April 5, 2013   MPWR-LTR-13-00019

U.S. Nuclear Regulatory Commission (NRC)
ATTN: Document Control Desk
11555 Rockville Pike
Rockville, MD 20852-2738

Babcock & Wilcox mPower, Inc.
Docket Number-PROJ0776
Project Number-776

Subject: Submittal of Babcock & Wilcox Nuclear Energy, Inc. (B&W mPower) Supplemental
            Information in support of NRC Acceptance Review of Core Topical Report
            R003-03-002106

Reference: ACCEPTANCE FOR REVIEW OF BABCOCK & WILCOX TOPICAL REPORT
            R003-03-002106, "CORE NUCLEAR DESIGN CODES AND METHODS
            QUALIFICATION" (PROJ0776), dated March 8, 2013

As discussed and agreed upon in a telephone conference with the NRC staff on March 7, 2013, and
documented in the above referenced letter, B&W mPower is providing the following supplemental
information in support of the NRC Acceptance Review of Core Topical Report R003-03-002106:

- The SPND data for the Three Mile Island (TMI-1) core follow cases contained in the reference
  Electric Power Research Institute (EPRI) reports and a description of the methodology and the
  associated information necessary to compare that data with the corresponding
  CASMO-5/SIMULATE-3 predictions at each time step.

- The MCNPX input decks for the Beginning of Cycle (BOC) (critical Hot Full Power (HFP) and All Rods
  Out (ARO) (HFP), 5 GWd/MTU (critical HFP before and after control rod exchange and ARO HFP), and
  10 GWd/MTU (critical HFP and ARO HFP) cases.

The above identified data is provided as files on a CD as Enclosure 2. Enclosure 3 entitled
"Summary of TMI Data Reduction and Analysis," is provided to assist with your understanding of
how the prediction of the assembly power was determined.

In addition we are providing, in Enclosure 4, errata pages to the Supplement to Topical Report
R003-03-002106 "Validation of B&W mPower Core Design Methods," MPWR-TOPR-000001. That
report was submitted to the NRC on August 30, 2012, letter number MPWR-LTR-00076.

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NRO

A portion of the information provided with this letter is Confidential Commercial Information (CCI). We request that the enclosures containing CCI be withheld from public disclosure in accordance with the requirements of 10 CFR 2.390.

Enclosure 1 is a signed affidavit that provides the justification for withholding the CCI information. Enclosure 2, the CD, is entirely CCI. It includes the TMI comparison data in Excel spreadsheets with embedded footers on all pages, indicating the confidential and proprietary nature of the information. (These footers will be present on printed versions of the spreadsheets.) This CD also includes the electronic MCNPX decks, which are also confidential and proprietary. No redacted version of the CD is provided.

Enclosure 3, "Summary of TMI Data Reduction and Analysis" contains CCI information marked in brackets. Enclosure 4, the errata pages, also contains CCI information marked in brackets. A redacted version of the errata pages is not provided in that the redacted version provided with the August 30, 2012 letter remains unchanged. Enclosure 5, the redacted version of the "Summary of TMI Data Reduction and Analysis" can be released to the public.

Questions concerning this submittal may be directed to Jeff Halfinger at 434-316-7507 (email: jahalfinger@babcock.com) or Peter Hastings at 980-365-2071 (email: pshastings@generationmpower.com).

Jeffrey A. Halfinger
VP, mPower NSSS Technology
B&W mPower

JAH/jlr

Enclosures: 1. Affidavit
              2. CD containing data and input decks (CCI)
              3. Summary of TMI Data Reduction and Analysis (CCI)
              4. Errata pages (CCI)
              5. Summary of TMI Data Reduction and Analysis (Redacted)

cc: Joelle L. Starefos, NRC, TWFN 9-F-27
       Stewart L. Magruder, Jr., NRC, TWFN 9-F-27

Enclosure 1
AFFIDAVIT of Jeffery A. Halfinger

Enclosure 1

AFFIDAVIT OF Jeffrey A. Halfinger

STATE OF VIRGINIA

CITY OF LYNCHBURG

I, Jeffrey A. Halfinger, being duly sworn, do hereby depose and say:

1. I am a citizen of the United States of America. I am a resident of Lynchburg, Virginia. My birth date is November 4th, 1961.

