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U.S. NUCLEAR REGULATORY COMMISSION (NRC)  
OFFICE OF NEW REACTORS  
REGULATORY AUDIT REPORT

Docket No.: 52-020

Applicant: AREVA NP, INC.  
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Application and Section: U.S. EPR AREVA FSAR SECTION 3.8

Audit Dates: January 26-30, 2009

NRC Audit Reviewers: Samir Chakrabarti, Lead Technical Reviewer (NRO/DE/SEB2)  
Michael Miernicki, Project Manager (NRO/DNRL/NARP)  
Jim Xu, Technical Reviewer (NRO/DNRL/NARP)  
Joseph Braverman, NRC Contractor (BNL)  
Charles Hofmayer, NRC Contractor (BNL)

Approved by: Sujit Samaddar, Branch Chief  
Structural Engineering Branch 2, NRO/DE

## **EXECUTIVE SUMMARY**

AREVA NP, INC.  
Docket No. 52-020

During January 26 - 30, 2009, the NRC staff visited the AREVA office in Charlotte, NC to perform a structural design audit of the U.S. EPR design. The scope of the audit covered the structures and information contained in Sections 3.8.1 through 3.8.5 of the U.S. EPR FSAR. The purpose of the audit was to review the manner in which AREVA implemented the structural design criteria presented in the FSAR, and to verify that key/representative design calculations were performed in accordance acceptable engineering practices.

The results of the audit are summarized below:

Selected portions of the design documents were reviewed during the audit. The focus of this review was to determine whether the reports or calculations were prepared in accordance with the criteria presented in the US EPR FSAR, Rev. 0, were in agreement with the regulatory guidance presented in the NRC Standard Review Plan (SRP) and Regulatory Guides, and were performed in an acceptable manner.

All of the important observations and issues identified during the review of the documents were noted and discussed with AREVA. A summary of the more significant observations and potential safety issues is presented below along with the path forward for resolving them.

1. No documented criteria could be identified which describes the process and basis for selecting the critical sections to be designed for each structure. AREVA needs to document the criteria used to select the appropriate critical sections to demonstrate that the EPR design is adequate for design certification. AREVA agreed to provide the basis/criteria in their response to the existing RAI on critical sections, which was recently transmitted to them.
2. The stability evaluation of the nuclear island (NI) needs to be updated and/or revised to develop the Factors of Safety which meets the SRP 3.8.5 acceptance criteria rather than just demonstrating a small displacement. The nonlinear analysis for sliding and overturning needs to consider the effects of both conditions of buoyancy and no buoyancy. An RAI on this topic was previously transmitted to AREVA. Therefore, the response to this RAI should include the above requested information. In addition, it should include a detailed description of the stability evaluation approach and the method for calculating the Factors of Safety for sliding and overturning, and the method used for calculating the soil bearing pressure. It was agreed that the NRC does not need to write another RAI on these items, since AREVA will include the requested information in the response to the existing RAI on this subject.

3. As a result of the review of the NI static model, it became apparent that it did not incorporate the latest revisions made to certain structures. The NI static model needs to be updated to incorporate the current configurations for some of the structures. An example is the revisions made to the Fuel Building. AREVA indicated that they will make the needed updates and these changes will be included in the future revision of the FSAR.
4. When using the seismic equivalent static method, a question arose regarding the use of seismic modification factors to reduce the acceleration values in some cases. AREVA needs to provide an explanation why these seismic modification factors are used and how they are developed. In addition, the technical adequacy for these values should be demonstrated and this information should be described in Section 3.8 of the FSAR. The NRC will prepare a new RAI to address this item.
5. During the review of the Reactor Building Internal Structures (RBIS) calculation, a question arose regarding the stability of this structure. Since there is no physical connection between the RBIS and the containment liner, and no connection between the containment liner and the NI basemat, there is a need to properly evaluate whether uplift of the RBIS could occur under seismic loadings. AREVA needs to demonstrate whether there is any uplift of the RBIS and the extent of the uplift. If significant, what impact does this have on the design of the NI structures including the containment liner? The NRC will prepare a new RAI to address this item.
6. As a result of the review performed on the Emergency Diesel Generator Building (EDGB), a question arose regarding the finite element analysis of this structure. The AREVA calculation containing the development of the FEM for the EPGB contains a mesh sensitivity analysis for one of the walls which had openings. This sensitivity analysis concluded that a load factor was required to account for the need of a finer mesh representation of the wall. AREVA needs to explain why this mesh sensitivity analysis was only performed for one wall and not for the other walls as well. The NRC will prepare a new RAI to address this item.
7. The NRC staff plans to perform a confirmatory analysis of a selected seismic Category I structure. For this purpose the staff selected the RBIS. During the meeting, discussions were held regarding this confirmatory analysis and the information needed by the NRC from AREVA to perform this analysis. The NRC indicated that they will formally transmit a list containing the specific information needed from AREVA to permit the staff to perform this confirmatory analysis.
8. The staff review of the calculations associated with the ultimate pressure capacity of the containment and the design of the containment to the requirements of 10 CFR 50.44 raised some questions. AREVA needs to revise the analyses to address several items identified by the staff such as the use of the correct strain limits and the use of material properties at the accident temperature conditions. AREVA agreed to address these items in the response to the existing RAI on this subject.

