

ATTACHMENT 28


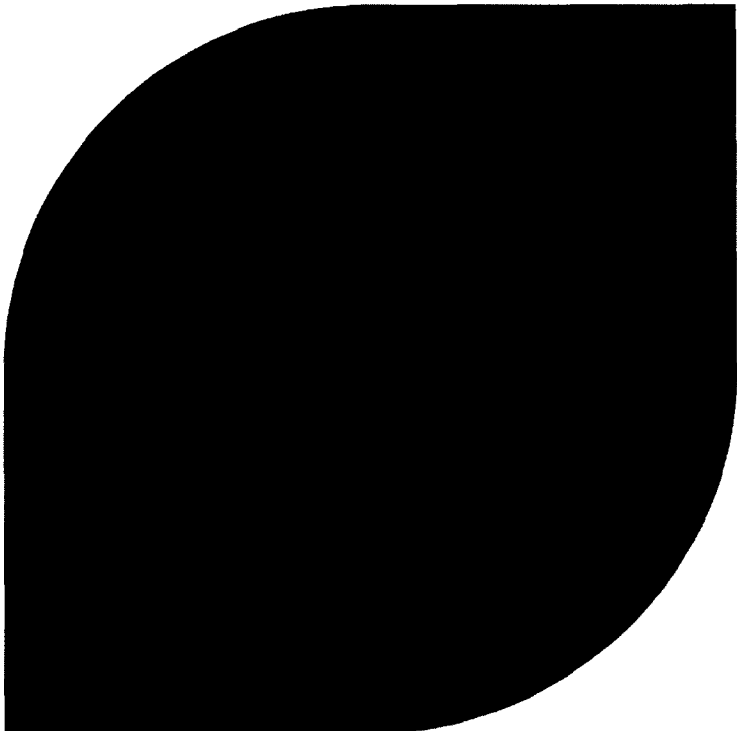
**Browns Ferry Nuclear Plant (BFN)
Units 1, 2, and 3**

Technical Specifications (TS) Change 478

**Addition of Analytical Methodologies to Technical Specification 5.6.5.b for Browns Ferry
1, 2, & 3, and Revision of Technical Specification 2.1.1.2 for Browns Ferry Unit 2, in
Support of ATRIUM-10 XM Fuel Use at Browns Ferry**

**Browns Ferry ACE Supplement
(Non-Proprietary)**

**Attached is the non proprietary version of the Browns Ferry specific ACE
supplemental report.**



ANP-3140(NP)
Revision 0

Browns Ferry Units 1, 2, and 3
Improved K-factor Model for
ACE/ATRIUM 10XM Critical Power Correlation

August 2012

AREVA NP Inc.

ANP-3140(NP)
Revision 0

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Nature of Changes

Item	Page	Description and Justification
1.	All	This is the initial release.

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Nomenclature

<u>Acronym</u>	<u>Definition</u>
ACE	AREVA Critical power Evaluator
AOO	Anticipated Operational Occurrence
BT	Boiling Transition
BWR	Boiling Water Reactor
CPR	Critical Power Ratio
ECPR	Experimental Critical Power Ratio; the ratio of calculated to the measured critical power
LOCA	Loss Of Coolant Accident
MCPR	Minimum Critical Power Ratio
PLR	Part Length Rod

1.0 Introduction and Summary

Reference 1 presents the approved ACE/ATRIUM 10XM critical power correlation for ATRIUM™* 10XM fuel. A concern with the calculation of the K-factor within the approved ACE correlation was identified. Since K-factor was integrated over the entire heated length of the assembly, it was possible for the local peaking factors in the upper lattices to contribute significantly to the K-factor used, even when dryout occurs much lower in the bundle.

Reference 2 presents a revision to the ACE critical power correlation for ATRIUM 10XM fuel. The Reference 2 correlation is very similar to the Reference 1 critical power correlation with a couple of exceptions. The K-factor methodology was modified in response to deficiencies found in the axial averaging process. In addition, the additive constants were revised as a result of the change to the K-factor model. Evaluations confirmed that the Reference 1 critical power correlation coefficients do not require revision as a result of these changes.