2. I am the Vice President, Babcock & Wilcox mPower (B&W mPower) NSSS Technology, located in Lynchburg, Virginia.

I have held this position since June 1, 2010. I have personal knowledge of the facts set forth in this affidavit, and if called and sworn as a witness in a deposition or before any court, I could and would testify competently under oath to these facts.

3. B&W mPower requests that the NRC withhold from public disclosure the information marked as "B&W Confidential Commercial Information" regarding certain design information being submitted to the NRC by the B&W mPower letter number MPWR-LTR-13-00019. This information is included in enclosures to that letter: Supplemental Information in support of NRC Acceptance Review of Core Topical Report R003-03-002106.

4. I have personal knowledge of the criteria and procedures used by B&W mPower in designating confidential commercial or financial information as proprietary and have been delegated the function to review the information to identify proprietary information and authorized to apply for its withholding. The need for confidentiality is driven by the following:

a) The information requested to be withheld reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) whose use by any of B&W mPower's competitors, without a license from the submitter, would constitute a competitive economic disadvantage to B&W mPower.

b) Use by a competitor of the information requested to be withheld would reduce a competitor's expenditure of resources, or improve its competitive position, in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product.

c) The information requested to be withheld reveals aspects of privately funded development plans or programs of commercial value to B&W mPower.

d) The information requested to be withheld consists of patentable ideas.

5. Specifically, the information identified in paragraph 3 above, is classified as proprietary because B&W mPower has developed the conceptual and technical approaches regarding details of the design of the B&W mPower™ Reactor core and associated analysis, and classifications, disclosure of which could adversely affect B&W mPower's competitive position by informing competitors of the degree of maturity and viability of the program, thereby motivating them to increase efforts to develop competing technologies. These features of the reactor design were privately funded by B&W mPower and are of commercial value to B&W mPower because of their nature in providing key elements of the B&W mPower™ reactor design analysis. All or parts of the approach described in the withheld material is patentable.

I declare under penalty of perjury under the laws of the United States of America that the foregoing is a true and correct statement of facts.
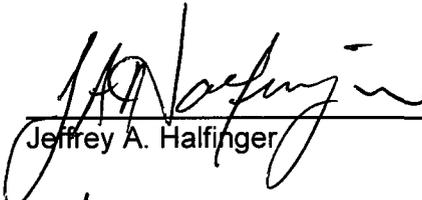
Jeffrey A. Halfinger

Subscribed and sworn to before me this _____5th_____ day of April, 2013.
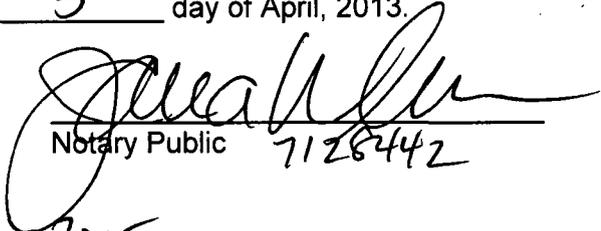
Notary Public 7126442

My commission expires: _Aug. 31, 2015_

**Enclosure 2
CD containing data and input decks
(CCI)**

Enclosure 5
Summary of TMI Data Reduction and Analysis
(REDACTED)

Summary of TMI Data Reduction and Analysis

Introduction

The analytical performance of the Babcock and Wilcox (B&W) Core Nuclear Design Codes and Methods in the prediction of assembly power distribution for TMI-1 Cycles 1 and 2 was determined by comparing the "measured" assembly power to the assembly power calculated by *CASMO-5/SIMULATE-3*. However, the measured assembly power was derived from Rhodium fixed incore detector signals measured in nano-amps that correspond to the neutron flux at the self-powered neutron detector (SPND) locations in the TMI core. These signals were converted to a measured power by multiplying each measured signal value by an analytically derived signal-to-power conversion factor calculated using *CASMO-5/SIMULATE-3*. The measured powers at the fixed SPND locations were processed to compute assembly power using a simple spline fit within the *EXCEL* software package.

