC)
Headquarters via GEH Electronic Reading Room
(eRR)
Phase 2: General Electric-Hitachi Nuclear Energy (GEH) Office
3901 Castle Hayne Road
Wilmington, NC 28401
Phase 3: U.S. NRC Headquarters via GEH eRR

DURATION: Phase 1 (eRR): August 6 through August 10, 2018
Phase 2 (GEH Site): August 13 through August 17, 2018
Phase 3 (eRR): August 20 through August 31, 2018

AUDIT TEAM: James Gilmer, NRO Reactor Systems Branch
Rebecca Karas, NRO Reactor Systems Branch Chief
Reed Anzalone, NRR, Nuclear Performance and Code Review
Adrian Muniz, NRO, Project Manager

GEH STAFF: Skip Schumitsch (PM)
Jerry Head
Mike Arcaro (PE)
Linda Dolan (Regulatory Affairs)
Tom Stoddard (Core and Fuel Engineering)
Lisa Schichlein
Randy Jacobs (Transient Analyses)
Mike Cook (Transient Analyses)
Necdet Kurul (Containment Analyses)

BACKGROUND:

By letter dated December 7, 2010, (Agencywide Documents Access and Management System (ADAMS) Accession No. ML110040176) GEH submitted for approval an application to renew

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the United States Advanced Boiling-Water Reactor (ABWR) design certification rule pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 52, "License, Certifications, and Approvals for Nuclear Power Plants." The U.S. Nuclear Regulatory Commission (NRC) staff is performing a detailed review of the renewal application including the incorporation of 10 CFR 50.46 reporting requirements that are used to bring up-to-date the cumulative model changes or errors that could impact the temperature calculation for the original ABWR design certification.

By letters dated October 12, 2016, and October 10, 2017 (ADAMS Accession No. ML16291A490 and ADAMS Accession No. ML17283A307, respectively), GEH reported emergency core cooling system (ECCS) evaluation model (EM) changes or errors that resulted in increased peak cladding temperature (PCT) in support of their application to renew the ABWR design certification in 10 CFR Part 52, Appendix A. These annual reports were made pursuant to the reporting requirement of the ECCS rule, 10 CFR 50.46, "Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors". As a result of public teleconference discussions between GEH and NRC staff, supplemental information was submitted for the 2016 annual report, in letter dated October 12, 2016 (ADAMS Accession No. ML16291A490) (GEH Letter MFN 16-059, Supplement 1). Estimates of the change in PCT were provided for each EM change or error identified since the original analyses were performed for the design certification. These estimates were based on evaluations performed for operating conventional boiling water reactor (BWR/2 – BWR/6) plants, as well as design evaluations performed for a non-domestic ABWR. Also, provided were proposed markups to the ABWR Design Control Document (DCD).

Additional supplemental information was provided by GEH in Letter M170071, dated March 20, 2017 (ADAMS Accession No. ML17079A353). This letter provided an explanation of the bases used to develop the PCT change estimates and also addressed an NRC staff concern that the effect of the changes on other design aspects should be evaluated. Further proposed DCD markups were also provided.

To facilitate the NRC staff's understanding and evaluation of information supporting the ABWR design certification renewal application, an audit was conducted at the GEH Wilmington, North Carolina facility and by means of the GEH eRR from NRC Headquarters. The focus of this audit was on documentation and other information used by GEH to form the bases for the estimates of the PCT changes and expected impacts on other design analyses and evaluations.

