

October 7, 2016

Mr. Gary Peters, Director
Licensing and Regulatory Affairs
AREVA Inc.
3315 Old Forest Road
Lynchburg, VA 24501

SUBJECT: SUMMARY REPORT FOR THE AUGUST 3 TO AUGUST 4, 2016 AUDIT IN SUPPORT OF THE REVIEW OF ANP-10333, REVISION 0, "AURORA-B: AN EVALUATION MODEL FOR BOILING WATER REACTORS; APPLICATION TO CONTROL ROD DROP ACCIDENT (CRDA)" (CAC NO. MF3889)

Dear Mr. Peters:

By letter dated March 31, 2014 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML14098A331), AREVA, Inc. (AREVA) submitted Topical Report (TR) ANP-10333P, Revision 0, "AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to CRDA," for review and approval by the U.S. Nuclear Regulatory Commission (NRC). The TR describes a methodology in which the AURORA-B evaluation model would be used to perform safety analyses related to the control rod drop accident.

An audit of understanding was requested to allow the NRC staff to review relevant documentation and discuss the methodology with cognizant technical experts at AREVA. This audit would support development of appropriately targeted requests for additional information (RAI) questions.

The audit was held at the AREVA facility in Richland, WA, from August 3 to August 4, 2016. The results of the audit will be used by the NRC staff to support development of draft RAI questions in a timely manner. Enclosure 1 to this letter provides the audit summary report. A copy of the audit plan was transmitted to AREVA via email prior to the audit and is included as Enclosure 2. A list of audit attendees is provided in Enclosure 3.

G. Peters

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If you have any questions, please contact me at (301) 415-4053 or Jonathan.Rowley@nrc.gov.

Sincerely,

/RA/

Jonathan Rowley, Project Manager
Licensing Processes Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Project No. 728

Enclosures:

1. Summary Report for Audit
2. Audit Plan
3. List of Attendees

G. Peters

- 2 -

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OFFICE	DPR/PLPB/PM	DPR/PLPB/LA*	DSS/SNPB/BC	DPR/PLPB/BC	DPR/PLPB/PM
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DATE	10/3/16	9/28/16	10/4/16	10/6/16	10/7/16

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SUMMARY REPORT FOR
AUGUST 3 TO 4, 2016, AUDIT OF AREVA, INC
TO SUPPORT REVIEW OF ANP-10333, REVISION 0,
“AURORA-B: AN EVALUATION MODEL FOR BOILING WATER REACTORS; APPLICATION
TO CONTROL ROD DROP ACCIDENT (CRDA)”
PROJECT NO. 728
TAC NO. MF3889

By letter dated March 31, 2014, AREVA, Inc. (AREVA) submitted a topical report (TR) which presents a methodology for the evaluation of the control rod drop accident (CRDA) for boiling water reactors (BWRs) using the AURORA-B anticipated operational occurrence (AOO) methodology currently under review by the NRC. The TR is entitled, “AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Control Rod Drop Accident (CRDA),” and can be identified by its TR number, ANP-10333P.

This TR builds on methodologies identified in the aforementioned general AURORA-B AOO methodology TR, ANP-10300P, Revision 0, “AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Transient and Accident Scenarios.” Once a safety evaluation was under development with the limitations and conditions known, the U.S. Nuclear Regulatory Commission (NRC) staff began review of ANP-10333P. Subsequently, the NRC staff determined that an audit for understanding would be the most effective approach to enable the NRC staff to develop focused RAI questions in order for AREVA to provide quality and timely responses.

The audit was held at the AREVA facilities in Richland, Washington, from August 3 to 4, 2016. The audit plan, along with further detail on the regulatory background, can be found in Enclosure 2. A list of attendees for the entrance meeting is provided in Enclosure 3. The NRC staff member who participated in the audit discussions was Scott Krepel, who is the lead technical reviewer for this TR.

The audit team held an entrance meeting on August 3, 2016. After introductions and opening remarks, several AREVA managers excused themselves, and the technical staff provided a presentation discussing AURORA-B and the CRDA methodology. By design, the presentation touched upon the specific topics that had been highlighted as areas of interest in the audit plan. During the presentation, the NRC staff member asked questions and engaged in discussion with the AREVA technical staff to obtain clarification and/or identify potential gaps in the documentation submitted as part of the TR.

