AREVA

November 12, 2014
NRC:14:060

U.S. Nuclear Regulatory Commission
Document Control Desk
11555 Rockville Pike
Rockville, MD 20852

10 CFR 50.46 Annual Report for the U.S. EPR Design Certification

Ref. 1: Letter, Sandra M. Sloan (AREVA NP Inc.) to Document Control Desk (NRC), "Application for Standard Design Certification of the U.S. EPR (Project No. 733)," NRC:07:070, December 11, 2007.

Ref. 2: Letter, Getachew Tesfaye (NRC) to Sandra M. Sloan (AREVA NP Inc.), "AREVA NP Inc. – Acceptance of the Application for Standard Design Certification of the U.S. EPR," February 25, 2008.

Ref. 3: Letter, Pedro Salas (AREVA NP Inc.) to Document Control Desk (NRC), "10 CFR 50.46 Report for the U.S. EPR Design Certification," NRC:13:083, November 26, 2013.

Ref. 4: Letter, Pedro Salas (AREVA Inc.) to Document Control Desk (NRC), "10 CFR 50.46 30 Day Report for the U.S. EPR Design Certification," NRC:14:013, March 28, 2014.

AREVA Inc. (AREVA) submitted the application for a Standard Design Certification of the U.S. EPR design in Reference 1. The NRC accepted the application for review in Reference 2. In accordance with 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light Water Reactors," AREVA is submitting this annual report of the emergency core cooling system (ECCS) evaluation model changes and errors for the U.S. EPR Standard Design (Docket 52-020). The previous annual report was submitted in Reference 3 and a 30 day report was provided in Reference 4.

This report addresses two evaluation models: one for the small break loss of coolant accident (SBLOCA) and one for the large break loss of coolant accident (LBLOCA). The summary of the changes and error corrections made between October 1, 2013 and September 30, 2014 for the LBLOCA evaluation model is provided in Attachment A. The summary of the changes and error corrections made between October 1, 2013 and September 30, 2014 for the SBLOCA evaluation model is provided in Attachment B.

The information included in this letter is generic and applies to all Combined License (COL) applications referencing the U.S. EPR Design Certification as of the date of this letter. The COL applicants are hereby

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notified (by copy of this letter) of the changes and errors in the U.S. EPR evaluation models as required by 10 CFR 50.46(a)(3)(iii).

If you have any questions related to this submittal please contact Ms. Gayle F. Elliott, Product Licensing Manager, by telephone at 434-832-3347 or by e-mail at Gayle.Elliott@areva.com.

Sincerely,

Pedro Salas, Director
Regulatory Affairs
AREVA Inc.

cc: J. P. Segala
G. F. Wunder
Docket 52-020

Attachment A:
Large Break Loss of Coolant Accident (LBLOCA) Evaluation Model

A report of changes and errors in the LBLOCA evaluation model (EM) for the period of October 1, 2013 to September 30, 2014 is presented below.

The NRC-approved LBLOCA evaluation model for the U.S. EPR design is ANP-10278PA, Revision 1.

1. The U.S. EPR has an axial economizer in the secondary side of the steam generator (SG) which partitions the downcomer into two sides. At power, the main feedwater (MFW) injects solely onto the cold side (downside) of the SG tube bundle, establishing a recirculation pattern in the SG in which more of the recirculated flow from the separator goes to the hot side. In order to obtain that flow distribution in the S-RELAP5 SG model, k-factors are adjusted in some of the junctions. A split downcomer was also modeled.

   It was concluded in 2011 that this modeling resulted in a non-physical circulation pattern in the bundle region of SG following reactor trip and termination of MFW. An adjustment was made to change the loss coefficients in the SG downcomer to reduce the non-physical behavior. This change was reported for 2011 in Reference A1.

   In late 2013, the U.S. EPR project became aware (through European colleagues) that experimental information existed which demonstrated that the original flow pattern (which was thought in 2011 to be non-physical) was correct. The previous adjustment (in 2011) to the loss coefficients has been reversed.

The estimated impact of this change on the LBLOCA analyses for the U.S. EPR plant is +79°F on the calculated peak cladding temperature. This is a reversal of the original PCT impact assessment made in 2011 (Reference A1).

2. It was found that the correlation for vapor absorptivity used in S-RELAP5 was being applied outside of its intended range of applicability (no limit on the pressure at which the correlation was applied).

