July 23, 2010

Ms. Sandra Sloan
AREVA NP, Inc.
3315 Old Forest Road
P.O. Box 10935
Lynchburg, Virginia 24506-0935

SUBJECT: AUDIT REPORT FOR THE JUNE 8 TO 10, 2010, AUDIT TO REVIEW SELECTED AREAS RELATED TO THE SAFETY EVALUATION OF U.S. EPR FINAL SAFETY ANALYSIS REPORT SECTION 15.6.5

Dear Ms. Sloan:

AREVA NP, Inc. (AREVA), submitted to the US Nuclear Regulatory Commission (NRC) a Final Safety Analysis Report (FSAR) for its application of the U.S. EPR in December 2007, accessible by Agencywide Documents Access and Management System (ADAMS) Accession No. ML073520305. To address Generic Safety Issue (GSI)-191 downstream effects for the U.S. EPR Design Certification Application, AREVA submitted Technical Report ANP-10293 Revision 0, "U.S. EPR Design Features to Address GSI-191," in February 2008. A public meeting on sump performance and downstream effects was held on April 29, 2010. The need for an additional audit on downstream effects was identified during the April 29, 2010, public meeting. By a letter dated May 20, 2010, AREVA submitted Revision 1 to ANP-10293 (ADAMS Accession No. ML101460420).

The staff review of ANP-10293, Revision 1, identified the need for additional information to cover important review areas handled by the Reactor Systems, Nuclear Performance, and Code Review Branch (SRSB). In order to address these concerns, the staff held an audit that at the AREVA office in Rockville, MD on June 8 - 10, 2010. The review of additional technical documents was facilitated by the presence of AREVA personnel at the audit. The audit report is contained in the enclosure to this letter. If you have any questions regarding this matter, I may be reached at 301-415-3361 or at Getachew.Tesfaye@nrc.gov.

Sincerely,

/RA/

Getachew Tesfaye, Senior Project Manager
EPR Projects Branch
Division of New Reactor Licensing
Office of New Reactors

Docket No. 52-020

Enclosure:
Audit Report
cc: DC AREVA – EPR Mailing List

Ms. Sandra Sloan
AREVA NP, Inc
3315 Old Forest Road
P.O. Box 10935
Lynchburg, Virginia 24506-0935

SUBJECT: AUDIT REPORT FOR THE JUNE 8 TO 10, 2010, AUDIT TO REVIEW SELECTED AREAS RELATED TO THE SAFETY EVALUATION OF U.S. EPR FINAL SAFETY ANALYSIS REPORT SECTION 15.6.5

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Sincerely,
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Getachew Tesfaye, Senior Project Manager
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Docket No. 52-020

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Audit Report
cc: DC AREVA – EPR Mailing List

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ADAMS Accession Number: ML101830115 **NRO-002**

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APPLICANT: AREVA NP, INC.

PROJECT: EPR DESIGN CERTIFICATION

SUBJECT: AUDIT REPORT FOR JUNE 8 TO 10, 2010, AUDIT TO REVIEW SELECTED AREAS RELATED TO U.S. EPR FSAR CHAPTER 15 SAFETY EVALUATION

BACKGROUND

AREVA NP, Inc. (AREVA), has submitted to the U.S. Nuclear Regulatory Commission (NRC) a Final Safety Analysis Report (FSAR) for its application of the U.S. EPR in December 2007. NRC staff initiated the design certification review on March 19, 2008. To address Generic Safety Issue (GSI)-191 downstream effects for the U.S. EPR Design Certification Application, AREVA submitted Technical Report ANP-10293 Revision 0, "U.S. EPR Design Features to Address GSI-191," in February 2008. In a public meeting held on July 8, 2009, AREVA announced its U.S. EPR sump performance strategy including the conduct of plant-specific testing. Fuel assembly blockage testing was performed at Continuum Dynamics, Inc. (CDI), on October 27 and 28, 2009, and again in March 2010. Debris bypass was investigated as part of U.S. EPR plant specific sump testing (strainer/retaining basket) that was performed in December 2009.

