



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

August 21, 2015

Vice President, Operations
Arkansas Nuclear One
Entergy Operations, Inc.
1448 S.R. 333
Russellville, AR 72802

SUBJECT: ARKANSAS NUCLEAR ONE, UNIT NO. 1 – CLOSURE EVALUATION FOR
REPORT PURSUANT TO 10 CFR 50.46 REQUIREMENTS RELATING TO
EFFECTS OF THERMAL CONDUCTIVITY DEGRADATION (TAC NO. MF5545)

Dear Sir or Madam:

By letter dated December 22, 2014, as supplemented by letter dated March 30, 2015, Entergy Operations, Inc. (Entergy, the licensee), submitted a Licensee Event Report concerning a significant error with respect to thermal conductivity degradation modeling in the emergency core cooling system evaluation, and an estimate of the effect of the error on the predicted peak cladding temperature during the most limiting transient for Arkansas Nuclear One, Unit 1. The report was submitted pursuant to paragraph 50.46(a)(3) of Title 10 of the *Code of Federal Regulations* (10 CFR).

The U.S. Nuclear Regulatory Commission (NRC) staff has completed its review of the report, as supplemented, and determined that Entergy has satisfied the reporting requirements of 10 CFR 50.46(a)(3). A copy of the associated NRC staff evaluation is enclosed with this letter. If you have any questions, please contact me at (301) 415-1081 or by e-mail at Andrea.George@nrc.gov.

Sincerely,

A handwritten signature in black ink, appearing to read "A. George", is positioned above the typed name.

Andrea E. George, Project Manager
Plant Licensing Branch IV-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-313

Enclosure:
Staff Evaluation

cc w/encl: Distribution via Listserv



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STAFF EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION
RELATED TO REPORT PURSUANT TO 10 CFR 50.46 REGARDING THERMAL
CONDUCTIVITY DEGRADATION MODELING ERROR
RENEWED FACILITY OPERATING LICENSE NO. DPR-51
ENTERGY OPERATIONS, INC.
ARKANSAS NUCLEAR ONE, UNIT NO. 1
DOCKET NO. 50-313

1.0 INTRODUCTION

By letter dated December 22, 2014 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML14357A098), as supplemented by letter dated March 30, 2015 (ADAMS Accession No. ML15090A307), Entergy Operations, Inc. (Entergy, the licensee), submitted a licensee event report describing a significant error with respect to thermal conductivity modeling in the emergency core cooling system (ECCS) loss-of-coolant accident (LOCA) evaluation model (EM), and an estimate of the effect of the error on the predicted peak cladding temperature (PCT) for Arkansas Nuclear One, Unit 1 (ANO-1). The report was submitted pursuant to paragraph 50.46(a)(3) of Title 10 of the *Code of Federal Regulations* (10 CFR).

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

2.0 REGULATORY EVALUATION

2.1 Regulatory Requirements

Acceptance criteria for ECCS performance for light-water nuclear power reactors are found in 10 CFR 50.46. In part, 10 CFR 50.46(a)(1)(i) requires that ECCS cooling performance be calculated in accordance with an acceptable EM. Paragraph (b) of 10 CFR 50.46 provides the acceptance criteria for ECCS performance evaluation. Specifically, 10 CFR 50.46(b)(1), "Peak cladding temperature," states that "The calculated maximum fuel element cladding temperature shall not exceed 2200 °F [degrees Fahrenheit]."

Enclosure

The regulations in 10 CFR 50.46(a)(3)(i) require licensees 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 the purpose of 10 CFR 50.46, a significant change or error is one which results in a calculated PCT difference of 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, 10 CFR 50.46(a)(3)(ii) requires the affected licensee to report the nature of the change 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 and include with the report a proposed schedule for providing a reanalysis or taking other action as may be needed to show compliance with 10 CFR 50.46 requirements.

