

**Proprietary Information**  
**Withhold from Public Disclosure Under 10 CFR 2.390**  
**This letter is decontrolled when separated from Enclosure 1**



Tennessee Valley Authority, 1101 Market Street, Chattanooga, Tennessee 37402

CNL-15-240

November 13, 2015

10 CFR 50.90

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

Browns Ferry Nuclear Plant, Units 1, 2, and 3  
Renewed Facility Operating License Nos. DPR-33, DPR-52, and DPR-68  
NRC Docket Nos. 50-259, 50-260, and 50-296

Subject: **Proposed Technical Specifications Change TS-505 - Request for License Amendments - Extended Power Uprate - Supplemental Information (CAC Nos. MF4851, MF4852, MF4853)**

Reference: Letter from TVA to NRC, CNL-15-169, "Proposed Technical Specifications (TS) Change TS-505 - Request for License Amendments - Extended Power Uprate (EPU)," dated September 21, 2015

By the reference letter dated September 21, 2015, Tennessee Valley Authority (TVA) submitted a license amendment request (LAR) for the Extended Power Uprate (EPU) of Browns Ferry Nuclear Plant (BFN) Units 1, 2 and 3. The proposed LAR modifies the renewed operating licenses to increase the maximum authorized core thermal power level from the current licensed thermal power of 3458 megawatts to 3952 megawatts.

Enclosure 1 of this letter provides supplemental information regarding recently identified issues with the AREVA analysis code MICROBURN-B2 and the effect of these issues on information provided in the BFN EPU LAR. It is expected that a supplement to the BFN EPU LAR will be submitted by December 15, 2015. The supplement to the BFN EPU LAR will provide revisions to the affected attachments that reflect the resolution of the identified issues.

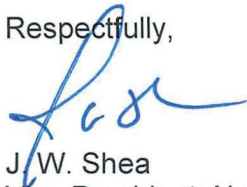
AREVA considers portions of the information provided in Enclosure 1 of this letter to be proprietary and therefore, exempt from public disclosure pursuant to 10 CFR 2.390, Public inspections, exemptions, requests for withholding. An affidavit for withholding information, executed by AREVA, is provided in Enclosure 3. A non-proprietary version of the document is provided in Enclosure 2. Therefore, on behalf of AREVA, TVA requests that Enclosure 1 be withheld from public disclosure in accordance with the AREVA affidavit and the provisions of 10 CFR 2.390.

TVA has reviewed the information supporting a finding of no significant hazards consideration and the environmental consideration provided to the NRC in the reference letter. The supplemental information provided in this submittal does not affect the bases for concluding that the proposed license amendment does not involve a significant hazards consideration. In addition, the supplemental information in this submittal does not affect the bases for concluding that neither an environmental impact statement nor an environmental assessment needs to be prepared in connection with the proposed license amendment. Additionally, in accordance with 10 CFR 50.91(b)(1), TVA is sending a copy of this letter and the non-proprietary enclosures to the Alabama State Department of Public Health.

There are no new regulatory commitments associated with this submittal. If there are any questions or if additional information is needed, please contact Mr. Edward D. Schrull at (423) 751-3850.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 13th day of November 2015.

Respectfully,



J.W. Shea  
Vice President, Nuclear Licensing

Enclosures:

1. Browns Ferry EPU Low Flow Issues Impact (Proprietary),  
AREVA FS1-0024528, Revision 1.0, November 2015
2. Browns Ferry EPU Low Flow Issues Impact (Non-Proprietary),  
AREVA FS1-0024530, Revision 1.0, November 2015
3. AREVA Affidavit

cc:

NRC Regional Administrator - Region II  
NRC Senior Resident Inspector - Browns Ferry Nuclear Plant  
State Health Officer, Alabama Department of Public Health (w/o Enclosure 1)

**Proprietary Information**  
**Withhold from Public Disclosure Under 10 CFR 2.390**  
**This letter is decontrolled when separated from Enclosure 1**

