AREVA

January 23, 2009
NRC:09:003

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

Additional Information in Support of NRC Confirmatory Analysis Regarding the U.S. EPR Leak-Before-Break (LBB) Methodology

Ref. 1: Letter, Sandra M. Sloan (AREVA NP Inc.) to Document Control Desk (NRC), "Presentation Materials from the NRC – AREVA NP Audit regarding the U.S. EPR Leak-Before-Break (LBB) Methodology," NRC:08:049, July 2, 2008 (ML081900623).

2. Letter, Sandra M. Sloan (AREVA NP Inc.) to Document Control Desk (NRC), "Response to U.S. EPR Design Certification Application RAI No. 48," NRC:08:072, September 18, 2008 (ML082680039).

3. Letter, Sandra M. Sloan (AREVA NP Inc.) to Document Control Desk (NRC), "Response to U.S. EPR Design Certification Application RAI No. 48, Supplement 1," NRC:08:089, November 7, 2008 (ML083170589).

4. Letter, Sandra M. Sloan (AREVA NP Inc.) to Document Control Desk (NRC), "Additional Information in Support of NRC Confirmatory Analysis Regarding the U.S. EPR Leak-Before-Break (LBB) Methodology," NRC:08:101, December 18, 2008 (ML083170589).

On June 26, 2008, AREVA NP Inc. (AREVA NP) supported an audit with NRC staff regarding the U.S. EPR Leak-Before-Break (LBB) methodology described in U.S. EPR FSAR Tier 2, Section 3.6.3. Presentation materials from this audit were provided to the NRC in Reference 1. At this audit, the NRC indicated they would be performing a confirmatory analysis of the U.S. EPR LBB methodology. Additional information in support of this confirmatory analysis was provided to NRC in References 2, 3, and 4. Based on a conference call with the NRC on January 8, 2009, AREVA NP is providing the following additional information to support the NRC confirmatory analysis:

- Screen shots of the input parameters using the EPRI PICEP Code, Revision 4, for the U.S. EPR surge line (SL) (Attachment 1).
- A figure of bending moment versus crack length comparing the results from the AREVA NP KRAKFLO code to the EPRI PICEP code and SQUIRT code (Attachment 2).
- Sample input and output files for the EPRI PICEP Code, Revision 4, for the SL (provided as separate files in the attached CD). Please use "Notepad" to open these files.
- Test stress-strain data for the flaw stability analysis for the SA-106 Grade C carbon steel material and for the 304 stainless steel base and weld metal (Attachment 3).

AREVA NP considers some of the material contained in the enclosure to be proprietary. As required by 10 CFR 2.390(b), an affidavit is enclosed to support the withholding of the

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information from public disclosure. Proprietary and non-proprietary versions of the attachments are provided on the enclosed CDs.

If you have any questions related to this submittal, please contact me by telephone at 434-832-2369 or by e-mail at sandra.sloan@areva.com.

Sincerely,

Sandra M. Sloan

Sandra M. Sloan, Manager
New Plants Regulatory Affairs
AREVA NP Inc.

Enclosures

cc: G. Tesfaye
Docket No. 52-020

AFFIDAVIT

COMMONWEALTH OF VIRGINIA)
) ss.
COUNTY OF CAMPBELL)

1. My name is Ronda M. Pederson. I am Licensing Manager, U.S. EPR Design Certification, Regulatory Affairs for New Plants 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 *Additional Information in Support of NRC Confirmatory Analysis Regarding the U.S. EPR Leak-Before-Break (LBB) Methodology,* 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.

[signature]

SUBSCRIBED before me this 23rd

day of January 2009.