The purpose of this document is to present the ACE/ATRIUM 10XM critical power correlation that will be used in licensing analyses for Browns Ferry Units 1, 2, and 3 until Reference 2 is generically approved and included in the Browns Ferry Plant Technical Specifications. The correlation presented in this document is exactly the same as that presented in Reference 2.

Reference 3 provides a description of the rod local peaking function (called K-factor). The improved K-factor method used in the Browns Ferry ACE/ATRIUM 10XM critical power correlation is described in this document. This modified method supersedes the one described in Reference 3 and used in Reference 1. This document also describes the minor changes in the method for determining additive constants that became necessary due to the changes in the K-factor methodology.

The comparison between measured and predicted critical power data is shown in Figure 1-1. The correlation experimental critical power ratio (ECPR) mean with the improved K-factor methodology and updated additive constants is [] and the ECPR standard deviation is []. The ECPR mean and standard deviation from Reference 1 were [] and [] respectively.

* ATRIUM is a trademark of AREVA NP Inc.

The range of applicability of the critical power correlation is unchanged from Reference 1. The modified correlation is applicable to Browns Ferry steady-state design and analysis, core monitoring, MCPR safety limit, anticipated operational occurrences (AOO's), accidents, LOCA, and instability analysis for the ATRIUM 10XM fuel design.



Figure 1-1: Comparison of Calculated to Measured Critical Power

2.0 Standard Review Plan Requirements

There are no critical power correlation specific requirements in the standard review plan.

All modern critical power correlations contain a function that accounts for rod peaking. This function is called K-factor in the ACE formulation of the correlation. The model equation for the ACE correlation is given in Equation 3.1 of Reference 1 (including symbol definitions). The revision is in the [] term:

[illegible]

1

3.1 Rod Peaking Function

1

This description of the local rod peaking function is unchanged from the description in References 1 and 3.

3.2 ***Applying Rod Peaking Function in the Critical Power Correlation***

[

] The maximum of the averaged K-factors over all the rods was then chosen for use in the critical power correlation according to Equation 3.46 in Reference 3. This averaging of the axial K-factor distribution for each rod was found to be inappropriate for the reasons discussed in Section 3.0 and is therefore excluded in the improved K-factor method.

[

] Thus this solution explicitly addresses both problems noted in Section 3.0.

In the improved method, [

]

3.3 ***Method for Calculation Additive Constants***

The spacers and bundle geometry characteristics influence the critical power behavior of the individual rods within the fuel bundle. Therefore, a factor is needed to distinguish the critical power performance of each rod. These position dependent factors are termed additive constants. Additive constants can be considered as a flow/enthalpy redistribution characteristic for a given bundle and spacer design.

In critical power testing, [

]

[

]

In accordance with the [] the CHF database was randomly divided into a defining data set and a validating data set.