**ENCLOSURE 1**


**Browns Ferry EPU Low Flow Issues Impact (Proprietary)**

**AREVA FS1-0024528, Revision 1.0, November 2015**

**ENCLOSURE 2**

**FS1-0024530 Revision 1.0, "Browns Ferry EPU Low Flow Issues Impact"**

**(Non-Proprietary)**

<b>IDENTIFICATION</b>	<b>REVISION</b>	<b>AREVA Front End BG</b> <b>Fuel BL</b>	
<b>FS1-0024530</b>	<b>1.0</b>		
<b>TOTAL NUMBER OF PAGES: 14</b>			

## Browns Ferry EPU Low Flow Issues Impact

**ADDITIONAL INFORMATION:**  
This document is the non-proprietary version of FS1-0024528.

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## REVISIONS

REVISION	DATE	EXPLANATORY NOTES
1.0	See 1 <sup>st</sup> page release date	New document

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## Nomenclature

2PT	2 Recirculation Pump Trip
APRM	Average Power Range Monitor
ARTS	APRM Rod Block Monitor Technical Specification Improvement
BFN	Browns Ferry Nuclear Plant
BSP	Backup Stability Protection
CPR	Critical Power Ratio
CRWE	Control Rod Withdrawal Error
DIVOM	Delta over Initial MCPR Versus Oscillation Magnitude
EPU	Extended Power Uprate
FUSAR	Fuel Uprate Safety Analysis Report
HCOM	Hot Channel Oscillation Magnitude
HFCL	High Flow Control Line
LAR	License Amendment Request
LHGRFACf	Linear Heat Generation Rate Flow Dependent Adjustment Factors
MCPR	Minimum CPR
MCPRf	Flow Dependent MCPR Operating Limits
NCL	Natural Circulation Line
OLMCPR	Operating Limit MCPR
OPRM	Oscillation Power Range Monitor
RLA	Reload Licensing Analysis
SS	Steady State

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## REFERENCES

1. Letter from J. W. Shea (TVA) to NRC, "PROPOSED TECHNICAL SPECIFICATIONS CHANGE TS-505 – REQUEST FOR LICENSE AMENDMENTS – EXTENDED POWER UPRATE", September 21, 2015. (Accession Number ML15282A152)
2. Fuel Uprate Safety Analysis Report
  - a) ANP-3403P Revision 2, *Fuel Uprate Safety Analysis Report for Browns Ferry Units 1, 2, and 3*, proprietary version (Attachment 8 of the BFN EPU LAR), AREVA Inc., August 2015.
  - b) ANP-3403NP Revision 2, *Fuel Uprate Safety Analysis Report for Browns Ferry Units 1, 2, and 3*, non-proprietary version (Attachment 9 of the BFN EPU LAR), AREVA Inc., August 2015.
3. Representative Cycle Reload Analysis Report
  - a) ANP-3404P Revision 2, *Browns Ferry Unit 3 Cycle 19 Representative Reload Analysis at Extended Power Uprate*, proprietary version (Attachment 20 of the BFN EPU LAR), AREVA Inc., August 2015.
  - b) ANP-3404NP Revision 2, *Browns Ferry Unit 3 Cycle 19 Representative Reload Analysis at Extended Power Uprate*, non-proprietary version (Attachment 21 of the BFN EPU LAR), AREVA Inc., August 2015.

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## 1. Purpose and Summary

The purpose of this document is to provide updated results for documentation supplied in support of an Extended Power Uprate (EPU) License Amendment Request (LAR) for the Browns Ferry Nuclear Plant (BFN) (Reference 1). The updated results address the effect of two recently identified issues within the AREVA MICROBURN-B2 core simulator code. Both issues are limited to low flow cases and the only identified effects on the BFN EPU LAR are associated with reactor stability calculations. These effects have been determined to be minor and do not affect any conclusions in the submitted reports.

This document is being provided to facilitate the NRC acceptance review of the BFN EPU LAR by quantifying the magnitude and potential effect of these issues on the previously provided results. AREVA will provide revisions to the affected reports in December 2015. This document provides an interim report on the effect of the identified issues.