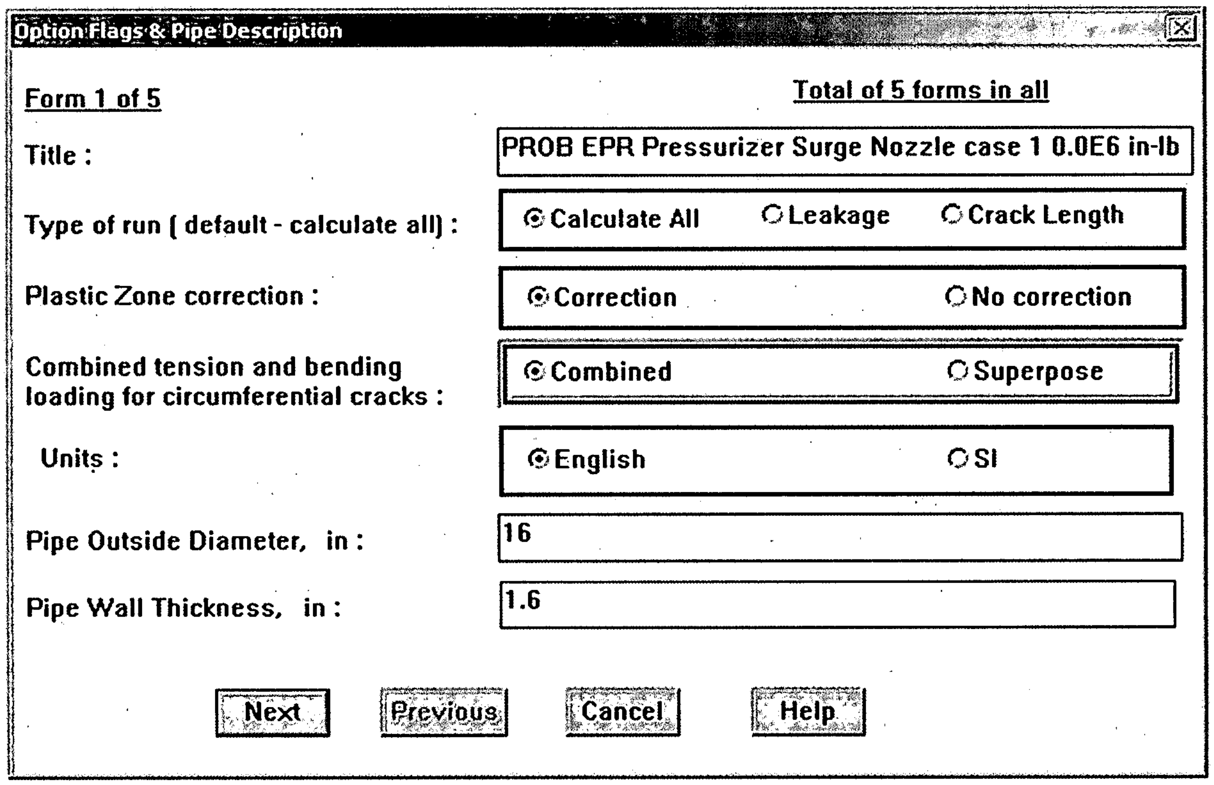
[signature]

Kathleen A. Bennett
NOTARY PUBLIC, COMMONWEALTH OF VIRGINIA
MY COMMISSION EXPIRES: 8/31/2011

KATHLEEN ANN BENNETT
Notary Public
Commonwealth of Virginia
110864
My Commission Expires Aug 31, 2011