## **REPORT DETAILS FOR JANUARY 26 - 30, 2009 AUDIT**

### Audit Scope/Summary:

The overall scope of the audit was to accomplish the following:

- Perform a structural design audit of the US EPR design, including the structures and information contained in Sections 3.8.1 through 3.8.5 of the US EPR FSAR.
- Review the manner in which AREVA has implemented the structural design criteria that is presented in the FSAR.
- Verify that key/representative design calculations have been performed in an acceptable way.

The agenda prepared for this five-day audit review is presented in Attachment 1. Representatives from NRC, BNL, AREVA, and Bechtel were present during the audit. These included some of the key technical personnel who participated in performing the calculations and designs. The list of attendees, who were present at the entrance meeting and/or participated in the audit, is provided in Attachment 2.

The audit began on January 26, 2009, Monday afternoon, at the AREVA Charlotte, NC offices. After the introductions, AREVA made presentations which summarized the EPR design criteria, analysis, and design documents; tendon system design; evaluation of the containment ultimate pressure capacity; nuclear island (NI) model; and other seismic Category I structures.

A list of the EPR civil/structural project documents was provided to the NRC review team to facilitate the audit. The list of EPR documents contained numerous reports and calculations categorized by: Criteria, loading, analysis, specialty subjects, critical sections, and input documents for the DCD. The staff used this list to identify and select the key/representative documents to review.

AREVA made available all of the documents presented on the project document list as discussed above. In addition, other supporting project documents, references from the reports and calculations, and related industry standards were made available and proved to be very useful.

Following the AREVA presentations, the NRC review team began reviewing some of the reports and calculations. The documents selected for review included one or more documents from the various categories identified on the list of EPR civil/structural project documents. The documents that were selected for review are provided in Attachment 3.

### Observations and Findings

Selected portions of the design documents as provided in Attachment 4 were reviewed during the audit. The focus of this review was to determine whether the reports or calculations were prepared in accordance with the criteria presented in the US EPR FSAR, Rev. 0, were in agreement with the regulatory guidance presented in the NRC Standard Review Plan (SRP) and Regulatory Guides, and were performed in an acceptable manner.

All of the important observations and issues identified during the review of the documents were noted and discussed with AREVA. A summary of the more significant observations and potential safety issues is presented below along with the path forward for resolving them.

1. No documented criteria could be identified which describes the process and basis for selecting the critical sections to be designed for each structure. AREVA needs to document the criteria used to select the appropriate critical sections to demonstrate that the EPR design is adequate for design certification. AREVA agreed to provide the basis/criteria in their response to the existing RAI on critical sections, which was recently transmitted to them.
2. The stability evaluation of the NI needs to be updated and/or revised to develop the Factors of Safety which meets the SRP 3.8.5 acceptance criteria rather than just demonstrating a small displacement. The nonlinear analysis for sliding and overturning needs to consider the effects of both conditions of buoyancy and no buoyancy. An RAI on this topic was previously transmitted to AREVA. Therefore, the response to this RAI should include the above requested information. In addition, it should include a detailed description of the stability evaluation approach and the method for calculating the Factors of Safety for sliding and overturning, and the method used for calculating the soil bearing pressure. It was agreed that the NRC does not need to write another RAI on these items, since AREVA will include the requested information in the response to the existing RAI on this subject.
3. As a result of the review of the NI static model, it became apparent that it did not incorporate the latest revisions made to certain structures. The NI static model needs to be updated to incorporate the current configurations for some of the structures. An example is the revisions made to the Fuel Building. AREVA indicated that they will make the needed updates and these changes will be included in the future revision of the FSAR.
4. When using the seismic equivalent static method, a question arose regarding the use of seismic modification factors to reduce the acceleration values in some cases. AREVA needs to provide an explanation why these seismic modification factors are used and how they are developed. In addition, the technical adequacy for these values should be demonstrated and this information should be described in Section 3.8 of the FSAR. The NRC will prepare a new RAI to address this item.
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7. The NRC staff plans to perform a confirmatory analysis of a selected seismic Category I structure. For this purpose the staff selected the RBIS. During the meeting, discussions were held regarding this confirmatory analysis and the information needed by the NRC from AREVA to perform this analysis. The NRC indicated that they will formally transmit a list containing the specific information needed from AREVA to permit the staff to perform this confirmatory analysis.
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#### Exit Meeting

On Friday, January 30, 2009, the NRC and BNL staff met to summarize the results of the audit in preparation for the exit meeting. The formal exit meeting attended by NRC, BNL, and AREVA staff and management. During the exit meeting, the staff summarized the work performed during the audit, highlights of the results, and the action items for the significant items discussed above.