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Analytical Process Description

The measured axial and radial power distributions were analyzed in an *EXCEL* spreadsheet using a technique that mimics, in a very simplified way, the processing performed by nuclear application software used in operating reactors. It was possible to develop this *EXCEL* spreadsheet with a minimal amount of calculational effort because the measured signals from TMI-1 Cycles 1 and 2, reported in Reference 1, were already corrected for the following effects:

1) SPND as-built variations in sensitivity
2) detector signal leakage
3) detector depletion

[CCI per Affidavit 4(a)-(d)]

Since the analysis of the core follow for TMI-1 Cycles 1 & 2 in *CASMO-5/SIMULATE*-3 was performed in one-eighth core symmetry, it was necessary to reduce the TMI-1 data to the equivalent geometry and correct the measured signal data for the power tilt on a quarter core basis. Simplified correction factors derived from the 16 symmetric In-Core Detector Assemblies (ICDAs) were used to calculate the power tilt (and the corresponding inversely proportional correction factor) for each quadrant. A small number of suspect SPNDs were identified and the measurements corrected by substituting their equivalent symmetric signals.

TMI-1 Core Description

The signal data reported in Reference 1 were given in nano-amps at seven axial SPND locations for each of the fifty-two assemblies (out of a total of 177 assemblies in the core) containing ICDAs. These data were provided for several state points during Cycles 1 and 2. Figure 1 presents the layout of the core and shows the locations of the ICDAs. This arrangement allows for one-eighth core representation to be constructed, providing a sufficient amount of data to predict the behavior of the whole core.
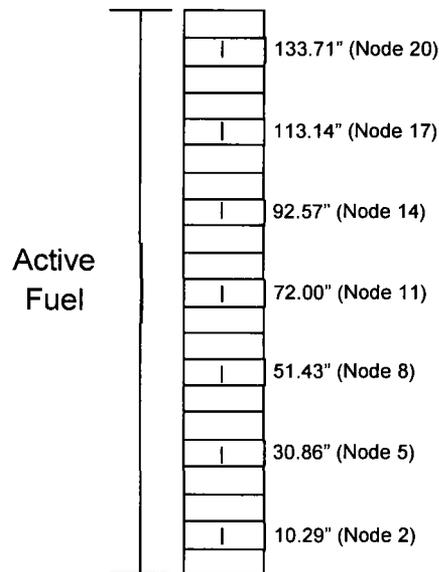
Figure 1: Core Cross-Section with Highlighted ICDAs
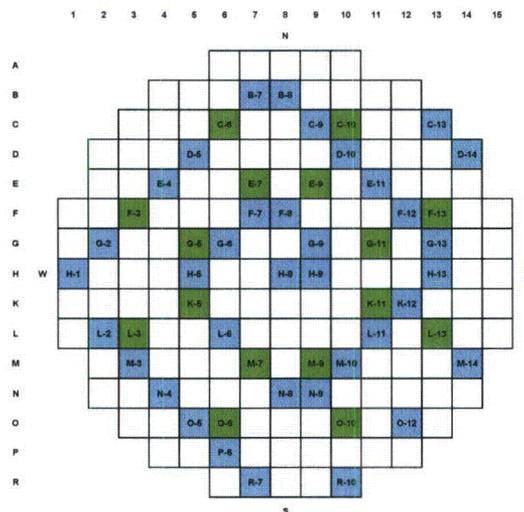
SIMULATE-3 Model Description