During the initial technical review of ANP-10293 Revision 0, the staff issued a set of requests for additional information (RAIs) considering downstream effects. RAI 30, Questions 15.06.05-18 and 15.06.05-19 were issued to the applicant on July 29, 2008. RAI 191, Questions 15.06.05-43 through 15.06.05-49 were issued to the applicant on March 11, 2009. The responses to these RAIs are currently under staff evaluation. In addition, the staff conducted audits in areas related to U.S. EPR FSAR 15.6.5 GSI-191 downstream effects at AREVA's Twinbrook office in Rockville, MD in April 2009 and in April 2010. The staff also witnessed fuel assembly blockage testing performed at CDI on October 27, 2009, and March 2010. Following the initial fuel assembly blockage testing, the staff issued RAI 362, Questions 15.06.05-56 to 15.06.05-60 on fuel blockage testing on January 29, 2010. The responses to these RAIs are currently under staff evaluation. In April 2010, the staff audited the U.S. EPR GSI-191 EPR deposition model (EPRDM) debris deposition model and analysis results presented by AREVA. Following the audit, the staff formulated potential RAI questions, which were discussed with the applicant at a teleconference on May 10, 2010.

In order to cover important review areas handled by the Office of New Reactors Reactor Systems, Nuclear Performance, and Code Review Branch (SRSB), the staff held an audit on June 8 - 10, 2010, at the AREVA office in Rockville, MD. The review of additional technical documents, made available by AREVA at its local office, was facilitated by the presence of AREVA personnel at the audit. The requested documentation included pertinent technical documentation to support discussion topics identified by the staff. The audit was needed to resolve existing questions in accomplishing the U.S. EPR review schedule in an efficient manner and to support the review in conformance with Standard Review Plan (SRP) Section 15.6.5. The staff will formulate potential RAI questions, which will be discussed with the applicant at a future teleconference. The audit attendee list is provided in Attachment B.

AUDIT APPROACH

The purpose of this audit was to review additional documents and calculations provided by AREVA that pertain to downstream effects, including U.S. EPR specific fuel assembly testing,

ENCLOSURE

bypass testing, and chemical effects testing. AREVA provided information on the testing done to date and proposed test protocols for future testing. A detailed agenda is provided in Attachment A. The topics covered in the audit specifically focused on testing and analysis performed in support of the applicant's downstream effects submittal.

Discussions on the following five major areas were held by AREVA representatives on June 8, 9, and 10, 2010:

Topic A- Testing of debris blockage of fuel assemblies
Topic B- Sump strainer bypass testing
Topic C- EPRDM debris deposition analysis
Topic D- Chemical effects evaluation
Topic E- Ex-Vessel Effects

To achieve the review goals in an efficient manner, the staff assembled an interdisciplinary audit team. The audit team included experts from NRC and consulting organizations. The audit was attended by representatives from AREVA who introduced the audit topics and provided supporting documents and technical evidence to the reviewers. The attendee list is provided in Attachment B.

AUDIT TOPICS

The main topics covered in the audit are presented in the following sections:

Topic A- Testing of Debris Blockage of Fuel Assemblies

Fuel Assembly Testing

In addressing GSI-191 downstream effects as part of the U.S. EPR Design Certification, testing of fuel assembly blockage was carried out by Continuum Dynamics, Inc. (CDI). CDI was contracted by AREVA to perform fuel assembly tests for the U.S. EPR design.

A test loop, previously designed and constructed by CDI to measure the pressure drop across a full-area, partial-height test fuel assembly with various bottom nozzles, was used to perform GSI-191 fuel assembly tests with AREVA fuel for Pressurized Water Reactor Owner's Group (PWROG). AREVA Engineering Information Record (EIR) 51-9102685-000 Revision 0, "GSI-191 Fuel Assembly Test Report for PWROG," March 2009, presents results of PWROG tests performed for current AREVA fuel designs. The document was prepared in support of WCAP-16793-NP Revision 1 released in April 2009.

