



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

December 17, 2015

Mr. Bryan C. Hanson  
President and Chief Nuclear Officer  
Exelon Nuclear  
4300 Winfield Road  
Warrenville, IL 60555

SUBJECT: THREE MILE ISLAND NUCLEAR STATION, UNIT 1 – CLOSURE EVALUATION  
FOR REPORT PURSUANT TO 10 CFR 50.46 REQUIREMENTS RELATED TO  
THERMAL CONDUCTIVITY DEGRADATION (CAC NO. MF5564)

Dear Mr. Hanson:

By letter dated December 22, 2014, as supplemented by letter dated April 6, 2015 (Agencywide Documents Access and Management System Accession Nos. ML14356A342 and ML15097A125, respectively), Exelon Generation Company, LLC submitted a report pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.46(a)(3) for the Three Mile Island Nuclear Station, Unit 1 (TMI-1). This report described a significant error identified in the emergency core cooling system evaluation model and an estimate of the effect of the error on the predicted peak cladding temperature for TMI-1.

The U.S. Nuclear Regulatory Commission (NRC) staff has completed its review of this report. Based on this evaluation, the NRC staff has determined that the report, as supplemented, satisfies the reporting requirements of 10 CFR 50.46(a)(3) for TMI-1. A copy of the staff's closure evaluation is enclosed.

This completes the NRC staff's efforts associated with Cost Activity Code No. MF5564. Should you have any questions, please contact me at (301) 415-1022 or [Robert.Gladney@nrc.gov](mailto:Robert.Gladney@nrc.gov).

Sincerely,

A handwritten signature in cursive script that reads "Robert L. Gladney".

Robert L. Gladney, Project Manager  
Plant Licensing Branch I-2  
Division of Operating Reactor Licensing  
Office of Nuclear Reactor Regulation

Docket No. 50-289

Enclosure:  
Staff's Closure Evaluation

cc w/enclosure: Distribution via Listserv



UNITED STATES  
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CLOSURE EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

STAFF RELATED TO REPORT PURSUANT TO 10 CFR 50.46

EXELON GENERATION COMPANY, LLC

THREE MILE ISLAND NUCLEAR STATION, UNIT 1

DOCKET NO. 50-289

1.0 INTRODUCTION

By letter dated December 22, 2014, as supplemented by letter dated April 6, 2015 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML14356A342 and ML15097A125, respectively), Exelon Generation Company, LLC (Exelon, the licensee) submitted a report pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 50.46(a)(3) for the Three Mile Island Nuclear Station, Unit 1 (TMI-1). This report described a significant error identified in the emergency core cooling system (ECCS) evaluation model (EM) and an estimate of the effect of the error on the predicted peak cladding temperature (PCT) for TMI-1.

The U.S. Nuclear Regulatory Commission (NRC) staff has completed its review of the report and determined, as discussed below, that the report, as supplemented, satisfies the reporting requirements of 10 CFR 50.46(a)(3) for TMI-1.

2.0 REGULATORY EVALUATION

2.1 Regulatory Requirements

Specific requirements with regard to ECCS for light-water nuclear power reactors are found in 10 CFR 50.46, "Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors." Within this regulation, 10 CFR 50.46(a)(1)(i) requires, in part, that, "ECCS cooling performance must be calculated in accordance with an acceptable evaluation model."

Paragraph (a)(3)(i) of 10 CFR 50.46 requires licensees to "estimate the effect of any change to or error in an acceptable evaluation model, or in the application of such a model, to determine if the change or error is significant." For the purposes of 10 CFR 50.46, a significant change or error is one that results in a calculated PCT difference of more than 50 degrees Fahrenheit (°F) "from the temperature calculated for the limiting transient using the last acceptable model, or is [an accumulation] 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, 10 CFR 50.46(a)(3)(ii) requires the affected licensee to report the nature of the change

Enclosure

or error and its estimated effect on the limiting ECCS analysis to the NRC at least annually. If the change or error is significant, the licensee is required to provide this report within 30 days. The report is to include "a proposed schedule for providing a reanalysis or taking other action as may be needed to show compliance with [10 CFR] 50.46 requirements."

Paragraph (b) of 10 CFR 50.46 provides the acceptance criteria for ECCS performance. In particular, 10 CFR 50.46(b)(1), "Peak cladding temperature," states, "The calculated maximum fuel element cladding temperature shall not exceed 2200° F."