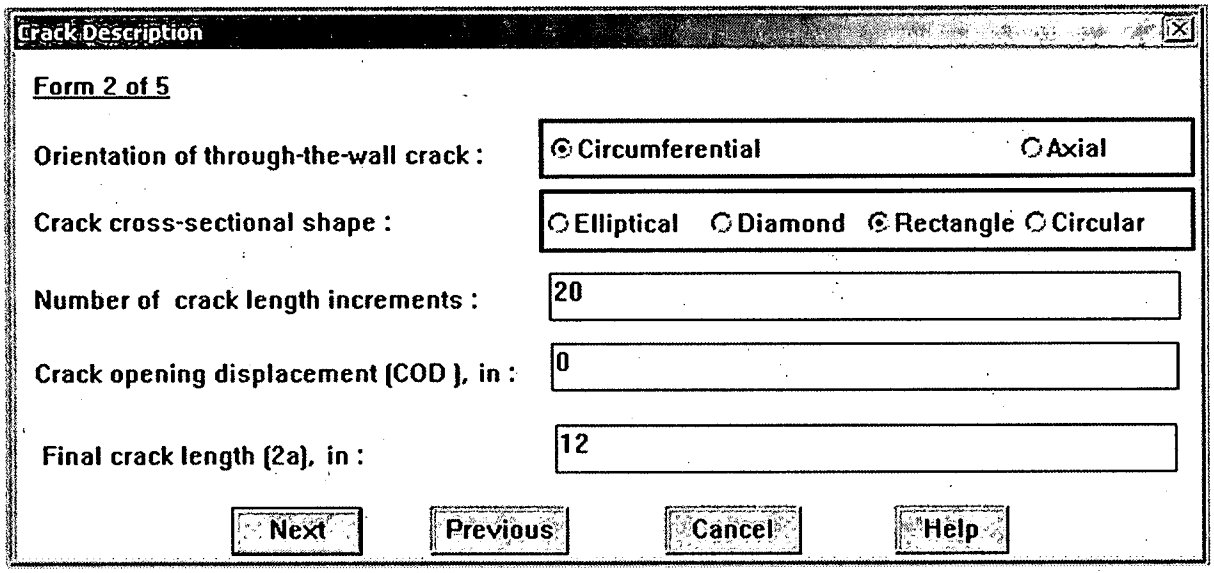
EPRI PICEP Code Screen Shot Input Parameters for the U.S. EPR SL

Input Screen 1



EPRI PICEP Code Screen Shot Input Parameters for the U.S. EPR SL

Input Screen 2



Crack Description

Form 2 of 5

Orientation of through-the-wall crack : ⦿ Circumferential ○ Axial

Crack cross-sectional shape : ○ Elliptical ○ Diamond ⦿ Rectangle ○ Circular

Number of crack length increments : 20

Crack opening displacement (COD), in : 0

Final crack length (2a), in : 12

Next Previous Cancel Help

EPRI PICEP Code Screen Shot Input Parameters for the U.S. EPR SL

Input Screen 3

Material Description

Form 3 of 5

Young's elastic modulus , psi :	2.5e+007
Yield stress , psi :	18000
Yield Strain :	0
Ramberg-Osgood coefficient alpha :	0
Ramberg-Osgood exponent n :	5.08
Flow stress , psi :	50000
Critical crack length Z correction factor :	0
Safety factor for critical crack length :	0

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EPRI PICEP Code Screen Shot Input Parameters for the U.S. EPR SL

Input Screen 4

Fluid Conditions and Pipe Loading

Form 4 of 5

Fluid Parameter :

- ○ Initially saturated liquid (stag temp. below)
- ○ Initially satuated liquid (stag pressure below)
- ◉ Initially subcooled liquid, pressure and temp
- ○ Wet steam, pressure and quality
- ○ Superheated steam, pressure and temp.

Fluid stagnation pressure , psi :	2250
Stagnation temperature , F :	654
Steam quality:	654
External pressure , psi :	14.7
Pipe (non pressure) axial load, Pound Force :	0
Pipe bending moment , inch-pound :	0
Primary axial stress , psi :	0
Primary bending stress, psi :	0