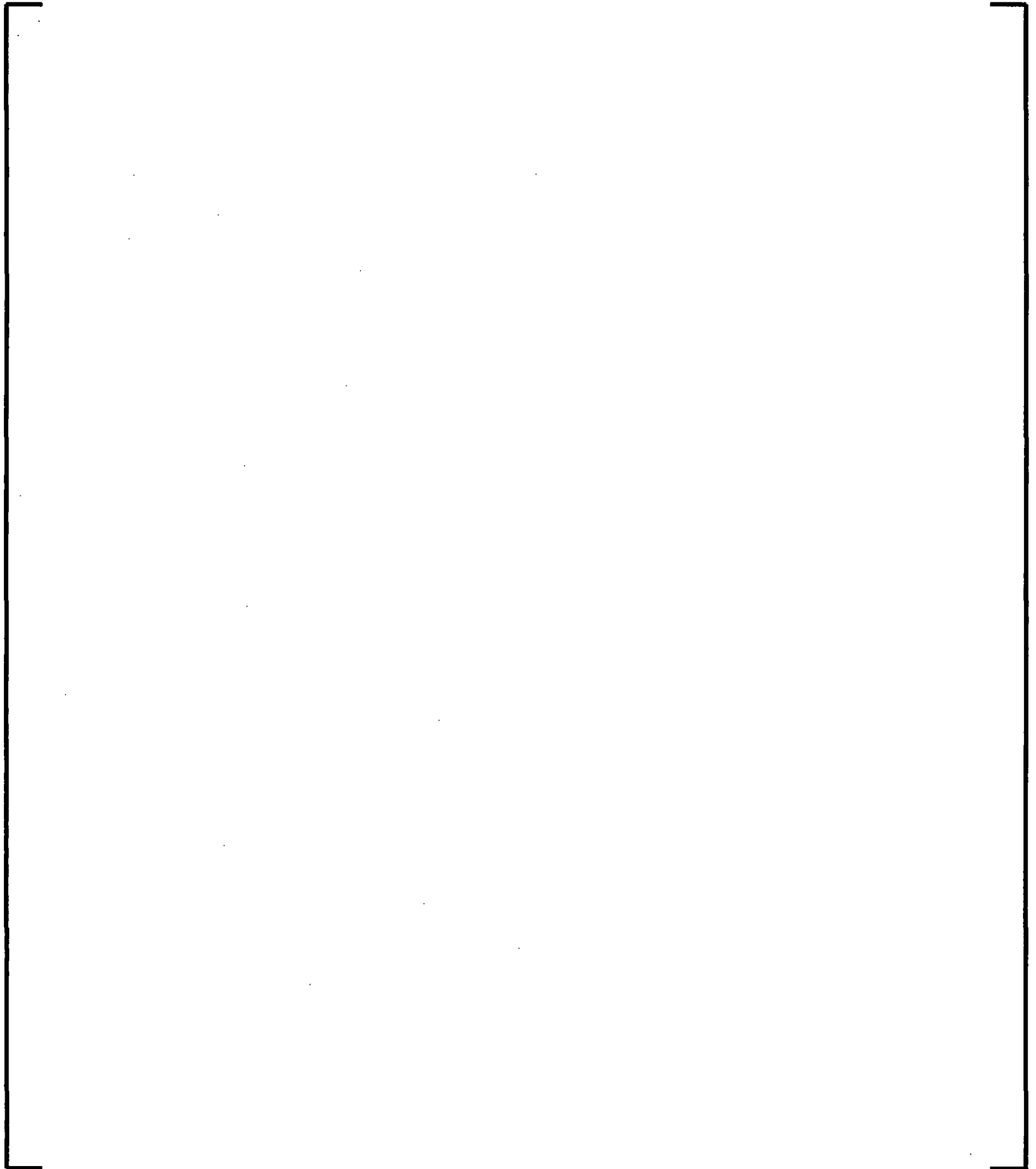
Approximately [] was set aside as the validating set of data. The remaining [] form the defining data set and were used to develop the critical power correlation. The additive constants for all the rod positions were determined from the defining data set. The calculation of additive constants uses the same partition of data as was used during the critical power correlation development. [

]

The defining and validating data sets used for correlation development in Reference 1 are unchanged. The additive constants are determined [

]

[]



3.3.4 Additive Constants for ACE/ATRIUM 10XM Correlation

The revised ATRIUM 10XM additive constants are shown in Figure 3-4. For comparison purposes, both the revised ATRIUM 10XM additive constants and the ACE/ATRIUM 10XM additive constants from Reference 1 are presented in Figure 3-5. The observed changes in additive constant are generally small and [

]