## 2.2 Background

The NRC-approved AREVA Inc. (AREVA) proprietary topical report BAW-10192P-A, "BWNT Loss-of-Coolant Accident Evaluation Model for Once-Through Steam Generator Plants" (hereinafter "BWNT LOCA EM"),<sup>1</sup> is the acceptable EM used to evaluate ECCS performance at TMI-1. In accordance with 10 CFR Part 21, "Reporting of Defects and Noncompliance," AREVA reported an error in its loss-of-coolant accident (LOCA) analysis for plants with a Babcock & Wilcox design, including TMI-1, by a letter to the NRC dated December 16, 2014 (ADAMS Accession No. ML14351A308).

In its report, AREVA stated that the current fuel "thermal conductivity model does not adequately represent the change in conductivity with burnup for the fuel." This defect relates to the uranium fuel thermal conductivity models in the fuel thermal-mechanical codes TACO3<sup>2</sup> and GDTACO,<sup>3</sup> which are part of the BWNT LOCA EM. The defect resulted in an under-prediction of the large-break PCT at TMI-1. To compensate for the under-prediction of PCT, AREVA stated that each affected plant, including TMI-1, was advised to reduce fuel linear heat rate (LHR) by 2 kilowatts per foot (kW/ft).

Based on AREVA's notification, Exelon submitted its December 22, 2014, letter to notify the NRC that the defect constituted an error in the ECCS EM for TMI-1. The licensee's letter provided (1) a description of the nature of the error and its estimated effect on the PCT; (2) a summary of actions taken to ensure compliance with 10 CFR 50.46 requirements, including implementing the 2 kW/ft LHR reduction; and (3) a commitment that a large break LOCA (LBLOCA) reanalysis, accounting for the effects of thermal conductivity degradation (TCD), would be performed for TMI-1 by March 31, 2017. (This commitment was superseded by the commitment submitted in the April 6, 2015, letter, which is described in Section 3.2 of this evaluation.)

The December 22, 2014, letter stated that the TCD-related defect was estimated to cause the PCT at TMI-1 to increase 393 °F. The licensee's implementation of a 2 kW/ft LHR reduction was estimated to offset the TCD effect by reducing the PCT by 375 °F. Therefore, the predicted

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<sup>1</sup> BAW-10192P-A describes the ECCS EM; however, the EM requires use of input from approved thermal-mechanical models. Plant-specific application is described in further detail in BAW-10179P-A, "Safety Criteria and Methodology for Acceptable Cycle Reload Analyses."

<sup>2</sup> AREVA NP Licensing Topical Report BAW-10162P-A, "TACO3 – Fuel Pin Thermal Analysis Code."

<sup>3</sup> AREVA NP Licensing Topical Report BAW-10184P-A, "GDTACO – Urania Gadolinia Fuel Pin Thermal Analysis Code."

PCT for TMI-1 increases from 1,890 °F to 1,908 °F, which remains less than the regulatory limit of 2200 °F.

### 2.3 Regulatory Commitment

The licensee provided the following commitment in its December 22, 2014, letter.

Exelon will perform a full LBLOCA reanalysis for TMI Unit 1 by March 31, 2017. The effects of fuel pellet thermal conductivity degradation will be accounted for by use of a fuel temperature uncertainty adjustment factor based on COPERNIC2.

However, in its April 6, 2015, letter, the licensee provided the following new commitment, which supersedes its December 22, 2014, commitment:

The full LBLOCA reanalysis will be completed within 21 months following NRC issuance of the final Safety Evaluation Report (SER) for BAW-10179 Revision 9, which incorporates by reference the supplement to BAW-10192P-A Revision 0.

Therefore, in its April 6, 2015, letter, the licensee committed to completing this reanalysis within 21 months following NRC issuance of a final SER, approving BAW-10179, Revision 9, for use.

The NRC staff determined that this commitment revision is acceptable as it does not affect the outcome of the NRC staff's review or the licensee's compliance with the regulations.

## 3.0 TECHNICAL EVALUATION

### 3.1 Use of an Acceptable Evaluation Model for Reanalysis

The December 22, 2014, letter indicated that Exelon would complete a full LBLOCA reanalysis incorporating the effects of TCD by March 31, 2017. This commitment was superseded by a commitment in the April 6, 2015, letter that indicated that the reanalysis will be completed "within 21 months following NRC issuance of the final Safety Evaluation Report (SER) for BAW-10179, Revision 9, which incorporates by reference the supplement to BAW-10192P-A, Revision 0." Section 4.3.2.3 of the BWNT LOCA EM requires licensees to use NRC-approved fuel thermal-mechanical models to be consistent with the topical report. The fuel temperature uncertainty values used in TACO3 and GDTACO are specified in the NRC-approved fuel performance methodology documented in BAW-10162P-A and BAW-10184P-A. The AREVA report identified that these uncertainty values need to be modified in order to account for TCD.