In October 2009, AREVA performed initial U.S. EPR experimental testing in examining the effects of debris blockage of fuel assemblies. First experimental results from tests conducted at the CDI have been produced. The audit examined the available test results to determine the adequacy of applicant's approach with regard to the following important factors:

- representation of U.S. EPR prototypical features by CDI test rig
- testing protocol, debris introduction, and ratio
- test data sufficiency and conclusiveness

During the audit, AREVA presented information relating to the fuel assembly testing performed in support of the U.S. EPR design certification application. Two main scenarios were covered:

1) Cold leg injection and 2) simultaneous (hot leg) injection. AREVA provided details on the approach used for fuel assembly testing in both scenarios.

The staff reviewed the information on cold side injection first. The applicant stated that work was complete on the cold side injection cases. For hot leg injection, AREVA personnel presented the fuel assembly testing completed to date on simultaneous injection, and a set of proposed tests for finishing the simultaneous injection portion of fuel assembly testing.

1. Cold Leg Injection Configuration

Addressing the cold leg injection configuration, AREVA represented test results obtained with a test loop employing a single partial-length fuel assembly. It was stated that the testing effort assuming cold leg injection only was considered completed. Test data from two different fuel assembly replicas equipped with 4 and 7 grids were discussed. The fuel blockage behavior was experimentally investigated under debris loads and flow rates pertaining to both cold leg and hot leg break locations. The establishment of the ΔP acceptance criteria for flow blockage was also presented. The applicant's major conclusion from the experimental effort was that the accepted ΔP criterion was satisfied in the case of cold leg break location whereas, in the case of hot leg break, the fiber debris, in combination with the corresponding amounts of particulates and chemical precipitants as determined for the U.S. EPR design, could lead to a complete fuel assembly flow blockage. As a result of these experimental finding indicating possible fuel assembly blockage, AREVA addressed the issue of core cooling with an entirely blocked inlet core flow area. Based on analytical calculations, it was stated that the bypass flow through the holes in the heavy neutron reflector with the core inlet assumed blocked would provide enough cooling flow for the reactor core. AREVA concluded that both types of breaks with cold leg injection were considered dispositioned. The staff is reviewing AREVA's position on this subject.

2. Simultaneous Cold and Hot Leg Injection

To address the simultaneous cold and hot leg injection configuration, AREVA stated that the performance of additional testing was planned. As part of this experimental effort, the construction of a new fuel assembly replica having features prototypical for the U.S. EPR was planned. The applicant expressed its intention to address the fuel assembly testing with a combined injection configuration at a coming public meeting in July 2010.

Topic B- Sump Strainer Bypass Testing

Under this area, the audit examined if proper consideration is given to all types of debris that can contribute to downstream effects on long-term core cooling. The types of debris that need to be considered include the following categories:

- debris from different types of insulation materials
- paint chips
- latent debris
- chemical precipitants

With regard to the first two categories, the audit examined the types of insulation materials, painted surfaces, other extraneous and contributing materials as well as latent debris. Based

on the confirmation of the debris source term, the audit also examined the sump strainer bypass ratios that could lead to limiting downstream effects with regards to core cooling.

Special attention was given to chemical debris consideration both with regard to their generation and transportation. Thermal-hydraulic conditions used as input to the chemical reactions leading to chemical products, such as temperature, were examined. In addition, the audit examined bounding pool chemistry conditions for the U.S. EPR design with regard to chemical products.

AREVA has attempted to determine the sump strainer bypass experimentally. The staff examined the bypass testing results. In consideration of bypass ratios, the staff considered debris combinations that could lead to limiting conditions on core coolability.

The audit was intended to identify additional information, by examination of related available documentation, resolution of open questions with regard to the downstream effect of the following debris generation/bypass items:

- types of debris bypassing the sump
- bypass ratios or bypass amounts for each debris type, timing and rates of debris bypassing

AREVA personnel detailed the approach used to determine the bypass fraction of fiber for the U.S. EPR design. It was noted that, bypass sampling was performed as part of the strainer head loss tests performed by AREVA at Alden Labs in Holden, MA.