Figure 3-1: Adjacent Rod Identification for K-factor Calculation



Figure 3-2: Rods Observed to Dryout in Testing



Figure 3-3: Peaked Symmetric Rods Not Observed to Dryout in Testing



Figure 3-4: ACE/ATRIUM 10XM Additive Constants

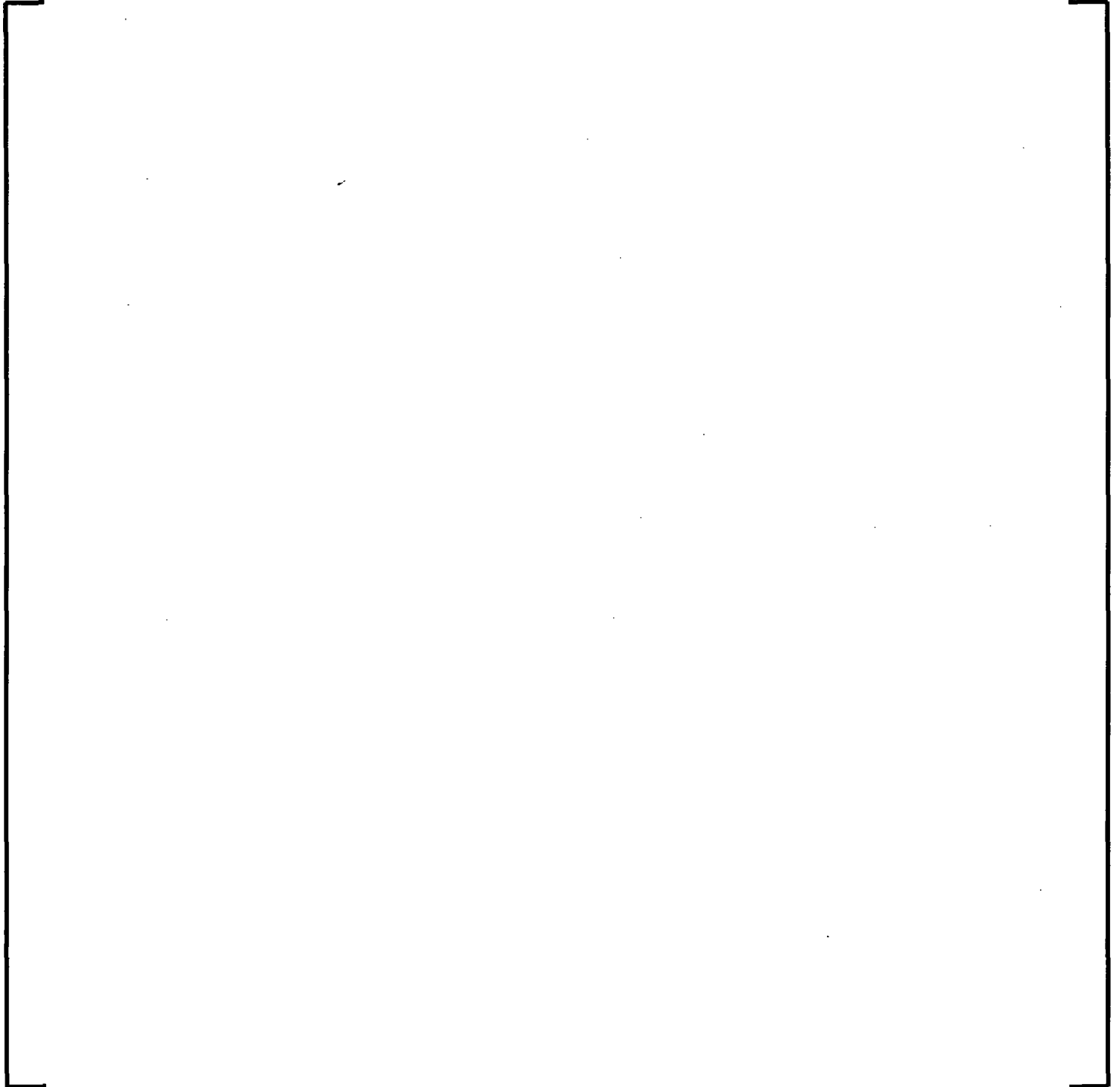


Figure 3-5: Additive Constant Comparison

3.4 ***Additive Constant Uncertainty***

The overall uncertainty in additive constants is determined [

] . The following steps are applied:

An additional high peaking uncertainty is imposed in the MCPR safety limit methodology for those rods whose local peaking exceeds [

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Table 3-1: Additive Constant Uncertainty for High Local Peaking

--	--

3.5 ***Critical Power Correlation Conservatism***

With the improved K-factor model, the Browns Ferry ACE/ATRIUM 10XM correlation has an average ECPR of [] with a standard deviation of []. For the Reference 1 correlation, the average ECPR was [] with a standard deviation of []. The correlation was used to assess each rod in each of the tests. The associated critical powers of each rod were then compared to the measured critical power and a count made of the number of rods which were predicted to be in boiling transition (BT) and this was compared to the number of rods actually observed to be in boiling transition in the experimental data. With the improved K-factor methodology and additive constants, this ratio of predicted to measured rods in boiling transition is []. This compares with a value of [] in Reference 1.