During the audit, AREVA presented to the NRC staff member a number of paper copies of documents related to the TR. At the request of the NRC staff member, a laptop was procured

with electronic copies of all documents. The documents presented by AREVA for review by the NRC are listed below:

1. "Supporting Figures and Tables for AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Control Rod Drop Accident (CRDA)." (AREVA Document No. FS1-0015501)
2. "Phenomena Identification and Ranking Table (PIRT) for Control Rod Drop Accident," AREVA Inc., January 2014. (AREVA Document No. 12-9163392-001)
3. "SPERT-III E-CORE S-RELAP5 Test Case Comparison," AREVA NP, August 2013. (AREVA Document No. 32-9197885-000)
4. "SPERT-III E-CORE MICROBURN-B2V2 Model Setup," AREVA NP, July 2013. (AREVA Document No. 32-9058967-000)
5. "AURORA-B CRDA METH Sample Plant A Part 2," AREVA Inc., February 2014. (AREVA Document No. FS1-0011125)
6. "CRDA Methodology Sample Plant A Part 3," AREVA NP, August 2013. (AREVA Document No. FS1-0011437)
7. "SPERT E-Core Transient Rod Drop Analyses (3" Radial Node Model)," AREVA NP, August 2013. (AREVA Document No. FS1-0010184)
8. "CRDA Sensitivity with Channel Regrouping," AREVA Inc., January 2014. (AREVA Document No. FS1-0013944)
9. "CRDA Sample Plant A 6x6 Drop Evaluation Startup Range," AREVA NP, December 2013. (AREVA Document No. FS1-0011853)
10. "FSQA-08 S-RELAP5 Models and Correlations Code Manual (Theory)." (AREVA Document No. FS1-0009406 Revision 3.0)
11. "FSQA-08 MB2-K Theory Manual: A Code for Advanced Neutron Kinetics Method for BWR Transient Analysis." (AREVA Document No. FS1-0008073 Revision 2.0)
12. TR BAW-10247PA, Revision 0, "Realistic Thermal Mechanical Fuel Rod Methodology for Boiling Water Reactors." (Nonproprietary Version - ADAMS Accession No. ML042810358)
13. "Guidelines for Input Development and Problem Execution for Analysis of BWR Events." (AREVA Document No. 51-9079012-000)
14. "FSQA-07 RODEX4-UAPR13-0_UsrMan-000," RODEX4 User's Manual. (AREVA Document No. FS1-0010616 Revision 1.0)

15. AREVA Response to RAIs on Supplement 1 to TR BAW-10247PA, Revision 0, “Realistic Thermal-Mechanical Fuel Rod Methodology for Boiling Water Reactors, Supplement 1: Qualification of RODEX4 for Recrystallized Zircaloy-2 Cladding, Responses to NRC Request for Additional Information.” (Nonproprietary Version - ADAMS Accession No. ML13329A455)
16. AREVA Response to RAIs on TR BAW-10247Q4P, Revision 0, “Response to Request for Additional Information – BAW-10247(P).” (Nonproprietary Version - ADAMS Accession No. ML072490417)
17. “Guideline for Analyses of the BWR CRDA with the AURORA-B Methodology.” (AREVA Document No. 51-9216365-000)
18. “FSQA-07 S-RELAP5 Input Data Requirements.” (User’s Manual) (AREVA Document No. FS1-0009130 Revision 2)
19. “FSQA-07 MB2-K User’s Manual.” (AREVA Document No. FS1-0008072 Revision 1)

During the audit, the NRC staff member reviewed the information provided in the package and discussed it with the AREVA staff. There was open communication throughout the audit and it was conducted in accordance with the audit plan with no known deviation. As a result of the discussions, 10 open items were identified for which the AREVA staff understood that further clarification or discussion would be necessary. These items will be captured in RAI questions by the NRC staff, along with any other questions that may emerge during the NRC staff’s continuing review of ANP-10333P.

At the conclusion of the audit, the NRC and AREVA staff members conducted an exit meeting on August 4, 2016. At this meeting, the AREVA staff went through a list of the identified open items and proposed resolution strategies. The NRC staff member provided feedback on whether each proposed path forward could reasonably be expected to adequately address the relevant clarification or concern. The purpose of this discussion was to achieve a mutual understanding on the necessary scope for the future responses to the RAI questions in order to avoid additional RAI questions.

