AREVA

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NRC:12:059

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

10 CFR 50.46 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, 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.

AREVA NP Inc. (AREVA NP) submitted its application for a Standard Design Certification of the U.S. EPR in Reference 1. The NRC accepted the application for review in Reference 2 and assigned Docket Number 52-020 to the application.

In accordance with 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light Water Reactors," AREVA NP is submitting this report of the emergency core cooling system (ECCS) evaluation model changes and errors for the U.S. EPR Standard Design. The previous annual report was submitted in Reference 3.

This report is made in accordance with 10 CFR 50.46 for the U.S. EPR (Docket 52-020). The 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 errors made between October 1, 2011 and September 30, 2012 for the LBLOCA evaluation model is provided in Attachment A. The summary of the changes and errors made between October 1, 2011 and September 30, 2012 for the SBLOCA evaluation model is provided in Attachment B.

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

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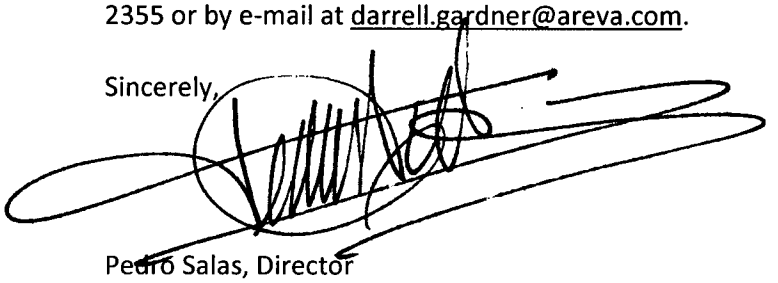
NRO

AREVA NP INC.
An AREVA and Siemens company

3315 Old Forest Road, P.O. Box 10935, Lynchburg, VA 24506-0935
Tel.: (434) 832-3000 - Fax: (434) 832-3840

If you have any questions related to this information, please contact Darrell Gardner by telephone at (704) 805-2355 or by e-mail at darrell.gardner@areva.com.

Sincerely,



Pedro Salas, Director
Regulatory Affairs
AREVA NP Inc.

Enclosures

cc: A. Snyder
Docket No. 52-020

Attachment A

Large Break Loss of Coolant Accident (LBLOCA) Evaluation Model

A report of changes and errors in the LBLOCA evaluation model for the period of October 1, 2011 to September 30, 2012 is presented below.

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

1. The Sleicher-Rouse correlation is one of the correlations used to define the heat transfer between the fuel and coolant. This correlation is applicable to both Large and Small Break analyses performed with the S-RELAP5 computer code.

   The error relates to the form of the equation calculating the exponent of the temperature ratio correction term. The Sleicher-Rouse correlation is derived from Reference 1, equation number (12).

   The form previously coded in S-RELAP5:

   $$Nu_b = 5 + 0.012*Re_b^{0.83} * (Pr_b + 0.29)*(T_w/T_b)^n \quad \text{with}$$

   $$n = - log_{10}(T_w/T_b)^{1/4} + 0.3 \qquad \textit{(Form A)}$$

   The alternative form:

   $$Nu_b = 5 + 0.012*Re_b^{0.83} * (Pr_b + 0.29)*(T_w/T_b)^n \quad \text{with}$$

   $$n = -[log_{10}(T_w/T_b)]^{1/4} + 0.3 \qquad \textit{(Form B)}$$

   The alternative form is more consistent with other heat transfer correlations, like equation (6-168) of Reference 2, and expected physical trends.

   The alternative form of the Sleicher-Rouse correlation has been incorporated into the S-RELAP5 code. The estimated impact of this change on the LBLOCA analyses for the U.S. EPR plant is +40 °F on the calculated peak cladding temperature.

2. In realistic large break loss of coolant accident (RLBLOCA) analyses, energy released through the oxidation of cladding is calculated from the Cathcart-Pawel correlation for oxide growth (Reference 3, Equation A2). The correlation has the form:

$$\delta^2/2 = A * exp(-Q/R*1/T)$$

where A and Q are experimentally determined constants and R and T are the gas constant and temperature, respectively. The uncertainty parameter for the A value is given in terms of the natural logarithm: ln(A). The value of ln(A) follows a normal distribution and the value of A follows a log-normal distribution. RLBLOCA applications implement the Cathcart-Pawel uncertainty using a log-normal function for the uncertainty multiplier, B, applied to a constant, A. The equation to determine the uncertainty multiplier, B, was determined to be incorrect.