In its April 6, 2015, letter, the licensee stated that AREVA will develop a supplement to its BWNT LOCA EM and submit it for NRC review and approval.<sup>4</sup> The licensee stated that the supplement will describe the modifications to the BWNT LOCA EM necessary for correction of the TCD issue. Based on this information, the NRC staff determined that the licensee has

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<sup>4</sup>By letter dated November 25, 2015 (ADAMS Accession No. ML15337A242), AREVA submitted Request for Review and Approval of BAW-10192PA-00, Supplement 1, Revision 0, "BWNT LOCA BWNT Loss-of-Coolant Accident Evaluation Model for Once-Through Steam Generator Plants."

adequately described how it will ensure that ECCS cooling performance is calculated using an acceptable EM.

### 3.2 Adequacy of Reanalysis Scope

As discussed above, the licensee stated that the TCD-related model changes will be incorporated as a supplement to the BWNT LOCA EM. The December 22, 2014, letter states that, "the reanalysis will address the significant EM error corrections to cover [in addition to the TCD-related error correction] the ECCS bypass error correction and column weldment modeling changes." Based on the magnitude of the estimated effect of a TCD correction on the TMI-1 ECCS evaluation, in addition to these additional, significant model changes and error corrections, the NRC staff determined that these model revisions would significantly change the predicted ECCS performance for TMI-1.

Regarding the evaluation of ECCS performance, 10 CFR 50.46(a)(1)(i) states, in part, that ECCS cooling performance "must be calculated for a number of postulated loss-of-coolant accidents of different sizes, locations, and other properties sufficient to provide assurance that the most severe postulated loss-of-coolant accidents are calculated." In its April 6, 2015, letter, the licensee stated:

The revised LBLOCA analyses will include a review of the current LBLOCA analyses to determine if the conclusion of the previous evaluation of a spectrum of break sizes, locations, and other properties is sufficient to verify the selection of the most severe hypothetical case. If the review determines that additional calculations are required to select the most severe hypothetical case, then the additional calculations will be performed.

Based on NRC staff experience, various issues associated with an ECCS evaluation may be addressed using an evaluation of a spectrum of break sizes, locations, and other properties, and this evaluation may be performed on a more general, simplified basis. Once a set of generally limiting properties is identified, a more detailed, plant-specific analysis identifies the exact limiting properties and determines the results for comparison against the 10 CFR 50.46(b) acceptance criteria. The licensee's statement above is consistent with this practice. Based on the discussion above, the staff determined that the licensee adequately described how it will provide assurance that the most severe postulated LOCAs are calculated.

### 3.3 Technical Specification (TS) Impacts

The TMI-1 TS 6.9.5.2 requires, in part:

The analytical methods used to determine the core operating limits addressed by the individual Technical Specifications shall be those previously reviewed and approved by the NRC for use at TMI-1, specifically:

- (1) BAW-10179 P-A, "Safety [Criteria]<sup>5</sup> and Methodology for Acceptable Cycle Reload Analyses." The current revision level shall be specified in the COLR.

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<sup>5</sup> Note that the word, "criteria," appears to be omitted from the TS core operating limit report reference.

The BWNT LOCA EM is incorporated into BAW-10179P-A by reference. In a letter dated March 8, 2015 (ADAMS Accession No. ML15020A737), the NRC staff noted that the application of TCD-corrected fuel temperature uncertainties to TACO3 and GDTACO may be inconsistent with Section 9.2.3, "Steady-State Fuel Data Input to LOCA EMs," of BAW-10179P-A. In its April 6, 2015, letter, the licensee stated that AREVA would also revise BAW-10179P-A to incorporate a reference to the BWNT LOCA EM supplement, and this revision would be submitted to the NRC for review and approval. The licensee stated that it will notify the NRC when the reanalysis is complete. Based on the discussion above, the NRC staff determined that the licensee has adequately described how it will comply with TS 6.9.5.2 with the application of the BWNT LOCA EM supplement.

#### 4.0 CONCLUSION

Based on its review, the NRC staff concluded that Exelon's report, as supplemented, satisfies the reporting requirements of 10 CFR 50.46(a)(3). The report described the nature of the TCD-related error and provided its estimated effect on the PCT for the limiting ECCS evaluation. The report also indicated that the licensee took action to reduce LHR limits to compensate for the effect of TCD and showed that the predicted PCT would remain below 2200 °F. The report, as supplemented, included a proposed schedule for performing reanalysis and taking other actions, as needed, to comply with 10 CFR 50.46 requirements.

Principal Contributors: B. Parks  
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R. Gladney

Date: December 17, 2015

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Sincerely,

*/RA/*

Robert L. Gladney, Project Manager  
Plant Licensing Branch I-2  
Division of Operating Reactor Licensing  
Office of Nuclear Reactor Regulation

Docket No. 50-289

Enclosure:  
Staff's Closure Evaluation

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