2.2 Background

Pursuant to 10 CFR 21, "Reporting of Defects and Noncompliance," by letter dated December 16, 2014 (ADAMS Accession No. ML14351A308), AREVA NP, Inc. (AREVA) notified the NRC of a defect regarding fuel thermal conductivity degradation (TCD) modeling in its LOCA analyses for Babcock and Wilcox (B&W) plants. Thermal conductivity degradation in nuclear fuel is a function of fuel burnup over time, and is caused by irradiation damage and the progressive buildup of fission products in fuel pellets, which results in reduced heat transfer from the fuel to the primary coolant (and, therefore, higher fuel centerline temperature analysis results at a given linear heat generation rate). Licensees rely on the computer codes of vendors such as AREVA for fuel performance calculations and to perform safety analyses.

The AREVA proprietary licensing topical report (LTR) BAW-10192P-A, "BWNT [B&W Nuclear Technologies] Loss-of-Coolant Accident Evaluation Model for Once-Through Steam Generator Plants" (BWNT LOCA EM),¹ is the NRC-approved EM used to evaluate ECCS cooling performance at ANO-1. This BWNT LOCA EM is used at ANO-1 to satisfy the requirements of 10 CFR 50.46(a)(1)(i).

In its report dated December 16, 2014, AREVA stated that its 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 TACO3² and GDTACO,³ which constitute part of the BWNT LOCA EM discussed above. The modeling defect resulted in an under-prediction of the large-break LOCA PCT at ANO-1. To compensate for the under-prediction of PCT, AREVA advised that each affected plant, including ANO-1, reduce its fuel linear heat rate (LHR) by 2 kilowatts per foot (kW/ft).

¹ LTR BAW-10192P-A describes the ECCS EM. However, the EM requires use of input from approved thermal-hydraulic models. The plant-specific application is described further in detail in TR BAW-10179P-A, "Safety Criteria and Methodology for Acceptable Cycle Reload Analyses."

² AREVA LTR BAW-10162P-A, "TACO3 – Fuel Pin Thermal Analysis Code."

³ AREVA LTR BAW-10184P-A, "GDTACO – Urania Gadolinia Fuel Pin Thermal Analysis Code."

Based on AREVA's notification, Entergy submitted its December 22, 2014, letter to notify the NRC that the defect constituted an error in the ECCS in the ECCS EM for ANO-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 statement that a reanalysis would be performed on an NRC agreed-upon schedule.

In Table 1 of its report dated December 22, 2014, the licensee provided a summary of the estimated effects of the TCD error on PCT, as well as the estimated effects of the compensatory measures put in place. The estimated effect of the TCD error on the large break LOCA analysis caused PCT to increase by 388 °F. The licensee's implementation of a 2 kW/ft LHR reduction was estimated to offset the TCD effect by reducing PCT by 388 °F. Therefore, the predicted PCT for ANO-1 remains at 2008.1 °F, which is below the regulatory limit of 2200 °F established in 10 CFR 50.46(b)(1).

3.0 TECHNICAL EVALUATION

3.1 Use of an Acceptable Evaluation Model for Reanalysis

In its letter dated December 22, 2014, the licensee stated that it would correct for the TCD deficiency in a future LOCA analysis on an NRC agreed-upon schedule. Section 4.3.2.3 of the BWNT LOCA EM requires licensees to use NRC-approved fuel thermal-mechanical models. 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 Part 21 Report dated December 16, 2014, identified that these uncertainty values need to be modified in order to account for TCD.

In the NRC staff's request for additional information (RAI) dated February 27, 2015 (ADAMS Accession No. ML15061A155), the staff noted that the TCD-corrected versions of the TACO3 and GDTACO fuel performance models have not been reviewed and approved by the NRC, and requested that Entergy explain how it will ensure that the corrected ECCS LOCA evaluation is performed in accordance with an acceptable EM, pursuant to 10 CFR 50.46(a)(1)(i) (RAI-1). In its supplemental letter dated March 30, 2015, the licensee stated that AREVA would develop, and submit for NRC approval, a supplement to BAW-10192P-A, which will describe the modifications to the BWNT LOCA EM necessary to correct for the TCD error. Since the licensee provided information to assure that its ECCS cooling performance analyses will be performed using acceptable methods, that is, those methods reviewed and approved by the NRC, the NRC staff concludes that RAI-1 is resolved.