However, the incorrect equation still has a log-normal distribution like the corrected equation for the uncertainty multiplier, B. In addition, the range of sampled values for B falls within the range expected for the corrected equation for the uncertainty multiplier, B. The estimated impact of this change on the LBLOCA analyses for the U.S. EPR design is +0°F on the calculated peak cladding temperature.

References

1. C. A. Sleicher and M. W. Rouse, "A Convenient Correlation for Heat Transfer to Constant and Variable Property Fluids in Turbulent Pipe Flow," International Journal of Heat and Mass Transfer, 18, pp. 677-683, 1975.

2. USNRC Document, "TRACE V5.0 Theory Manual - Field Equations, Solution Methods, and Physical Models," ADAMS Number ML120060218.

3. J.V. Cathcart and R.E. Pawel, "Zirconium Metal-Water Oxidation Kinetics: IV. Reaction Rate Studies," ORNL/NUREG-17, August 1977.

Table A1 LBLOCA Margin Summary Sheet – Annual Report

Plant Name: U.S. EPR Standard Design Certification

Evaluation Model: RLBLOCA (ANP-10278P, 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	+140°F
B.	Current 10 CFR 50.46 Changes: - This Report			
	1 S-RELAP5 Sleicher-Rouse correlation	ΔPCT =	+40°F	+40°F
	2 Cathcart-Pawel uncertainty implementation	ΔPCT =	+0°F	+0°F
	Sum of 10 CFR 50.46 Changes for this Reporting Period	ΔPCT =	+40°F	+40°F

Estimate of PCT including changes and errors = 1707°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.

The sum of the absolute values of the errors is less than 50°F for this reporting period (October 1, 2011 to September 30, 2012).

Attachment B

Small Break Loss of Coolant Accident (SBLOCA) Evaluation Model

A report of changes and errors in the SBLOCA evaluation model for the period of October 1, 2011 to September 30, 2012 is presented below.

The SBLOCA evaluation model for the U.S EPR 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 Sleicher-Rouse correlation is one of the correlations used to define the heat transfer between the fuel and coolant. This correlation is applicable to both Large and Small Break analyses performed with the S-RELAP5 computer code.

The error relates to the form of the equation calculating the exponent of the temperature ratio correction term. The Sleicher-Rouse correlation is derived from Reference 1, equation number (12).

The S-RELAP5 form is

$$Nu_b = 5 + 0.012*Re_b^{0.83} * (Pr_b + 0.29)*(T_w/T_b)^n \quad \text{with}$$

$$n = - log_{10}(T_w/T_b)^{1/4} + 0.3 \qquad \textit{(Form A)}$$

The alternative form used in other industry codes is:

$$Nu_b = 5 + 0.012*Re_b^{0.83} * (Pr_b + 0.29)*(T_w/T_b)^n \quad \text{with}$$

$$n = -[log_{10}(T_w/T_b)]^{1/4} + 0.3 \qquad \textit{(Form B)}$$

The alternative form is more consistent with other heat transfer correlations, like correlation (6-168) of Reference 2, and expected physical trends.

The alternative form of the Sleicher-Rouse correlation has been incorporated into the S-RELAP5 code. The estimated impact of this change on the SBLOCA analyses for the U.S. EPR plant is -2°F on the calculated peak cladding temperature.

References

1. C. A. Sleicher and M. W. Rouse, "A Convenient Correlation for Heat Transfer to Constant and Variable Property Fluids in Turbulent Pipe Flow," International Journal of Heat and Mass Transfer, 18, pp. 677-683, 1975.

2. USNRC Document, "TRACE V5.0 Theory Manual - Field Equations, Solution Methods, and Physical Models," ADAMS Number ML120060218.

Table B1 SBLOCA Margin Summary Sheet – Annual Report

Plant Name: U.S. EPR Standard Design Certification

Evaluation Model: SLBLOCA (ANP-10263PA and EMF-2638PA)

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 (see note below)	ΔPCT =	- 124°F	+136°F
B	Current 10 CFR 50.46 Changes – This Report			
	S-RELAP5 Sleicher-Rouse correlation	ΔPCT =	-2°F	+2°F
	Sum of 10 CFR 50.46 Changes for this Reporting Period	ΔPCT =	-2°F	+2°F

Estimate of PCT including changes and errors = 1512°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.

The sum of the absolute values of the errors is less than 50°F for this reporting period (October 1, 2011 to September 30, 2012).

Note: The SG recirculation error reported in the previous annual report was incorrectly estimated at -124°F. The correct value is -108°F. An additional adjustment of +2°F has been made to the prior 10 CFR 50.46 changes in order to match the current calculation result.