The applicant presented findings from scaled test results performed to determine the amount of fiber bypassing the U.S. EPR sump screen. The test rig configuration and test procedures, including sampling the concentration of fiber of different fiber lengths in the coolant downstream the sump screen, were presented. In addition, the source fiber properties and preparation for testing were discussed. Test data showing measured fiber concentrations in the coolant downstream the sump strainer for fiber in three different fiber length size categories at different points in time were presented and discussed. The staff asked several clarifying questions on how fiber samples were prepared for the bypass testing, and how the samples taken from the test were measured.

Topic C- EPRDM Debris Deposition Analysis

AREVA has developed and has implemented a debris deposition model (EPRDM) to conservatively assess accumulation of debris sediments on core fuel surfaces and related effects on fuel clad temperatures and possible fuel blockage for the U.S. EPR design. The approach implemented appears to be consistent with the PWROG efforts in this regard. As mentioned in the first section of the audit plan, the EPRDM debris deposition model and the results from its implementation were audited at the AREVA Twinbrook office on April 28, 2010. Following the audit, the staff prepared draft RAI questions, which were discussed with the applicant at a teleconference on May 10, 2010. A question identified by the staff and related to the decay heat multiplier that is used in the analysis was resolved adequately. As the applicant stated, the deposition model analysis results were based on a decay heat multiplier of 1.2.

The audit in this area focused on addressing open items in regard to the following safety-related aspects of the EPRDM analyses.

- consistency of addressing chemical products in terms of thermal-hydraulic conditions used in chemical products generation analysis
- debris amounts and rates of introduction
- modeling of debris deposition mechanisms and related assumptions
- effects of fuel deformation (bowing, ballooning) and non-uniform growth of deposits
- cylindrical versus slab geometry for modeling heat transfer across debris deposits

The presentation by AREVA briefly addressed the talking points on the applicant's EPRDM debris deposition model. The talking points addressed questions from staff related to the EPRDM model as well as results from its implementation first presented during the audit at the AREVA Twinbrook office on April 28, 2010. A question related to the decay heat multiplier assumed in the analysis was discussed and clarified. The applicant stated that the model used a value of 1.2, which was found appropriate by staff. In addition, the applicant discussed the usage of slab geometry instead of cylindrical in assessing the thickness of deposits on fuel surfaces by pointing out that the assumption, with other parameters being equal, would yield a thicker deposits layer.

Topic D- Chemical Effects Evaluation

The applicant presented the results of chemical effects evaluation for the U.S. EPR in resolving GSI-191. The presentation was focused on the technical information included in Appendix D, "Chemical Effects Evaluation for the U.S. EPR," to ANP-10293, Revision 1 submitted in May 2010. The applicant discussed the results from the chemical effects testing performed for different debris materials. The experimental evidence was used to support U.S. EPR IRWST sump chemistry modeling, which was performed using OLI *CorrosionAnalyzer*™. Details regarding the pool thermal-hydraulic conditions assumed in the analyses, including fluid temperature, were questioned. In particular, the applicant stated that additional information would be provided regarding the assumptions used in determining the sump liquid temperature response applied in the U.S. EPR sump chemistry analyses.

Topic E- Ex-Vessel Effects

During the audit, the staff and AREVA discussed AREVA's proposed approach for addressing ex-vessel downstream component (including pumps) effects in debris-laden conditions. AREVA stated that the component vendor will be provided bypass fiber characteristics identified in component specifications after the design certification is issued. The vendor will explain component operability during mission time based on debris bypass analysis and will provide test and evaluation data for equipment qualification. The staff noted that this approach is not sufficient to make its safety finding for component design adequacy prior to issuance of a design certification. The staff finds that the methodology and acceptance criteria need to be developed by AREVA in conjunction with the EPR design certification. As a result of the audit, the staff identified the need for AREVA to develop a specific methodology and acceptance criteria for evaluating the functionality of ex-vessel downstream components. In addition, if such an approach is to be used, the staff identified the need for the U.S. EPR FSAR to provide an Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC) for a test to verify ex-vessel downstream component functionality in debris-laden conditions for the required mission time. The staff took action to issue draft RAIs requesting the necessary information from the applicant.