OBJECTIVES:

The objectives of this audit were for the NRC staff to:

- gain a better understanding of the detailed calculations, analyses, and bases underlying the estimates of PCT changes resulting from licensing basis EM changes and error corrections;
- better understand the differences between domestic ABWR design parameters and those for the conventional BWRs and international ABWR used in generating the PCT estimates (e.g., fuel type, thermal power);
- better understand the impact, if any, to other loss-of-coolant accident (LOCA) acceptance criteria (e.g., maximum cladding oxidation, hydrogen generation);

- better understand if the methodology continues to meet NRC regulations and conforms to regulatory guidance for 10 CFR 50.46 and Appendix K to 10 CFR Part 50;
- better understand the bases behind statements in GEH's Letter M170071, dated March 20, 2017, related to the continued applicability of ABWR containment analyses, radiological analyses, and various Chapter 15 analyses in the DCD;
- confirm that models other than the ECCS EM, and therefore not subject to the same errors, were used for analyses related to combustible gas, station blackout, reactor pressure vessel (RPV) fluence and decay heat, as stated in GEH's Letter M170071, dated March 20, 2017;
- develop requests for additional information for issues not fully resolved by audit or that require a formal, docketed response;
- discuss with GEH appropriate ways to document the expected changes in the DCD.

REGULATORY AUDIT BASIS:

Title 10 of the *Code of Federal Regulations* (CFR), Section 50.46, sets forth the requirements for the design and evaluation of light water reactor ECCS, including the need to calculate the ECCS cooling performance using an acceptable EM for a number of postulated LOCAs of different sizes, locations, and other properties sufficient to provide assurance that the most severe LOCAs have been evaluated. Pursuant to 10 CFR 50.46(a)(3), each holder of or applicant for a standard design certification approval under Part 52 is required to estimate the effect of any change to or error in an acceptable EM or in the application of such a model to determine if the change or error is significant. For this purpose, a significant change or error is one which results in a calculated peak fuel cladding temperature different by more than 50° F from the temperature calculated for the limiting transient using the last acceptable model, or is a cumulation of changes and errors such that the sum of the absolute magnitudes of the respective temperature changes is greater than 50° F. For each change to or error discovered in an acceptable EM or in the application of such a model that affects the temperature calculation, the applicant or holder of a construction permit, operating license, combined license, or manufacturing license shall report the nature of the change or error and its estimated effect on the limiting ECCS analysis to the Commission at least annually.

Title 10 of the CFR, Section 52.47(a)(4), states, in part, that a DC application must contain an Final Safety Analysis Report that includes:

An analysis and evaluation of the design and performance of structures, systems, and components with the objective of assessing the risk to public health and safety resulting from operation of the facility and including determination of the margins of safety during normal operations and transient conditions anticipated during the life of the facility, and the adequacy of structures, systems, and components provided for the prevention of accidents and the mitigation of the consequences of accidents.

Title 10 of the CFR, Section 52.57(a), states that a DC renewal application must:

Not less than 12 nor more than 36 months before the expiration of the initial 15-year period, or any later renewal period, any person may apply for renewal of the certification. An application for renewal must contain all information necessary to bring up to date the information and data contained in the previous application. The Commission will require, before renewal of certification, that information normally contained in certain procurement specifications and construction and installation specifications be completed and available for audit if this information is necessary for the Commission to make its safety determination. Notice and comment procedures must be used for a rulemaking proceeding on the application for renewal. The Commission, in its discretion, may require the use of additional procedures in individual renewal proceedings.

An audit was conducted to confirm the basis for the PCT change estimates and qualitative assessments of other design impacts made by GEH in the various annual reports and which ultimately are reflected in revisions to the ABWR renewal application, consistent with the requirement of 10 CFR 52.57(a) to bring the information up to date.

