AREVA

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Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Information Regarding the U.S. EPR Mass and Energy Release Methodology for Containment Analyses

Ref. 1: E-mail, Getachew Tesfaye (NRC) to Ronda M. Pederson (AREVA NP Inc.), dated January 7, 2008.

To address Questions 2 and 3 in Reference 1, AREVA NP Inc. (AREVA NP) is providing the attached white paper that identifies the U.S. EPR mass and energy release methods for containment analyses and provides a roadmap to approved AREVA NP topical reports used in the analyses.

AREVA NP considers some of the material contained in Attachment A to be proprietary. As required by 10 CFR 2.390(b), an affidavit is enclosed to support the withholding of the information from public disclosure. Attachment B is a non-proprietary version of the white paper.

If you have any questions related to this submittal, please contact Ms. Sandra M. Sloan, Regulatory Affairs Manager for New Plants Deployment. She may be reached by telephone at 434-832-2369 or by e-mail at sandra.sloan@areva.com.

Sincerely,

Ronnie L. Gardner

Ronnie L. Gardner, Manager
Site Operations and Corporate Regulatory Affairs
AREVA NP Inc.

Enclosures

cc: J. Rycyna
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Project 733

D077
NRO

AFFIDAVIT

STATE OF VIRGINIA)
) ss.
COUNTY OF CAMPBELL)

1. My name is Ronda M. Pederson. I am Licensing Manager, Design Certification Project, Regulatory Affairs, New Plants Deployment, for AREVA NP Inc. and as such I am authorized to execute this Affidavit.

2. I am familiar with the criteria applied by AREVA NP to determine whether certain AREVA NP information is proprietary. I am familiar with the policies established by AREVA NP to ensure the proper application of these criteria.

3. I am familiar with the AREVA NP information contained in Attachment A to AREVA NP Letter NRC:08:009, *Information Regarding the U.S. EPR Mass and Energy Release Methodology for Containment Analyses,* dated January 25, 2008, and referred to herein as "Document." Information contained in this Document has been classified by AREVA NP as proprietary in accordance with the policies established by AREVA NP for the control and protection of proprietary and confidential information.

4. This Document contains information of a proprietary and confidential nature and is of the type customarily held in confidence by AREVA NP and not made available to the public. Based on my experience, I am aware that other companies regard information of the kind contained in this Document as proprietary and confidential.

5. This Document has been made available to the U.S. Nuclear Regulatory Commission in confidence with the request that the information contained in this Document be withheld from public disclosure. The request for withholding of proprietary information is made in

accordance with 10 CFR 2.390. The information for which withholding from disclosure is requested qualifies under 10 CFR 2.390(a)(4) "Trade secrets and commercial or financial information".

6. The following criteria are customarily applied by AREVA NP to determine whether information should be classified as proprietary:

(a) The information reveals details of AREVA NP's research and development plans and programs or their results.

(b) Use of the information by a competitor would permit the competitor to significantly reduce its expenditures, in time or resources, to design, produce, or market a similar product or service.

(c) The information includes test data or analytical techniques concerning a process, methodology, or component, the application of which results in a competitive advantage for AREVA NP.

(d) The information reveals certain distinguishing aspects of a process, methodology, or component, the exclusive use of which provides a competitive advantage for AREVA NP in product optimization or marketability.

(e) The information is vital to a competitive advantage held by AREVA NP, would be helpful to competitors to AREVA NP, and would likely cause substantial harm to the competitive position of AREVA NP.

The information in the Document is considered proprietary for the reasons set forth in paragraphs 6(b) and 6(c) above.

7. In accordance with AREVA NP's policies governing the protection and control of information, proprietary information contained in this Document have been made available, on a limited basis, to others outside AREVA NP only as required and under suitable agreement providing for nondisclosure and limited use of the information.

8. AREVA NP policy requires that proprietary information be kept in a secured file or area and distributed on a need-to-know basis.

9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

SUBSCRIBED before me this 25th

day of January 2008.

Kathleen A. Bennett
NOTARY PUBLIC, STATE OF VIRGINIA
MY COMMISSION EXPIRES: 08/31/2011

KATHLEEN ANN BENNETT
Notary Public
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My Commission Expires Aug 31, 2011

U.S. EPR Mass and Energy Release Methods for Containment Analysis

Introduction

The U.S. EPR Final Safety Analysis Report Section 6.2.1 references the AREVA NP Inc. Containment Analysis Topical Report BAW-10252(P)(A) (Reference 5) for the development of the mass and energy release calculations. Section 5.1.2.3 of the topical report describes the methodology for the development of conservative loss of coolant accident (LOCA) mass and energy release. The methodology outlined in topical report BAW-10252(P)(A) is based primarily on NRC-approved Appendix K methods utilizing the RELAP5/MOD2-B&W computer code as described in the following four referenced reports:

1. BAW 10164(P)(A) – RELAP5/MOD2-B&W – An Advanced Computer Program for Light-Water Reactor LOCA and non-LOCA Transient Analysis, Revision 06, September 2007.
2. BAW-10166(P)(A) – BEACH – Best Estimate Analysis Core Heat Transfer, A Computer Program for Reflood Heat Transfer during LOCA, Revision 05, April 2004.
3. BAW-10168(P)(A) – BWNT Loss-of-Coolant Accident Evaluation Model for Recirculating Steam Generator Plants, Revision 03, January 1997.
4. BAW-10192(P)(A) – BWNT Loss-of-Coolant Accident Evaluation Model for Once-Through Steam Generator Plants, Revision 00, July 1998.
5. BAW-10252(P)(A) – Analysis of Containment Response to Postulate Pipe Ruptures Using Gothic, Revision 00, December 2005.

These methods are applicable for the U.S. EPR since they were developed for and benchmarked against tests and plant configurations that closely resemble the U.S. EPR.

In a January 7, 2008 email, the NRC requested additional information that is provided in the following sections regarding the fundamental models and assumptions of RELAP for each of the phases of a LOCA.

Blowdown Phase

During reactor coolant system (RCS) blowdown the U.S. EPR core heat transfer is modeled by the RELAP5/MOD2-B&W computer code (Reference 1) with certain modifications based on Section 5.1.2.3.1 of (Reference 5) to maximize the rate at which the core stored energy is transferred into the containment. The LOCA mass and energy release rate calculations utilizes the RELAP5/MOD2-B&W code exclusively to calculate the transient progression for the blowdown, refill, and the reflood periods. The RELAP5/MOD2-B&W code package includes both the system blowdown and core heat transfer models and the core refill and reflood heat transfer models described in the BEACH topical report (Reference 2). The BEACH heat transfer models contained in the RELAP5/MOD2-B&W code were approved by the NRC for use in licensing calculations in Reference 2.

Refill Phase

The approved AREVA NP Inc. containment analysis methodology described in Reference 5 uses techniques to shorten the lower plenum refill time. The LOCA mass and energy release methodology presented in Section 5.1.2.3.1 stipulates that [

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Reflood Phase

SRP 6.2.1.3 indicates that the calculation of liquid entrainment should be based on the PWR FLECHT experiments and that the steam quenching should be justified by comparison with applicable experimental data. [

] Detailed FLECHT-SEASET benchmark results are available in Appendix G of Reference 2. While BEACH was effectively benchmarked to the FLECHT data, the M&E calculations move a portion of the accumulator injection to the reactor vessel (RV) lower plenum to decrease the ECCS bypass fraction and increase the effective flooding rate beyond what would be predicted if the accumulator injection location was not modified. Modeling free spinning RCP rotors also helps increase the reflooding rate. Higher flooding rates quench the core faster and provide the potential to get the core stored energy in the containment faster. Less ECCS bypass refills the RV faster and the higher flooding rates can also remove stored energy from the steam generators faster.

SRP 6.2.1.3 indicates that for cold leg breaks the steam leaving the steam generators (SG) should be assumed to be superheated to the temperature of the secondary coolant. For non-mechanistic calculations, this assumption is appropriate to provide conservative results. However, the current LOCA models mechanistically consider the heat transfer through the SG tubes from the secondary side to the primary fluid using approved correlations that have been benchmarked to test data. These models predict superheated steam at the exit of the steam generator. [

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Post Reflood Phase

The RELAP5/MOD2 computer code includes options for modeling core level swell. The mass and energy release rates for the U.S. EPR included the RELAP5/MOD2-B&W slug drag model which was benchmarked to the Wilson Drag Model in Appendix H of Reference 1 to support the core void distribution and the prediction of core level swell. These benchmarks included comparisons to the NRC-approved FOAM2 code and with small break LOCA experiments performed at the Oak Ridge National Laboratory (ORNL) Thermal-Hydraulic Test Facility (THTF). These benchmarks showed that RELAP5 accurately predicted the void fractions in the mixture region and the cladding temperatures in the steam region based on the ORNL data.

Furthermore, the cold leg piping was modeled in RELAP using non-homogeneous junctions and non-equilibrium control volumes. During the long-term phase, these volumes can predict horizontal stratification. The condensation in the cold leg can be under-predicted in this environment, however, when the subcooled liquid reaches the core, it reduces the core steaming rates. Any effect of lower condensation rates in the cold leg is short-lived which results in a slight timing shift of the break energy release in a non-critical period of the M&Es. For a cold leg break, the lower condensation can result in short-term higher steam release rates to the containment.