Action Items:

1. AREVA will submit the completed cold leg injection documentation on the docket so that the staff can begin reviewing the information in a timely manner.
2. The staff will document areas of concern identified during the audit with AREVA's proposed downstream effects approach in support of a public meeting to be held in July 2010.
3. The staff will formulate potential RAIs as necessary.
4. For ex-vessel downstream effects, the staff will issue draft RAIs on the need for ITAAC to demonstrate the performance of ex-vessel components under debris loading.
5. A teleconference will be held prior to the public meeting to discuss areas of concern, potential RAIs, the agenda and logistics for the public meeting.

Areas of Concern Identified During the Audit

Topic A- Testing of debris blockage of fuel assemblies

1. Credit for heavy reflector flow: Based on the current data available, AREVA determined that debris may completely clog the core inlet and stop the flow into the core through the fuel assembly (FA) inlet during the first hour of operation into the hot leg during the LBLOCA. Flow through heavy reflector cooling channels needs to be credited to maintain core cooling. This conclusion led to the following staff questions and comments: 1) Crediting flow through heavy reflector may lead to significant new analysis effort from AREVA and staff review effort as the thermal-hydraulic phenomenon associated with this scenario is not clearly defined and readily analyzed using existing state-of-art computer codes and analysis tools. AREVA would need to evaluate the conservatism associated with by-pass testing and find a way to reduce the clogging as much as possible; 2) If the complete blockage is inevitable, more detailed analysis is needed from AREVA to demonstrate: PCT is less than 800°F with 1.2 decay heat level; the availability of heavy reflector flow channel with potential debris clogging; ITAAC and Technical Specifications to ensure the availability of these flow paths.

2. Thermal-hydraulic considerations: For the cold leg break case, as the DP available is relative small, significant thermal-hydraulic phenomena affecting DP need to be evaluated and considered. These phenomena include, but not limited to, down-comer boiling, boron precipitation, loop seal formation, non-uniform flow and void distribution in the core.

3. Determination of ΔP fuel assembly blockage acceptance criteria: The assumptions used in the analytical calculations to determine the ΔP acceptance criteria need to be examined closely. The examination should consider flow configurations, participating phenomena, and conditions that could have a significant effect on the results and thus compromising the conservative margin in the established values. An example could include blockage of loop seals. Another factor that was not considered by the applicant includes the effect on the liquid density in the core of boric acid accumulation.

4. Prototypicality of test fuel assembly: The applicant stated that components of the fuel assembly replicas, used to produce the test data, including grid spacers, were not prototypical for the U.S. EPR design. This adds uncertainty to the validity of the test results for the U.S. EPR design.

5. Fuel assembly blockage test procedures: The relatively low fiber load per fuel assembly for the U.S. EPR, used for cold leg injection with a cold leg break, elevates the importance of the effect of introducing the fiber load in a single batch during testing. Effect of incremental debris load introduction in smaller amounts needs to be addressed.

The staff took action to issue draft RAIs requesting the necessary information from the applicant.

Topics B- Sump strainer bypass

1. Contingency to additional thin bed testing: If the strainer head loss testing shows overflow, the current by-pass testing becomes questionable as it assumed all fiber enters the debris basket first.

2. Flow rate assumption: The worst by-pass scenario is all four trains operating and all debris is distributed uniformly among four strainers. It is not clear whether AREVA has considered this as part of by-pass testing plan and testing conditions.

3. By-pass debris mass measurement: The current methodology of measuring debris penetrating through the strainer relied on the assumption of uniform debris distribution within certain fluid volume through the strainer. It is not clear whether the assumption is reasonable and how the volume is determined accurately. In addition, certain calculation procedures were used to calculate debris mass based on SEM pictures and small samples. This approach could introduce uncertainties of the debris by-pass amount. Alternative measurement method was discussed, such as installing a fine mesh debris catcher at the pump discharge and measuring the by-pass fraction by weighing the total debris mass while, at the same time, use SEM to characterize the debris sizing distribution.