The Rhodium SPNDs corresponding to those detailed in Reference 1 were explicitly modeled in the *SIMULATE-3* analysis of the TMI-1 operating cycles. The calculated reaction rates resulting from the absorption of thermal and fast neutrons in the simulated SPNDs are directly proportional to the measured nano-amp signals that would be obtained from an incore system in an actual plant. Figure 2 provides a representation of how each assembly was axially divided into twenty-one nodes such that each SPND (4.75 inches in length) would be fully encompassed by a single node. The seven SPNDs in each ICDA were located 10.29, 30.86, 51.42, 72.00, 92.57, 113.14, and 133.71 inches from the bottom of the core, corresponding to the 2nd, 5th, 8th, 11th, 14th, 17th, and 20th nodes, respectively.

Figure 2: SPND/Nodal Representation

133.71" (Node 20)

113.14" (Node 17)

92.57" (Node 14)

Active Fuel

72.00" (Node 11)

51.43" (Node 8)

30.86" (Node 5)

10.29" (Node 2)

SIMULATE-3 Core Follow Data

A detailed core follow *SIMULATE-3* calculation was then performed for both TMI-1 operating cycles. The output files were post-processed to extract the calculated SPND reaction rates and corresponding calculated nodal powers. The following specific output data from *SIMULATE-3* were input into the *EXCEL* spread sheets: a) the calculated reaction rates for the seven (7) axial SPND positions corresponding to measured signal locations in the TMI core and b) the calculated nodal power data. The control rod insertion data was added so that the control rod positions could be overlaid on the generated power profiles as a visual aid to the analysis.

Processing the SPND Data

The equivalent measured data from Reference 1 were also input to the *EXCEL* spreadsheets. Figure 2 shows the flow of the data processing starting with both the measured data from Reference 1 and the calculated data from *CASMO-5/SIMULATE-3*. Once all of the measured data was input into the *EXCEL* files, it was rearranged (using the tilt correction factor for the signal data in each quadrant, as detailed above) into a one-eighth core configuration by "folding" the measured data for the assemblies throughout the core into a one-eighth core arrangement of 29 assemblies. The inner and outer symmetrical rings (consisting of 8 ICDAs each) were reduced to the average reading of the 8 SPNDs in each ring. Those assemblies are highlighted in green in Figure 4. For those locations where there were two symmetrical SPNDs, a simple average of the two readings is used for the eighth-core assembly reading. Those assemblies are highlighted in teal in Figure 4.