4.0 Transient Benchmarking

An industry accepted standard in BWR transient methodology is that steady-state dryout correlations are conservative for use in transient methodology. Transient dryout tests [] were performed to reconfirm this for the ATRIUM 10XM fuel design when using the ACE/ATRIUM 10XM critical power correlation.

The limiting transient tests of interest are the simulated load rejection without bypass (LRNB) events that consist of power and pressure ramps and flow decay and the simulated loss of flow events that consist of flow decay and power decay. The power, pressure, and flow were all controlled by a function generator. The forcing functions were programmed to produce the transient rod surface heat flux typical of the various events.

A total of [] ATRIUM 10XM LRNB and loss of flow transients were run which were either measured or predicted to have dryout. Of these [] transient critical power tests, []

[] The initial conditions for these tests are given in Table 7-7 of Reference 1.

Evaluations of the transient critical power tests were repeated using the improved K-factor methodology. []

[] The AREVA NP transient thermal hydraulic code XCOBRA-T (References 5 and 6), was used to predict the transient test results using the ACE/ATRIUM 10XM critical power correlation. The test power forcing function provides the boundary condition of power, which is modeled in XCOBRA-T []

[]

[

]

The results [] are summarized in Table 4-1.

[

]

The transient benchmark results with the modified correlation are consistent with those presented in Reference 1.

1

[illegible]

1

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[]

5.0 [] K-factor Method

With the improved K-factor method, the critical power correlation is used to [

]

6.0 Implementation of Improved K-factor Methodology

The improved K-factor methodology has been implemented into MICROBURN-B2 (Reference 8), POWERPLEX®*-XD Core Monitoring Software System (CMSS), SAFLIM3D (Reference 7), XCOBRA (Reference 11), XCOBRA-T (References 5 and 6), RELAX (Reference 9), and RAMONA5-FA (Reference 10). It will be used in Browns Ferry core design and analysis, core monitoring, MCPR safety limit methodology, AOO's, LOCA, and other codes and methods that use the critical power correlations.

The MCPR safety limit methodology performs a rod-by-rod evaluation to estimate the number of rods in BT associated with a particular safety limit. [

]

* POWERPLEX is a trademark of AREVA NP Inc. registered in the United States and various other countries.

7.0 References

1. ANP-10298PA Revision 0, "ACE/ATRIUM 10XM Critical Power Correlation," AREVA NP Inc., March 2010.
2. ANP-10298PA Revision 0, Supplement 1P Revision 0, "Improved K-Factor Model for ACE/ATRIUM 10XM Critical Power Correlation," AREVA NP, Inc., December 2011.
3. ANP-10249PA Revision 1, "ACE/ATRIUM-10 Critical Power Correlation," AREVA NP Inc., September 2009.
4. C. Bennett and N. L. Franklin. "Statistical Analysis in Chemistry and the Chemical Industry," Marbern House, October 1987.
5. XN-NF-84-105(P)(A) Volume 1 and Volume 1 Supplements 1 and 2, "XCOBRA-T: A Computer Code for BWR Transient Thermal-Hydraulic Analysis," Exxon Nuclear Company, February 1987.
6. XN-NF-84-105(P)(A) Volume 1 Supplement 4, "XCOBRA-T: A Computer Code for BWR Transient Thermal-Hydraulic Core Analysis Void Fraction Model Comparison to Experimental Data," Advanced Nuclear Fuels Corporation, June 1988.
7. ANP-10307PA Revision 0, "AREVA MCPR Safety Limit Methodology for Boiling Water Reactors," AREVA NP Inc., June 2011.
8. EMF-2158(P)(A) Revision 0, "Siemens Power Corporation Methodology for Boiling Water Reactors: Evaluation and Validation of CASMO-4 / MICROBURN-B2," Siemens Power Corporation, October 1999.
9. EMF-2361(P)(A) Revision 0, "EXEM BWR-2000 ECCS Evaluation Model," Framatome ANP Richland, Inc., May 2001.
10. BAW-10255PA Revision 2, "Cycle-Specific DIVOM Methodology Using the RAMONA5-FA Code," AREVA NP Inc., May 2008.
11. XN-NF-80-19(P)(A) Volume 3 Revision 2, "Exxon Nuclear Methodology for Boiling Water Reactors, THERMEX: Thermal Limits Methodology Summary Description," Exxon Nuclear Company, Inc., January 1987.
12. []