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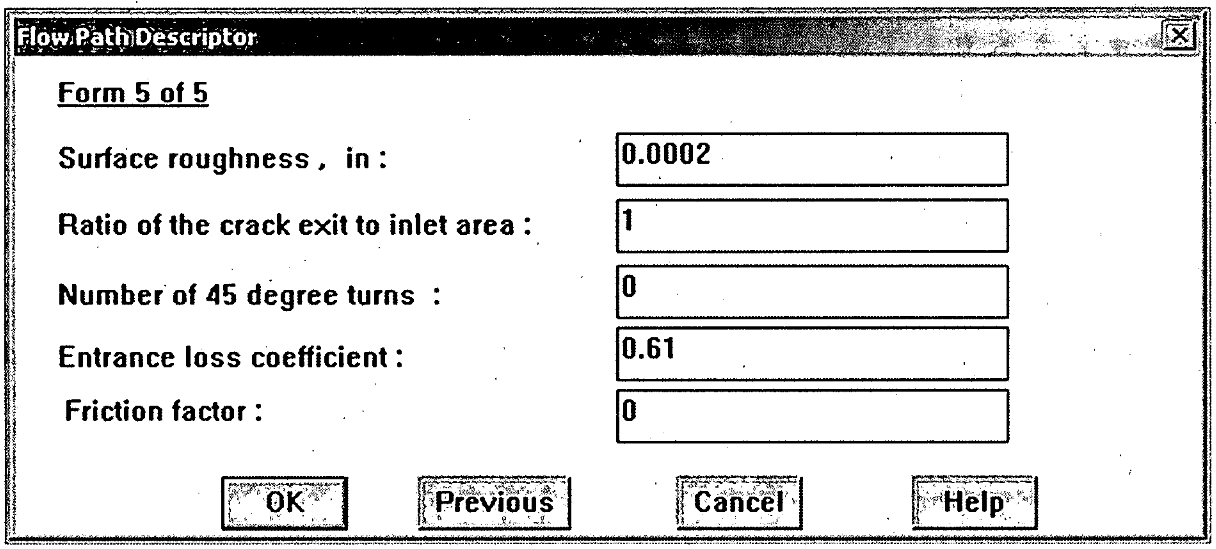
EPRI PICEP Code Screen Shot Input Parameters for the U.S. EPR SL

Input Screen 5



EPRI PICEP Code Screen Shot Input Parameters for the U.S. EPR SL

Sample Output Screen

	CRACK LENGTH in.	(THETA/PI)	COD in.	fL/D	LEAK FLOW RATE GPM @ 200 F	CHOKED
1	.6000	(.0133)	.000183	1446.6	.0021	YES
2	1.2000	(.0265)	.000377	404.3	.0159	YES
3	1.8000	(.0398)	.000582	193.0	.0524	YES
4	2.4000	(.0531)	.000798	115.8	.1220	YES
5	3.0000	(.0663)	.001025	78.2	.2349	YES
6	3.6000	(.0796)	.001264	56.7	.4020	YES
7	4.2000	(.0928)	.001516	43.1	.6355	YES
8	4.8000	(.1061)	.001783	33.9	.9488	YES
9	5.4000	(.1194)	.002068	27.2	1.3583	YES
10	6.0000	(.1326)	.002375	22.3	1.8832	YES
11	6.6000	(.1459)	.002707	18.5	2.5470	YES
12	7.2000	(.1592)	.003069	15.4	3.3784	YES
13	7.8000	(.1724)	.003467	13.0	4.4125	YES
14	8.4000	(.1857)	.003906	11.0	5.6918	YES
15	9.0000	(.1989)	.004394	9.3	7.2677	YES
16	9.6000	(.2122)	.004938	7.9	9.2020	YES
17	10.2000	(.2255)	.005548	6.7	11.5678	YES
18	10.8000	(.2387)	.006233	5.7	14.4513	YES
19	11.4000	(.2520)	.007005	4.9	17.9527	YES
20	12.0000	(.2653)	.007876	4.2	22.1868	YES

(THETA/PI) IS THE NORMALIZED CRACK HALF ANGLE

1

OK

Results from KRAKFLO Compared to the Results from the PICEP and SQUIRT Codes

Flaw Stability Analysis Test Stress-Strain Data

SA-106 Grade C Material

Table A3-1 provides the stress-strain data for SA-106 Grade C material. The Ramberg-Osgood fit for this data (using $\alpha = 1.48$ and $n = 5.08$) is provided in Figure A3-1.