The NRC staff member indicated that AREVA should expect to see the RAI questions by the end of fall 2016. The NRC emphasized that a timely response to these RAI questions would greatly assist the staff in completing the review process before the requested approval date at the end of 2017.

AUDIT PLAN FOR AREVA, INC.

LICENSING TOPICAL REPORT ANP-10333P, REVISION 0

AURORA-B: AN EVALUATION MODEL FOR BOILING WATER REACTORS:

APPLICATION TO CONTROL ROD DROP ACCIDENT (CRDA)

PROJECT NO. 728

TAC NO. MF3889

1.0 INTRODUCTION

By letter dated March 31, 2014, AREVA, Inc. (AREVA) submitted a topical report (TR) which presents a methodology for the evaluation of the control rod drop accident (CRDA) for boiling water reactors (BWRs) using the AURORA-B AOO methodology currently under review by the U.S. Nuclear Regulatory Commission (NRC). The TR is entitled, "AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Control Rod Drop Accident (CRDA)," and can be identified by its TR number, ANP-10333P.

The AURORA-B AOO Evaluation Model (EM) was developed to predict the dynamic response of BWRs during transient, postulated accident, and beyond design-basis scenarios. The EM is used by NRC licensees to demonstrate compliance with the regulatory requirements associated with different events (the actual requirements vary depending on the event, but they are broadly captured by the General Design Criteria (GDC) in Title 10 of the *Code of Federal Regulation* (10 CFR) Part 50, Appendix A). The U.S. Nuclear Regulatory Commission (NRC) staff is currently completing the review process of the general AURORA-B TR, ANP-10300P, Revision 0, "AURORA-B: An Evaluation Model for Boiling Water Reactors; Application to Transient and Accident Scenarios." The current expectation is that this TR will be approved soon.

The acceptance criteria used to determine regulatory compliance for the CRDA event includes a pellet/cladding mechanical interaction failure threshold that is dependent on the hydrogen content of the cladding. The hydrogen pickup model that will be used to determine the hydrogen content of the cladding was described as part of the NRC review of Supplement 1Q2P to BAW-10247PA, Revision 0, "Realistic Thermal-Mechanical Fuel Rod Methodology for Boiling Water Reactors, Supplement 1: Qualification of RODEX4 for Recrystallized Zircaloy-2 Cladding." The NRC approval of this TR supplement is also expected to occur shortly.

The TR currently under review was submitted to document and obtain NRC approval for an analysis methodology specifically addressing the CRDA event. The general AURORA-B EM TR did not address the CRDA event, so ANP-10333P was submitted to describe and validate a methodology for evaluating this event with the AURORA-B EM. The specific regulatory requirements associated with the CRDA event are GDC 13, "Instrumentation and control," and GDC 28, "Reactivity limits," as well as radiation dose limits from 10 CFR 50.67, "Accident source term," and 10 CFR 100.11, "Determination of exclusion area, low population zone, and

population center distance.” The TR uses interim acceptance criteria for the reactivity initiated accident (RIA) provided in the Standard Review Plan (SRP) Section 4.2, Appendix B, but this review will also consider the draft regulatory guide, DG-1327, which is intended to establish final acceptance criteria for RIAs. The NRC guidance related to the BWR CRDA event is presented in SRP Section 15.4.9.

The TR provides: (1) additional assessment of the AURORA-B EM to validate its predictions of the dynamic response of the reactor during reactivity excursions, (2) a specific methodology to perform the CRDA analysis, (3) technical justification for generic analysis assumptions, and (4) an example CRDA analysis. Since the NRC review and approval of ANP-10300P will provide reasonable assurance for the predictive capabilities of the codes associated with most of the expected phenomena for the expected general plant response to typical analyzed events, the NRC staff focus is on the key issues unique to the CRDA event. This includes the assessments of the AURORA-B EM’s ability to predict the reactivity response to control rod drop events, the treatment of the Doppler reactivity feedback, the sensitivity studies performed to support the CRDA analysis methodology, and any other technical justification for generic issue resolutions that will not be evaluated on a cycle-specific basis.

The NRC staff has determined that an audit, following Office of Nuclear Reactor Regulation Office Instruction LIC-111, “Regulatory Audits,” will be beneficial in identifying additional information required to complete the review.