## 2. Description of Issues and Extent of Condition

The two issues described in this document are being addressed within AREVA's corrective action program. The investigation has not yet been completed for either issue. AREVA has identified solutions to technically address each issue; however, the final corrective actions have not been identified. The results presented in this document have been performed and reviewed by technically qualified individuals, but the supporting analyses have not yet been documented and reviewed according to AREVA's Quality Assurance Program.


The identified issues within MICROBURN-B2 are described in more detail below, but it is noted that both are only a concern in regard to low flow calculations.

- CR2015-7013: Potential hydraulic non-convergence in MICROBURN-B2 at low flow conditions.
- CR2015-7948: Behavior of the MICROBURN-B2 void quality correlation for low flow conditions.

Both issues are part of an active investigation within the AREVA corrective action program. AREVA will revise the affected reports with the new results upon completion of the investigation.

### 2.1. MICROBURN-B2 Hydraulic Convergence at Low Flow Conditions

Condition report CR2015-7013 identifies that at some low flow conditions (i.e., below 50% rated core flow), the MICROBURN-B2 code hydraulic convergence might not be sufficient to ensure the accuracy of the resulting solutions. An evaluation was performed on existing analyses with statepoints in this flow range to determine whether the solutions were hydraulically converged. No unconverged solutions were identified above 40% rated core flow for Browns Ferry.

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For the BFN EPU LAR, the potentially affected analyses include:

- Stability Option III Delta over Initial MCPR Versus Oscillation Magnitude (DIVOM) calculations
- MICROBURN-B2/STAIF calculations for Backup Stability Protection (BSP)
- Oscillation Power Range Monitor (OPRM) Setpoint Analyses
- Flow Runup Analyses including both flow dependent Linear Heat Generation Rate adjustment factors (LHGRFACf) and flow dependent operating limits (MCPRf)
- Transients, infrequent events, or design basis accidents in which MICROBURN-B2 is used to set the initial conditions.
- Low power/flow ARTS\* Control Rod Withdrawal Error (CRWE) cases

Evaluation of the BFN EPU analyses determined that only the stability related calculations included any non-converged hydraulic calculations. The affected analyses include the BSP, DIVOM, and two recirculation pump trip (2PT) MCPR calculations for the OPRM setpoint. All other analyses supporting the Reference 1 submittal were found to be unaffected by the identified issue.

A new version of the MICROBURN-B2 code has been issued with a revised low flow convergence scheme that addresses this non-convergence issue. This new version of the code has been used in the revised calculations discussed later in this document.

## 2.2. **Void Quality Correlation Behavior at Low Flow Conditions**

Condition report CR2015-7948 identifies that the current implementation of the void quality correlation used within MICROBURN-B2 includes by default [ ]. Investigations that have been carried out revealed that the correlation produces some potentially non-physical results at very low flow mass fluxes and high flow qualities, which is part of the reason for the implementation of the [ ] into the correlation in MICROBURN-B2. This [ ] was implemented in the UNOV10 version of MICROBURN-B2.


The non-physical behavior is inherent in the formulation of the correlation and is not an implementation issue within the MICROBURN-B2 code. Investigation has determined that the correlation behaves in an expected manner for the following range of conditions†:

[ ]

All versions of the MICROBURN-B2 code since the release of UNOV10 have included a default [ ]. While this appears to have mitigated the correlations non-physical

\* ARTS refers to Average Power Range Monitor (APRM), Rod Block Monitor (RBM), and Technical Specification (TS) improvements.

† The range of applicability has been defined in a conservative manner. Falling outside this range does not mean that the void-quality correlation will provide a non-physical result; instead it indicates that the potential exists. Analyses inside of this range of conditions produce the expected result.

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behavior it has been determined [ ] .

The evaluation of the effect of this issue is similar in scope in regard to the potentially affected calculations. Similar to the low flow convergence issue, the only BFN EPU LAR analyses that were determined to be affected were the stability related calculations.

Revised calculations were performed by eliminating the [ ] with an existing MICROBURN-B2 input. The analyses were then reviewed to ensure that the cases fall within [ ] is as expected.