4. Size distribution of test fiber: The fibrous debris material used in testing was represented by NUKON®. The same insulation material is intended to be used in the U.S. EPR. It was pointed out that the length size distribution of the source fiber used in testing could have an important effect on the bypass fraction determined with a particular fiber test batch. As no such information was obtained in the testing, this issue requires further examination.

5. Test debris ingredients: As with the fuel assembly blockage testing, the sump bypass investigation effort did not employ micro-porous insulating material (represented by Microtherm in the U.S. EPR design). The item needs further examination with regard to debris bed behavior including thin bed formation.

The staff took action to issue draft RAIs requesting the necessary information from the applicant.

Topic C- EPRDM Debris Deposition Analysis

- Completion of EPRDM model review

The staff took action to issue draft RAIs requesting the necessary information from the applicant.

Topic D- Chemical effects evaluation

- Sump thermal-hydraulic conditions for chemistry modeling: As the temperature is an important factor in determining the chemical reaction rates, it is necessary to understand the degree of conservatism in the thermal-hydraulic conditions implemented in the chemistry analyses. Contributing factors that require attention include the decay heat multiplier and other assumptions related to ECCS operation and containment conditions can have important impact on the results.

The staff took action to issue draft RAIs requesting the necessary information from the applicant.

Topic E- Ex-Vessel Effects

1. As a result of the audit, the staff identified the need for AREVA to develop a specific methodology and acceptance criteria for evaluating the functionality of ex-vessel downstream components.

2. In addition, if such an approach is to be used, the staff identified the need for the U.S. EPR FSAR to provide an ITAAC for a test to verify ex-vessel downstream component functionality in debris-laden conditions for the required mission time.

The staff took action to issue draft RAIs requesting the necessary information from the applicant.

Audit Summary

The June 8 - 10, 2010, downstream effects audit was performed successfully at the AREVA office in Rockville, MD. The information presented by the applicant provided the staff with a better understanding of the U.S. EPR sub-compartment and containment analysis developed to support the U.S. EPR design, and this information will support the safety evaluation of U.S. EPR FSAR Chapter 15, and associated technical reports.

This audit identified the need for more information to support the safety evaluation of the U.S. EPR FSAR Chapter 15. It is expected that subsequent RAIs will be issued to obtain relevant technical information that will support the safety evaluation of the U.S. EPR FSAR Chapter 15.

Agenda

AUDIT TO REVIEW SELECTED AREAS RELATED TO THE SAFETY EVALUATION OF U.S. EPR FINAL SAFETY ANALYSIS REPORT, SECTION 15.6.5

June 8 - 10, 2010

Rockville, MD

Item No.	Time	Item	Responsible Party
		06/08/2010	
1	1:00 p.m.-.5:00 p.m.	Overview of Downstream effects approach and documentation	AREVA
		06/09/2010	
2	8:30 a.m.-12:00 p.m.	Clarification of NRC questions on downstream effects documentation.	NRC staff and AREVA
3	1:00 p.m.-.4:30 p.m.	Clarification of NRC questions on downstream effects documentation.	NRC staff and AREVA
		06/10/2010	
4	8:30 a.m.-12:00 p.m.	Clarification of NRC questions on downstream effects documentation.	NRC staff and AREVA
5	1:00 p.m. - 3:00 p.m.	Clarification of NRC questions on downstream effects documentation.	NRC staff and AREVA
6	3:00 p.m. - 4:00 p.m.	NRC internal caucus	NRC staff
7	4:00 p.m.– 4:30 p.m.	Audit Summary / Exit	NRC staff and AREVA

Attendee List

AUDIT TO REVIEW SELECTED AREAS RELATED TO THE SAFETY EVALUATION OF U.S. EPR FINAL SAFETY ANALYSIS REPORT, SECTION 15.6.5
June 8 - 10, 2010, AREVA NP, Inc., Rockville, MD

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Shanlai Lu	NRC
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