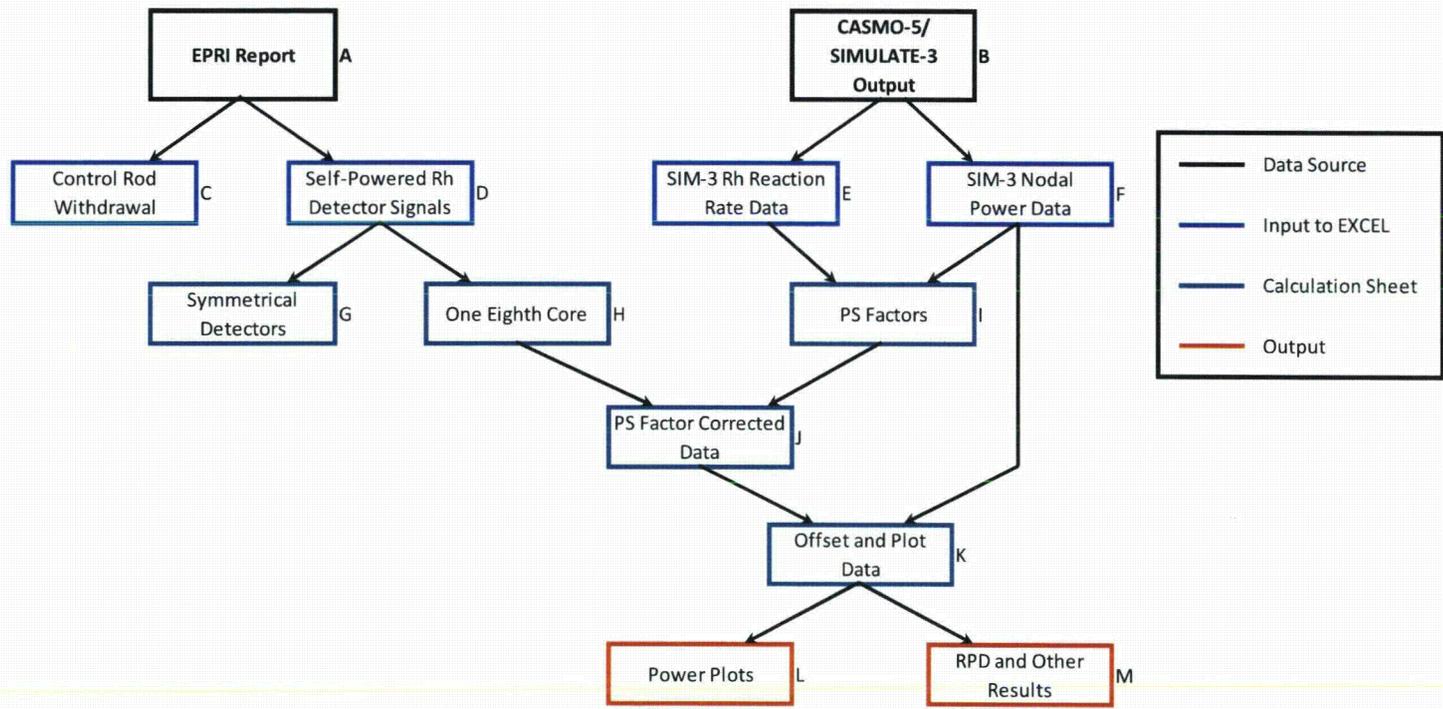# Figure 3: EXCEL Processing Flowchart

Figure 4: One-Eighth Core Representation

	8	9	10	11	12	13	14	15
H	H-8	H-9	F-8	H-5	N-8	H-13	B-8	H-1
K		G-9	F-7/C-6	K-11	K-12/N-9	G-13/C-9	B-7/G-2	R-7
L			L-6	L-11/M-10	D-10/F-12	L-13	L-2/P-6	R-10
M				E-11	D-5/E-4	M-3/O-5	M-14	
N					N-4	O-12	D-14	
O						C-13		

Formulation of the Signal-to-Power Conversion Factor

To convert the measured nano-amp signals to measured power signals, a signal-to-power conversion factor was determined from the calculated power density in the node and the calculated signals, which are directly proportional to the reaction rates within the rhodium detector, using the following equation:

$$\left(\frac{Power_{calculated}}{Reaction\ Rate_{calculated}}\right)$$

Converting the SPND Signals to Measured Power Signals

The measured nano-amp signal data were then multiplied by the signal-to-power conversion factor determined above to convert measured signal to power signal as follows:

$$P_{m\ i,j,k} = S_{m\ i,j,k} \times \left(\frac{P_c}{S_c}\right)_{i,j,k}$$

Where:
P_m = measured Power
S_m = measured Signal
P_c = Calculated Power
S_c = Calculated Signal (equal reaction rate)

The seven measured power signals were then expanded to 21 points using a normal cubic spline function (in **EXCEL** through the XIXtrFun add-in), using -3 and 147 inches as the zero points. The values between 0 inches and 144 inches represented the axial power shape distribution. To guarantee that the total core measured power is equal to the calculated power, the measured assembly power shapes were normalized to a value of one. The average of the axial measured relative power distribution along the assembly provided the measured radial relative power distribution, similar to that calculated by **SIMULATE-3**.

Statistical Analysis Results

The standard deviation was calculated for each cycle, with a resulting value of 0.03589 for Cycle 1 and 0.03326 for Cycle 2. The combined standard deviation for both cycles was 0.03453. Note that these standard deviations are the combined measured and calculated deviations; and thus the calculated standard deviations are less than the above indicated values.