### 3. Effects to BFN EPU LAR Documentation

The identified effects are limited to stability calculation results provided in two of the BFN EPU LAR reports\* (References 2 and 3). The effects are provided in a series of tables and figures that contain both the revised and original results. **Red bold font** and **red triangular symbols** are used to identify the revised results. The new results include the corrective actions for both of the identified low flow issues (described in Section 2 above). All revised cases have been verified to be hydraulically converged and outside of the area of concern for non-physical behavior of the void-quality correlation.

#### 3.1. Fuel Uprate Safety Analysis Report (FUSAR)

The FUSAR was provided in both proprietary (Reference 2.a) and non-proprietary (Reference 2.b) versions as Attachments 8 and 9 of the BFN EPU LAR, respectively. The effects of both issues have been incorporated and the effect to this report is limited to the BSP decay ratio results, the DIVOM plot, and the OPRM Setpoint results. These effects to the FUSAR are discussed below:

##### BSP Analyses (FUSAR Tables 2.8-2 and 2.8-3)


The revised BSP analyses result in minor changes to the decay ratios reported in the FUSAR. The BSP results are provided in FUSAR Tables 2.8-2 and 2.8-3 for nominal and reduced feedwater temperature conditions, respectively.

Table 1 and Table 2 of this document provide both the revised (**in red bold font**) and original results for the same conditions. As can be seen in these tables, the effect on the reported decay ratios is minor with some increasing and some decreasing in magnitude when compared to the original reported decay ratios. In all cases, the limiting decay ratios continue to meet acceptance criteria and no change in the BSP regions is required as a result of the low flow convergence or void-quality issues.

##### DIVOM Analyses (FUSAR Figure 2.8-3)

The FUSAR provided the limiting DIVOM result as Figure 2.8-3. Figure 1 of this document provides a comparison of both the original and revised (**in red triangular symbols**) limiting DIVOM results. As can

\* Proprietary and non-proprietary versions of these reports will be revised for a total of four affected documents.

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be seen in Figure 1, the effect on DIVOM results are minor and the generic slope of 0.45 continues to be supported. Consequently, there is no downstream effect on the OPRM setpoint calculation due to DIVOM.

#### OPRM Setpoint Analyses (FUSAR Table 2.8-1)

The results for the OPRM setpoint analysis for the EPU Equilibrium Cycle are provided in Table 2.8-1 of the FUSAR. The OPRM setpoint calculation includes two cycle-specific components that had the potential to be affected by the low flow issues in MICROBURN-B2, the DIVOM slope and the transient two recirculation pump trip (2PT) results. The other component of interest in the OPRM setpoint analysis is a plant-specific Hot Channel Oscillation Magnitude (HCOM) value. The HCOM analysis for BFN was performed with non-AREVA methods and is not affected by the MICROBURN-B2 issues addressed by this document.

The DIVOM slope is used in the calculation of the required OLMCPR for both the steady-state (SS) results and the transient 2PT results. As discussed above, the generic DIVOM slope remains supported so this component did not affect the reported results. Because this is the only cycle-specific component used for the SS results, the OLMCPR(SS) column of FUSAR Table 2.8-1 is not affected.

The 2PT results include the effect of the flow runback on the initial MCPR by use of a MCPR\_P1 to MCPR\_P2 (i.e., P1/P2) ratio where P1 represents the full power statepoint and P2 represents the post trip statepoint on the natural circulation line. The low flow issues have the potential to effect the P2 MCPR result. Because the P1/P2 ratio is a multiplier in the calculation of OLMCPR(2PT), increases or decreases in the P1/P2 ratio will have a corresponding effect on the 2PT results. For the equilibrium cycle analysis, the P1/P2 ratio decreases with the corrections to address the low flow issues with a corresponding decrease in the OLMCPR(2PT) results.

The effect on the FUSAR Table 2.8-1 results is provided in Table 3 of this document. This table provides both the original and revised (**in red bold font**) results. The discussion on allowable OPRM setpoint in Section 2.8.3.1.2 of the FUSAR is not affected by the changes in the OLMCPR(2PT) results.