   The equation used for the absorption coefficient of vapor contains the term of the pressure which needs to be truncated in order to obtain the correct emissivity values for an optically thick steam. No lower pressure limit on the vapor absorptivity correlation is required as the correlation is developed for optically thin gases, which already applies at low pressures.

   Results show that limiting the vapor absorptivity correlation to within its intended pressure range allows S-RELAP5 to predict the wall temperatures for Thermal-Hydraulic Test Facility (THTF) within the uncertainty bands or above the uncertainty bands (conservative).

   For RLBLOCA, single phase steam only exists for a very limited time just before the beginning of reflood. During the majority of the blowdown phase and during the entire reflood phase, which are the important RLBLOCA phases, the core is in a dispersed flow regime. The S-RELAP5 methodology uses the FLECHT-SEASET reflood tests to determine the heat transfer bias and uncertainty under these conditions. In addition, the transient progression is very quick and the system depressurizes in the first few seconds after the break opening. Due to the fast depressurization, the amount of time that the correlation for vapor absorptivity used in RLBLOCA is applied outside of the range of applicability is limited and therefore the results predicted in the FSAR remain valid.

The correction for the vapor absorptivity correlation was incorporated into the S-RELAP5 code. The estimated impact of this change on the LBLOCA analyses for the U.S. EPR plant is +0°F on the calculated peak cladding temperature.

3. In RLBLOCA, the axial power shapes are mapped to the number of heat structure nodes and elevation points required by S-RELAP5. The mapping procedure currently used is called modal decomposition and it uses a set of orthogonal sine functions to perform the mapping.

   A recent evaluation of the modal decomposition method led to a detailed examination of the actual axial shapes that were produced by the mapping procedure and it was initially observed that some of these resulting shapes were significantly different from the shape that was generated. These shapes may exhibit a superimposed oscillation created by the modal decomposition that leads to non-physical artificial local peaks and valleys in the shape. When such shapes are generated and used in the LOCA analyses they tend to shift the PCT location and also alter the PCT values from what would normally occur. In general, the evaluation of the modal decomposition method led to the conclusion that in future application of ANP-10278P, the modal decomposition method will not be used and a linear interpolation will be used for the mapping instead.

The evaluation for the set of cases and axial shapes applied to the U.S. EPR LBLOCA FSAR analysis shows that the axial shapes mapped using modal decomposition provide a good fit compared to the input (pre-mapped) axial shapes. Therefore, the LBLOCA FSAR analysis remains valid and the estimated impact of this change on the LBLOCA analyses for the U.S. EPR plant is +0°F on the calculated peak cladding temperature.

Ref. A1: Letter, Sandra M. Sloan (AREVA NP Inc.) to Document Control Desk (NRC), "10 CFR 50.46 Report for the U.S. EPR Design Certification," NRC:11:119, December 16, 2011.

Ref. A2: Letter, Pedro Salas (AREVA Inc.) to Document Control Desk (NRC), "10 CFR 50.46 30 Day Report for the U.S. EPR Design Certification," NRC:14:013, March 28, 2014.

Table A1 LBLOCA Margin Summary Sheet – Annual Report

Plant Name: U.S. EPR Standard Design Certification

Evaluation Model: RLBLOCA (ANP-10278PA Revision 1)

Initial Peak Cladding Temperature (PCT) = 1695°F

			Net PCT Effect	Absolute PCT Effect
A.	Prior 10 CFR 50.46 Changes or Error Corrections – previous Years	ΔPCT =	+28°F	+196[1]°F
B	Current 10 CFR 50.46 Changes – This Report			
	Steam Generator Loss Coefficient at low power[2]	ΔPCT =	+79°F	+79°F
	Correlation for vapor absorptivity	ΔPCT =	+0°F	+0°F
	Non-physical axial power shapes	ΔPCT =	+0°F	+0°F
	Sum of 10 CFR 50.46 Changes for this Reporting Period	ΔPCT =	+79°F	+79°F
	Estimate of PCT including changes and errors	=	1802°F	

The sum of the PCT from the most recent analysis using an acceptable evaluation model and the estimates of PCT impact for changes and errors identified since this analysis is less than 2200°F.

[1] This value was inadvertently reported as 186 in Reference A2.
[2] This error correction was previously reported in a 30 day report, Reference A2.