ATTACHMENT 29

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Units 1, 2, and 3**

Technical Specifications (TS) Change 478

**Addition of Analytical Methodologies to Technical Specification 5.6.5.b for Browns Ferry
1, 2, & 3, and Revision of Technical Specification 2.1.1.2 for Browns Ferry Unit 2, in
Support of ATRIUM-10 XM Fuel Use at Browns Ferry**

AREVA NP Affidavits

**Attached are the AREVA NP affidavits supporting the request to withhold
proprietary information from the public.**

AFFIDAVIT

STATE OF WASHINGTON)
) ss.
COUNTY OF BENTON)

1. My name is Alan B. Meginnis. I am Manager, Product Licensing, 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 the report ANP-3150P, Revision 0, "Mechanical Design Report for Browns Ferry ATRIUM™10XM Fuel Assemblies," dated October 2012 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.

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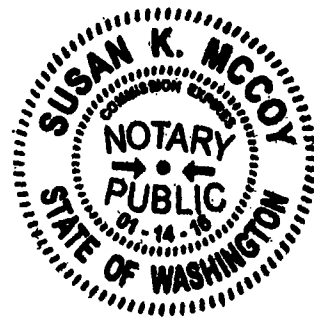
9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

Mr E Meyer

SUBSCRIBED before me this 19th
day of October, 2012.

Susan K McCoy

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



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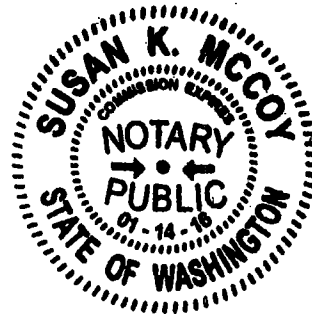
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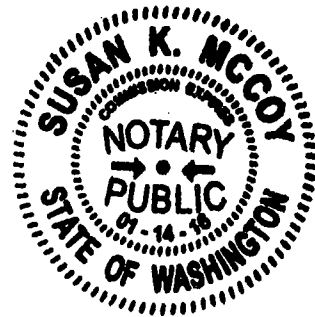
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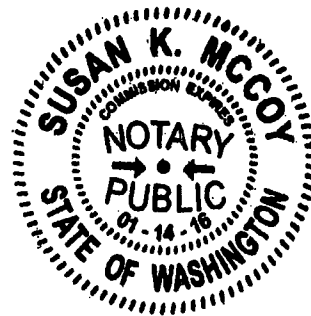
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M. G. M.

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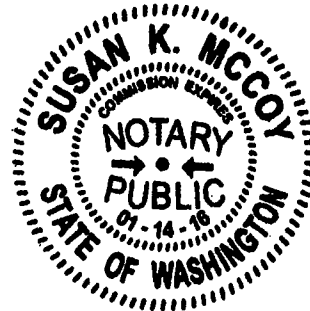
9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

Al S. McCoy

SUBSCRIBED before me this 4th
day of October, 2012.