### **3.2. Reload Licensing Analysis (RLA) Report for the Unit 3 Cycle 19 Reference Cycle**


The RLA report was included in both proprietary (Reference 3.a) and non-proprietary (Reference 3.b) versions as Attachments 20 and 21 of the BFN EPU LAR, respectively. The effect of both low flow issues discussed in Section 2 has been incorporated in the results discussed below. The effect to the RLA report is limited to the OPRM Setpoint results as discussed below:

#### BSP Analyses (RLA Table 4.4)

The BSP results are provided in RLA Table 4.4 for both nominal and reduced feedwater temperature conditions. The revised decay ratios continue to meet the acceptance criteria. Therefore, the BSP endpoints remain valid and no changes are required to this table.

#### OPRM Setpoint Analyses (RLA Table 4.3)

As discussed in Section 3.1, the OPRM setpoint analysis can be affected by changes in the cycle-specific DIVOM and 2PT MCPR P1/P2 ratio.

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The reanalysis of the DIVOM calculation for the reference cycle continues to support the generic slope of 0.45. No specific DIVOM results are reported so no changes to the RLA are required for the DIVOM results. Because this is the only cycle-specific component used for the OPRM setpoint SS results, the OLMCPR(SS) column of RLA Table 4.3 is not affected.

Similar to the equilibrium cycle analysis, the P1/P2 ratio for the reference cycle decreases with the corrections to address the low flow issues with a corresponding decrease in the OLMCPR(2PT) results. The effect on the RLA Table 4.3 results is provided in Table 4 of this document. This table provides both the original and revised **(in red bold font)** results.

#### 4. Conclusion

The evaluation of the effects on the BFN EPU LAR of the identified low flow issues within MICROBURN-B2 identified only minor effects on the stability calculations. All other analyses supporting the LAR submittal are not affected.

Effects on the BSP calculations were minor changes to the decay ratios, with some limiting results experiencing small increases and some small decreases. In all cases, the stability acceptance criteria remain supported and no change in the BSP regions is required.

The DIVOM analyses showed small effects to the individual results but the generic 0.45 DIVOM slope remains supported.

The OPRM setpoint calculation for the OLMCPR(SS) results is unaffected because the assumed DIVOM slope does not change. The OLMCPR(2PT) results change; however, the change is a reduction in the required OLMCPR because the limiting P1/P2 ratio decreases for both the equilibrium and reference cycle cores.

**Table 1 FUSAR Equilibrium Cycle - BSP Region Intercepts, Nominal Feedwater Temperature (Table 2.8-2)**

Region Boundary Intercept	EPU Power (% rated)	Core Flow (% rated)	Original / Revised Calculation	Core/Global Decay Ratio	Regional Decay Ratio	Channel Decay Ratio
<b>REGION 1: SCRAM Region</b>						
1A (HFCL)	56.55	40	Original	0.733	0.472	0.137
			<b>Revised</b>	<b>0.714</b>	<b>0.474</b>	<b>0.129</b>
1B (NCL)	39.34	29	Original	0.654	0.506	0.205
			<b>Revised</b>	<b>0.698</b>	<b>0.505</b>	<b>0.177</b>
<b>REGION 2: CONTROLLED ENTRY Region</b>						
2A (HFCL)	64.50	50	Original	0.698	0.423	0.089
			<b>Revised</b>	<b>0.701</b>	<b>0.423</b>	<b>0.089</b>
2B (NCL)	27.54	29	Original	0.526	0.420	0.068
			<b>Revised</b>	<b>0.513</b>	<b>0.376</b>	<b>0.055</b>

**Table 2 FUSAR Equilibrium Cycle - BSP Region Intercepts, Reduced Feedwater Temperature (Table 2.8-3)**

Region Boundary Intercept	EPU Power (% rated)	Core Flow (% rated)	Original / Revised Calculation	Core/Global Decay Ratio	Regional Decay Ratio	Channel Decay Ratio
<b>REGION 1: SCRAM Region</b>						
1A (HFCL)	56.55	40	Original	0.830	0.606	0.154
			<b>Revised</b>	<b>0.833</b>	<b>0.608</b>	<b>0.154</b>
1B (NCL)	37.00	29	Original	0.837	0.596	0.180
			<b>Revised</b>	<b>0.817</b>	<b>0.576</b>	<b>0.165</b>
<b>REGION 2: CONTROLLED ENTRY Region</b>						
2A (HFCL)	64.50	50	Original	0.749	0.478	0.089
			<b>Revised</b>	<b>0.753</b>	<b>0.479</b>	<b>0.090</b>
2B (NCL)	27.54	29	Original	0.500	0.389	0.064
			<b>Revised</b>	<b>0.505</b>	<b>0.378</b>	<b>0.058</b>