3.2 Adequacy of Reanalysis Scope

As discussed above, the licensee stated that the TCD-related model changes will be incorporated into a supplement to the BWNT LOCA EM. The licensee's letter dated December 22, 2014, states "that the LOCA EM that used TACO3 must be modified by application of additional fuel temperature uncertainty to account for the effects of TCD." Based on the magnitude of the estimated effect of a TCD correction on the ANO-1 ECCS performance evaluation, the NRC staff determined that this model revision would significantly change the predicted ECCS performance for ANO-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 RAI dated February 27, 2015, the NRC staff requested additional information regarding how the licensee would comply with the above requirement in revising their ECCS performance analyses (RAI-2).

In the licensee's RAI response dated March 30, 2015, the licensee provided the following response:

The revised [large-break LOCA (LBLOCA)] analyses will review 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.

In the NRC staff's experience, various issues associated with 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 above statement is consistent with this practice. Based on the above, the NRC staff concludes that the licensee has adequately described how it will provide assurance that the most severe postulated LOCAs are calculated. Therefore, RAI-2 is resolved.

3.3 Technical Specification (TS) Impacts

ANO-1 TS 5.6.5, "Core Operating Limits Report (COLR)," requires, in part, that:

The analytical methods used to determine the core operating limits shall be those previously reviewed and approved by the NRC, specifically those described in ... Babcock & Wilcox Topical Report BAW-10179P-A, "Safety Criteria and Methodology for Acceptable Cycle Reload Analyses" (the approved revision at the time the reload analyses are performed).

The BWNT LOCA EM is incorporated into BAW-10179P-A by reference. In its RAI dated February 27, 2015, 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. The NRC staff requested that the licensee explain how Entergy will ensure that the reanalysis referenced in its letter dated December 22, 2014, will adhere to the TS requirement above (RAI-3).

In its RAI response dated March 30, 2015, the licensee stated that once the supplement to BAW-10192P-A (discussed in Section 3.1 of this staff evaluation) is reviewed and approved by the NRC, a modification will be made to BAW-10179P-A to reference the new supplement to

BAW-10192P-A. BAW-10179P-A is the only methodology referenced in the ANO-1 TSs pertaining to large break LOCA analyses. The licensee also stated that once BAW-10192P-A and BAW-10179P-A are approved by the NRC, the cycle-specific COLR will be updated to reference the correct revision of BAW-10179P-A, as required by TS 5.6.5. The licensee further stated that its LOCA reanalysis will be completed 21 months after the NRC approves the updated BAW-10179P-A. Based on the discussion above, the NRC staff determined that the licensee has adequately described how it will comply with TS 5.6.5 in regards to the updated LOCA EMs. Therefore, RAI-3 is resolved.

4.0 CONCLUSION

Based on its review, the NRC staff concludes that Entergy's letter dated December 22, 2014, 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 (LBLOCA). The report also indicated that the licensee has taken action to reduce LHR limits to compensate for the effect of TCD, and demonstrating that these actions would limit the predicted PCT to less than 2200 °F as required by 10 CFR 50.46(b)(1). The report, as supplemented, also contained a schedule for performing reanalysis and taking other actions as may be needed to comply with 10 CFR 50.46 requirements. Specifically, a LOCA reanalysis will be performed within 21 months following NRC review and approval of BAW-10192P-A and BAW 10179P-A, and the licensee will evaluate the scope of the reanalysis to ensure that it identifies the limiting hypothetical LOCA.

Principal Contributor: B. Parks, NRR/DSS

Date: August 21, 2015

August 21, 2015

Vice President, Operations
Arkansas Nuclear One
Entergy Operations, Inc.
1448 S.R. 333
Russellville, AR 72802

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Sincerely,

/RA/

Andrea E. George, Project Manager
Plant Licensing Branch IV-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-313

Enclosure:
Staff Evaluation

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*email dated

**memo dated

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