Susan K. McCoy

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



AFFIDAVIT

STATE OF WASHINGTON)
) ss.
COUNTY OF BENTON)

1. My name is Alan B. Meginnis. I am Manager, Product Licensing, 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 the report ANP-2860P, Revision 2, Supplement 1P Revision 0, "Browns Ferry Unit 1 – Summary of Responses to Request for Additional Information Extension For ATRIUM 10XM," dated November 2012 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.
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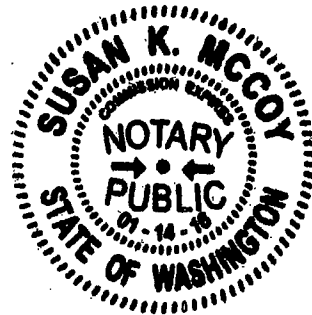
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8. AREVA NP policy requires that proprietary information be kept in a secured file or area and distributed on a need-to-know basis.

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

Mr E May

SUBSCRIBED before me this 16th
day of November, 2012.



Susan K McCoy

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

AFFIDAVIT

STATE OF WASHINGTON)
) ss.
COUNTY OF BENTON)

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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 the report ANP-3170P, Revision 0, "Evaluation of Fuel Conductivity Degradation for ATRIUM 10XM Fuel for Browns Ferry Units 1, 2, and 3," dated November 2012 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.

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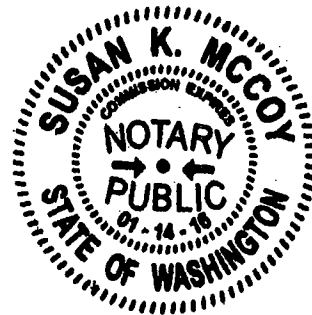
9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

W B Meg

SUBSCRIBED before me this 12th
day of November, 2012.

Susan K McCoy

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



AFFIDAVIT

STATE OF WASHINGTON)
) ss.
COUNTY OF BENTON)

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3. I am familiar with the AREVA NP information contained in the report ANP-3159P, Revision 0, "ATRIUM™ 10XM Fuel Rod Thermal-Mechanical Evaluation for Browns Ferry Unit 2 Cycle 19 Reload BFE2-19," dated October 2012 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.

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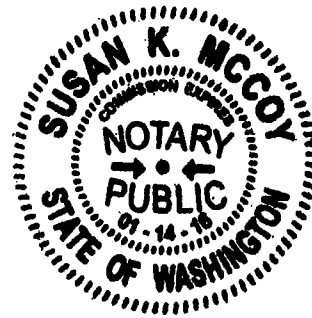
9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

W E Meyer

SUBSCRIBED before me this 30th
day of October, 2012.

Susan K McCoy

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



AFFIDAVIT

STATE OF WASHINGTON)
) ss.
COUNTY OF BENTON)

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3. I am familiar with the AREVA NP information contained in the report ANP-3148(P), Revision 0, "Browns Ferry ATRIUM™10XM Equilibrium Cycle Design Summary," dated August 2012 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.

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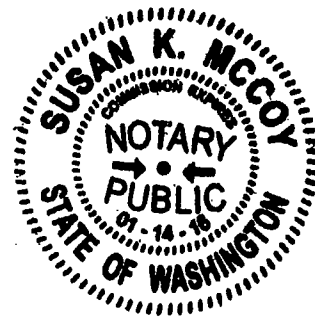
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9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

Mr & Mrs

SUBSCRIBED before me this 22nd
day of August, 2012.



Susan K. McCoy

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

AFFIDAVIT

STATE OF WASHINGTON)
) ss.
COUNTY OF BENTON)

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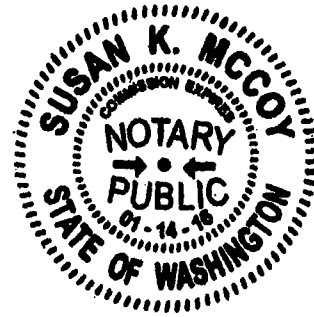
9. The foregoing statements are true and correct to the best of my knowledge,
information, and belief.

Mr. B. Meyer

SUBSCRIBED before me this 30th
day of October, 2012.

Susan K. McCoy

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



AFFIDAVIT

STATE OF WASHINGTON)
) ss.
COUNTY OF BENTON)

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

Air 2 McCoy

SUBSCRIBED before me this 28th
day of November, 2012.

Susan K McCoy

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