DOCUMENTS REVIEWED:

1. neDRF 0000-0108-0967, "Development of Annual Reporting Transmittal Based on ABWR Design Certification Document," dated January 14, 2012
2. neDRF Section 0000-0142-0898
3. ECO 0011466, "Development of Annual Reporting Transmittal(s) Based on ABWR Design Certification Document," (December 12, 2014)
4. CAR 55165, "Corrective Action Report"
5. 000N5325, Revision 2, "HGE Report Rev. 0 design notes; "UK Horizon ABWR General Design Assessment, Task 1.05 – ECCS-LOCA Evaluation," July 2014
6. DBR-0004038, Revision 2, "Design Basis Record Design Notes, Annual Reporting per 10 CFR 50.46 for 2017"
7. PLM Spec. DBR-0004038, ECO 0011466 (12/12/2014), "Development of Annual Reporting Transmittal(s) Based on ABWR Design Certification Document"
8. neDRF Section 0000-0144-2439, Analysis of record – SSAR Revision 5 – internal Revision 8
9. neDRF Section 0000-0053-3405, Revision 1, 0000-0017-5408 (8/2/2006), 2006-01 Database Update and Notification Letter for SBL Top Skewed Power Shape, Revision 1
10. L12-00875-00/Section 11, 2002-02 SAFER/GESTR Analysis for Bulk Water Level-Dryer ΔP – Bulk water level PCT Impact Evaluation
11. neDRF Section 0000-0118-4330, Revision 0, July 4, 2012, PRIME implementation in LOCA; 10 CFR 50.46 Change Notice Evaluation

12. GEH Letter No. FLN-2001-13, "Summary of Changes and Errors in ECCS Evaluation Models," August 10, 2001.
13. neReport 0000-0006-9933, November 20, 2002, "Steam separator loss coefficient and elevation term incorrectly included in calculation"
14. neDRF Section 0000-0099-9825, "Increased Stored Energy Study"
15. neDRF 0000-0118-4330, "PRIME Implementation in LOCA 10 CFR 50.46 Change Notice Evaluation"
16. 0000-0152-1518, "PRIME PCT Estimation"
17. neDRF 0000-0168-2586 (November 19, 2013), "Development of Annual Reporting"
18. neDRF-0000-0060-9279, "Monticello SAFER PRIME"

AUDIT ACTIVITIES:

During the audit, the audit team examined the above-listed GEH internal documentation which had been utilized by GEH in developing the PCT change estimates for each year's annual report. The annual estimates were provided by GEH in Table 1 of the GEH Annual PCT 10 CFR 50.46 Report Letter (MFN-16-059, Supplement 1) dated October 12, 2016 (ADAMS Accession No. ML16291A490). The documents examined provide the rationale utilized by GEH for applying or disregarding operating fleet evaluation results to estimate the PCT impact which could be expected for the ABWR design. EM changes or errors that affected the core region were assumed to apply to the ABWR because of similarity in fuel designs. Discussions were also held as needed with GEH subject matter experts.

OBSERVATIONS:

The audit team confirmed that GEH appropriately identified the errors that were applicable to the ABWR design. The audit team also identified several errors that GEH originally determined were applicable to the ABWR design that, upon further review, were found to be not applicable.

The audit concluded with an August 30, 2018, exit meeting, during which the audit team conveyed the following observations to GEH on the PCT change estimates and qualitative assessments:

- The annual estimates of PCT changes were believed by the audit team to have been conservatively made. As a result of discussions during the audit, several of the annual changes were identified as having been applied to the ABWR design unnecessarily, so could be removed from the annual reports.
- Introduction of modern methods and fuel to the DCD, as proposed by GEH in Letter M170071, would be considered by the NRC to be a new application rather than a renewal of the certified design. This would result in a significant additional review effort. Nevertheless, justification should be provided that the Evaluation Model used for design basis analyses continues to be acceptable.

- The DCD should indicate that the PCT adjustment by adder is considered as part of the evaluation method.
- DCD figures and tables should indicate that results have not been adjusted to account for PCT errors. The results table should preserve the original (certified) result but should add a column to indicate the adjusted results.

During the exit meeting, GEH described how each of the audit observations would be addressed in the planned revision to Letter M170071.

CONCLUSIONS:

The objectives of the audit were met since the audit team attained sufficient understanding of the approach and bases used to develop the reported PCT error estimates in the annual reports. The staff expectations for the DCD changes needed were communicated to GEH and were discussed during the audit.