**Table 3 FUSAR Equilibrium Cycle - Option III Setpoints (Table 2.8-1)**

OPRM Amplitude Setpoint	OLMCPR(SS)		OLMCPR(2PT)	
	Original	Revised*	Original	Revised
1.05	1.15	<b>1.15</b>	1.11	<b>1.06</b>
1.06	1.17	<b>1.17</b>	1.12	<b>1.06</b>
1.07	1.19	<b>1.19</b>	1.14	<b>1.06</b>
1.08	1.20	<b>1.20</b>	1.16	<b>1.07</b>
1.09	1.22	<b>1.22</b>	1.18	<b>1.09</b>
1.10	1.24	<b>1.24</b>	1.20	<b>1.11</b>
1.11	1.26	<b>1.26</b>	1.22	<b>1.12</b>
1.12	1.28	<b>1.28</b>	1.24	<b>1.14</b>
1.13	1.30	<b>1.30</b>	1.26	<b>1.16</b>
1.14	1.33	<b>1.33</b>	1.28	<b>1.18</b>
1.15	1.35	<b>1.35</b>	1.30	<b>1.20</b>
<b>Acceptance Criteria</b>	<b>Off-rated OLMCPR at 45% Flow</b>		<b>Rated Power OLMCPR</b>	


\* There are no changes in the OLMCPR(SS) results.



**Table 4 RLA Report Representative Cycle - Option III Setpoints (Table 4.3)**

OPRM Amplitude Setpoint	OLMCPR(SS)		OLMCPR(2PT)	
	Original	Revised*	Original	Revised
1.05	1.15	<b>1.15</b>	1.16	<b>1.08</b>
1.06	1.17	<b>1.17</b>	1.18	<b>1.10</b>
1.07	1.19	<b>1.19</b>	1.20	<b>1.11</b>
1.08	1.20	<b>1.20</b>	1.22	<b>1.13</b>
1.09	1.22	<b>1.22</b>	1.24	<b>1.15</b>
1.10	1.24	<b>1.24</b>	1.26	<b>1.17</b>
1.11	1.26	<b>1.26</b>	1.28	<b>1.19</b>
1.12	1.28	<b>1.28</b>	1.30	<b>1.21</b>
1.13	1.30	<b>1.30</b>	1.32	<b>1.23</b>
1.14	1.33	<b>1.33</b>	1.34	<b>1.25</b>
1.15	1.35	<b>1.35</b>	1.36	<b>1.27</b>
<b>Acceptance Criteria</b>	<b>Off-rated OLMCPR at 45% Flow</b>		<b>Rated Power OLMCPR</b>	

\* There are no changes in the OLMCPR(SS) results.

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**Figure 1 FUSAR Equilibrium Cycle - Limiting Cycle Specific DIVOM Results (Figure 2.8-3)**

**ENCLOSURE 3**

**AREVA Affidavit**



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 to determine whether information should be classified as proprietary:

- (a) The information reveals details of AREVA'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.
- (d) The information reveals certain distinguishing aspects of a process, methodology, or component, the exclusive use of which provides a competitive advantage for AREVA in product optimization or marketability.
- (e) The information is vital to a competitive advantage held by AREVA, would be helpful to competitors to AREVA, and would likely cause substantial harm to the competitive position of AREVA.

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

7. In accordance with AREVA'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 only as required and under suitable agreement providing for nondisclosure and limited use of the information.

8. AREVA 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.

Alan S. Maguire

SUBSCRIBED before me this 9<sup>th</sup>  
day of November, 2015.

Susan K. McCoy

Susan K. McCoy  
NOTARY PUBLIC, STATE OF WASHINGTON  
MY COMMISSION EXPIRES: 1/14/2016