304 Stainless Steel Base and Weld Metal

Tensile specimens were extracted from the weld materials and base materials of the pipe coupons, as shown in Table A3-2. The tensile specimens were tested in accordance with ASTM E21-05. The tensile test results are summarized in Table A3-3 for the welds and Table A3-4 for the base metals. As expected, the yield and ultimate stress show a decrease with an increase in test temperature. The results are provided in Figure A3-2 for the weld samples and Figure A3-3 for the base metal tests. The engineering stress-strain data are provided in Table A3-5 for weld metal and Table A3-6 for base metal. Thermal aging effect on tensile properties will increase the yield and ultimate strengths; therefore, this data is conservative.

The true stress and true strain values were calculated from the engineering stress and engineering strain data as follows:

$$\sigma = S(1 + e)$$
$$\varepsilon = \ln(1 + e)$$

where:
σ = true stress
ε = true strain
S = engineering stress from the tensile test data
e = engineering strain from the tensile test data

The calculation of the true stress-strain curve was performed up to the ultimate stress since this relationship is invalid beyond the ultimate stress where the specimen begins to converge (i.e., neck). The true stress-strain curves are provided in Figure A3-4 and Figure A3-5. The true stress-strain data are provided in Table A3-7 for weld metal and Table A3-8 for base metal.

The following Ramberg-Osgood equation was fit to the base metal and weld metal lower bound true stress-true strain curves. The Ramberg-Osgood fitting parameters were determined by minimizing the sum of the errors squared (least-squares fit) of the data points about the fitted curve.

$$\frac{\varepsilon}{\varepsilon_0} = \frac{\sigma}{\sigma_0} + \alpha\left(\frac{\sigma}{\sigma_0}\right)^n$$

Where:
σ_0 is the reference stress which was fixed at the yield stress
ε_0 is the reference strain or yield strain
n, α are Ramberg-Osgood fitting parameters.
n was limited to a range of 1 to 7

To get a better fit to the tensile curve, different Ramberg-Osgood fits were made to the low strain region (from where the curve deviates from elastic response to about 2%) and the mid strain region (about 2% strain to about 10%) separately. Figure A3-6 and Figure A3-7 show the lower-bound true stress-strain curves with the two Ramberg-Osgood fits. Table A3-9 lists the Ramberg-Osgood parameters for the applicable strain ranges.

Table A3-1—Stress-Strain Data for SA-106 Grade C Material

Table A3-1—Stress-Strain Data for SA-106 Grade C Material

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Table A3-2—Tensile Test Matrix

Table A3-3—Tensile Test Results Summary for Welds

Table A3-4—Tensile Test Results Summary for Base Metals

Table A3-5—Unaged Engineering Stress-Strain Data for the Weld Metals

Table A3-5—Unaged Engineering Stress-Strain Data for the Weld Metals

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Table A3-6—Unaged Engineering Stress-Strain Data for the Base Metals

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Table A3-6—Unaged Engineering Stress-Strain Data for the Base Metals

Table A3-7—Unaged True Stress-Strain Data for the Weld Metals

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Table A3-7—Unaged True Stress-Strain Data for the Weld Metals

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Table A3-8—Unaged True Stress-Strain Data for the Base Metals

Table A3-8—Unaged True Stress-Strain Data for the Base Metals

Table A3-9—Ramberg-Osgood Parameters

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Figure A3-1—Ramberg-Osgood Fit to the Test Data for SA 106, Grade C

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Figure A3-2—Engineering Stress-Strain Curves for the Welds

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Figure A3-3—Engineering Stress-Strain Curves for the Base Metals

Figure A3-4—True Stress-Strain Curves for the Welds

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Figure A3-5—True Stress-Strain Curves for the Base Metals

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Figure A3-6—Ramberg-Osgood Fit to the True Stress-Strain Curve for the Weld

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Figure A3-7—Ramberg-Osgood Fit to the True Stress-Strain Curve for the Base Metal

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