2.0 REGULATORY AUDIT BASES

The application of the AURORA-B EM for CRDA analysis purposes was developed primarily to satisfy NRC regulatory guidelines to meet the regulatory requirements established in 10 CFR Part 50, “Domestic Licensing of Production and Utilization Facilities,” Appendix A, “General Design Criteria for Nuclear Power Plants,” Criterion 28, “Reactivity limits.” This requirement is met by satisfying interim acceptance criteria defined for the RIA in Section 4.2, Appendix B of the SRP and the “Service Limit C” maximum reactor pressure criterion defined in the American Society of Mechanical Engineers *Boiler and Pressure Vessel Code*.

If fuel rod failures are identified, a radiological evaluation is performed to verify that 10 CFR 50.67, “Accident source term,” and 10 CFR 100.11, “Determination of exclusion area, low population zone, and population center distance,” requirements are met by using guidance in Regulatory Guide 1.183, SRP Section 4.2, and PNNL-1812, Revision 1, to demonstrate that the release term is bounded by the licensing basis source term.

The NRC staff will audit ANP-10333P and supporting documentation, to identify appropriate additional information to request for submittal. Such information would be that required to determine (1) whether the proposed extension of the AURORA-B EM to analyze the CRDA event is supported by the assessments and technical justifications provided by AREVA, and (2) whether the CRDA analysis methodology, as described in ANP-10333P, is sufficient to meet the aforementioned regulatory requirements and NRC guidance.

3.0 REGULATORY AUDIT SCOPE/OBJECTIVES

The audit is planned to cover the following five topics below.

3.1 OVERVIEW OF ANP-10333P

The NRC staff understands that AREVA plans to deliver a presentation with a basic overview of ANP-10333P. The presentation is expected to provide a framework to allow the NRC staff and AREVA staff to have a structured discussion about specific aspects of the content provided in the TR.

Areas of special focus include:

- SPERT assessments and conclusions
- Sensitivity studies and conclusions
 - Calculation details (input perturbations)
 - Conclusions supporting generic assumptions in the CRDA analysis methodology
- Fuel temperature treatment for Doppler feedback
- Generic disposition of at-power CRDA

3.2 REVIEW OF INPUT PROCESSING

The NRC staff will audit the typical process of running the analysis computer codes during the audit. This activity should provide the NRC staff with a general overview of the relevant input files. This will support NRC staff review of inputs in calculation files during subsequent audit activities.

3.3 REVIEW OF SPECIFIC ANP-10333P CALCULATIONS AND ANALYSES

The NRC staff will audit calculation files for the sensitivity studies and the CRDA analyses, as necessary, to address any further questions or gaps in understanding after Objective 3.3.

3.4 ADDITIONAL DISCUSSION AND EXIT MEETING

At the conclusion of the audit, an exit meeting will be held to summarize additional information, if any, that AREVA will be requested to submit to continue the review. Other appropriate next steps, including an update to the licensing topical report review schedule, will be discussed, as well.

4.0 TEAM ASSIGNMENTS

The following personnel will be supporting the review:

<u>NAME</u>	<u>AFFILIATION</u>
Scott Krepel	Technical Reviewer, NRC/NRR/DSS

5.0 LOGISTICS AND SCHEDULE

The audit will take place on Wednesday and Thursday, August 3 through 4, 2016. The location is the AREVA facilities at 2101 Horn Rapids Road in Richland, Washington.

Wednesday, August 3, 2016:

- Overview/Discussion
- Begin Input Processing

Thursday, August 4, 2016:

- Continue Input Processing (if needed)
- Specific Calculation Files
- Exit Meeting

LIST OF ATTENDEES

AUGUST 3 TO 4, 2016, AUDIT

TO SUPPORT REVIEW OF ANP-10333, REVISION 0,

“AURORA-B: AN EVALUATION MODEL FOR BOILING WATER REACTORS; APPLICATION

TO CONTROL ROD DROP ACCIDENT (CRDA)”

Name	Organization
Alan Meginnis	AREVA, Inc. (AREVA)
Kevin Quick	AREVA
Scott Ghan	AREVA
Monte Giles	AREVA
Robert Schnepf	AREVA
Paul Keller	AREVA
Kenneth Carlson	AREVA
Stan Jones	AREVA
Dan Jordheim	AREVA
Scott Krepel	U.S. Nuclear Regulatory Commission