## ATTACHMENT 1

### AREVA EPR FSAR SECTION 3.8 AUDIT (January 26 – 30, 2009)

#### AGENDA

**Date:** Week of January 26, 2009

**Place:** Charlotte, NC – AREVA Offices

**Subject:** Audit of FSAR Sections 3.8.1 through 3.8.5 – Seismic Category I Structures

#### **Monday**

Start Time: 1:00 PM (Tentative)

Introductions – AREVA & NRC

Purpose of Audit and Discussion of Audit Plan - NRC

Brief Overview of the following items - by AREVA\*:

EPR Design Criteria, Analysis, and Design Type Documents

Details of the tendon system - configuration, design, construction techniques, inservice inspection, and monitoring

Evaluation of the containment ultimate pressure capacity

Evaluation for hydrogen generated design basis loading to meet ASME Service Level C limits

Initiate Staff Review of Project Design Criteria Type Documents\*

Initiate Staff Review of Calculations and Reports Related to:\*\*

##### Nuclear Island Structures

Development of NI structural model – containment, internal structures, reactor shield bldg, fuel bldg., safeguard bldgs., and separate tendon model

Development of loadings to apply to NI structural model

Analysis of NI structure model

##### Other Seismic Category I Structures

Development of structural models for other seismic Category I structures

Development of loadings to apply to structural models

Analysis of structural models

Summary of the day and action items – NRC & AREVA

#### **Tuesday**

Staff Review of Calculations and Reports Related to:

### Nuclear Island Structures

Continue review of related calculations and reports described above on Monday

Thermal Analysis

Design of concrete containment

Design of internal structures

Design of reactor shield building, fuel bldg., safeguard bldgs.

Submodels and analysis for containment penetrations (concrete and steel)

Design Reports

### Other Category I Structures

Continue review of related calculations and reports described above on Monday

Design of emergency power generating bldgs., and essential service water bldgs.

Design Reports

Initiate Discussion of NRC Confirmatory Analysis

Summary of the day and action items – NRC & AREVA

## **Wednesdays**

Staff Review of Calculations and Reports Related to:

### Nuclear Island Structures

Continue review of related calculations and reports described above on Monday

Containment ultimate pressure/thermal capacity calculations/reports

### Other Category I Structures

Continue review of related calculations and reports described above on Monday

Analysis and design of foundations

Complete Discussion of NRC Confirmatory Analysis. Identify and arrange for transfer of information needed by the staff.

Staff Review of Computer Code Validation Packages

Summary of the day and action items – NRC & AREVA

## **Thursday**

Continue Staff Review of Calculations/Reports related to NI structures and other Seismic Category I structures

Discuss RAIs for which AREVA either desires a clarification or wishes feedback on a proposed technical approach.

Summary of the day and action items – NRC & AREVA

## **Friday**

Complete Staff Review of Calculations/Reports related to NI structures and other Seismic Category I structures

Complete Discussion of RAIs

Summary of the day and action items – NRC & AREVA

Exit Meeting

## **NOTES:**

\*It would be useful if a list of the available and final EPR design criteria, calculations for analysis and design, and design reports with a short description (if not evident from the title of the document) is prepared ahead of time.

\*\*It would be most productive if key AREVA personnel who are knowledgeable with the details of the analysis and design are present to answer and/or discuss items that may arise.

## ATTACHMENT 2

Audit EPR DC FSAR Section 3.8  
1/26 - 1/30/09, Areva Offices, Charlotte NC



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### ATTACHMENT 3

Document No./ Revision	Title	Category
114-5061152-008	Plant Technical Requirements for EPR Design Certification	Criteria Document
115-9005578-005	System Design Requirements Document for EPR Standard Plant Structures	Criteria Document
15-5072657-001	System Description Document for EPR Nuclear Island Structural System	Criteria Document
32-9056705-000	US EPR Standard Plant Structural Loads – Accidental Torsion Loads	Loading
32-9011974-001	US EPR Standard Plant Structural Loads – Post-Tensioning Loads	Loading
32-9011970-001	US EPR Standard Plant Structural Loads - Soil Loads	Loading
32-9015773-006	Static Structural Analysis of the EPR Nuclear Island Common Basemat Structure	Analysis
32-9060763-000	Static Analysis and Design of Emergency Diesel Generator Building	Analysis
32-9057206-000	Calculation of Static Spring Values and Distribution for AREVA EPR Nuclear Island Basemat	Analysis
32-9058233-000	Basis for Coefficient of Friction Mat Concrete Soil Interface	Analysis
32-9027301-001	US EPR Standard Plant Structural Analysis - Stability of Reactor Building Internal Structures (RBIS)	Specialty
32-9057320-002	Nuclear Island Nonlinear Analysis for Sliding and Overturning	Specialty
32-9061580-001	US EPR Standard Plant Structural Analysis – Differential Settlement Common Basemat Structure	Specialty
32-9051133-001	US EPR Standard Plant - Probability Safety Analysis for the Ultimate Strength Capacity of the Reactor Containment	Specialty
32-9047968-002	US EPR Standard Plant – Ultimate Capacity Analyses	Specialty
32-9029330-001	US EPR Standard Plant DC Containment Design – Wall to Foundation Connection	Critical Section