Attachment B
Small Break Loss of Coolant Accident (SBLOCA) Evaluation Model

A report of changes and errors in the SBLOCA evaluation model (EM) for the period of October 1, 2013 to September 30, 2014 is presented below.

The SBLOCA evaluation model for the U.S. EPR design is described in the topical report ANP-10263PA and in the topical report EMF-2328PA. The primary computer code in the SBLOCA evaluation model is S-RELAP5.

The non-physical axial power shapes error (discussed in Attachment A for LBLOCA) does not apply to SBLOCA.

1. The U.S. EPR has an axial economizer in the secondary side of the steam generator (SG) which partitions the downcomer into two sides. At power, the main feedwater (MFW) injects solely onto the cold side (downside) of the SG tube bundle, establishing a recirculation pattern in the SG in which more of the recirculated flow from the separator goes to the hot side. In order to obtain that flow distribution in the S-RELAP5 SG model, k-factors are adjusted in some of the junctions. A split downcomer was also modeled.

   It was concluded in 2011 that this modeling resulted in a non-physical circulation pattern in the bundle region of SG following reactor trip and termination of MFW. An adjustment was made to change the loss coefficients in the SG downcomer to reduce the non-physical behavior. This change was reported for 2011 in Reference B1.

   In late 2013, the U.S. EPR project became aware (through European colleagues) that experimental information existed which demonstrated that the original flow pattern (which was thought in 2011 to be non-physical) was correct. The previous adjustment (in 2011) to the loss coefficients has been reversed.

The estimated impact of this change on the SBLOCA analyses for the U.S. EPR plant is +108°F on the calculated peak cladding temperature. This is a reversal of the original PCT impact assessment made in 2011 (Reference B1 and as modified in Reference B2).

2. It was found that the correlation for vapor absorptivity used in S-RELAP5 was being applied outside of its intended range of applicability (no limit on the pressure at which the correlation was applied).

   The equation used for the absorption coefficient of vapor contains the term of the pressure which needs to be truncated in order to obtain the correct emissivity values for an optically thick steam. No lower pressure limit on the vapor absorptivity correlation is required as the correlation is developed for optically thin gases, which already applies at low pressures.

   Results show that limiting the vapor absorptivity correlation to within its intended pressure range allows S-RELAP5 to predict the wall temperatures for THTF within the uncertainty bands or above the uncertainty bands (conservative).

The correction for the vapor absorptivity correlation was incorporated into the S-RELAP5 code. The estimated impact of this change on the SBLOCA analyses for the U.S. EPR plant is +20°F on the calculated peak cladding temperature.

Ref. B1: Letter, Sandra M. Sloan (AREVA NP Inc.) to Document Control Desk (NRC), "10 CFR 50.46 Report for the U.S. EPR Design Certification," NRC:11:119, December 16, 2011.

Ref. B2: Letter, Pedro Salas (AREVA NP Inc.) to Document Control Desk (NRC), "10 CFR 50.46 Report for the U.S. EPR Design Certification," NRC:12:059, November 30, 2012.

Ref. B3: Letter, Pedro Salas (AREVA Inc.) to Document Control Desk (NRC), "10 CFR 50.46 30 Day Report for the U.S. EPR Design Certification," NRC:14:013, March 28, 2014.

Table B1 SBLOCA Margin Summary Sheet – Annual Report

Plant Name: U.S. EPR Standard Design Certification

Evaluation Model: SBLOCA (ANP-10263PA and EMF-2328PA)

Initial Peak Cladding Temperature (PCT) = 1638°F

			Net PCT Effect	Absolute PCT Effect
A.	Prior 10 CFR 50.46 Changes or Error Corrections – previous Years	ΔPCT =	-126°F	+138°F
B	Current 10 CFR 50.46 Changes – This Report			
	Steam Generator Loss Coefficient at low power[1]	ΔPCT =	+108°F	+108°F
	Correlation for vapor absorptivity	ΔPCT =	+20°F	+20°F
	Sum of 10 CFR 50.46 Changes for this Report	ΔPCT =	+128°F	+128°F
	Estimate of PCT including changes and errors	=	1640°F	

The sum of the PCT from the most recent analysis using an acceptable evaluation model and the estimates of PCT impact for changes and errors identified since this analysis is less than 2200°F.

[1] This correction was previously provided in a 30-day report (Reference B3).