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U.S. Nuclear Regulatory Commission
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Babcock & Wilcox Nuclear Energy, Inc.
Docket Number-PROJ0776
Project Number-776

Subject: Submittal of Babcock & Wilcox Nuclear Energy, Inc. (B&W NE) Control Rod Drive Mechanism (CRDM) Design Details and Development Plan Technical Report (NP)

On October 28, 2010, a proprietary version of the subject report was sent to the NRC. This letter provides a redacted, non-proprietary version of that report to be placed in our project file.

Questions concerning this submittal may be directed to T. J. Kim at 434-382-9791 (email: tjkim@babcock.com) or to J. A. Halfinger at 434-316-7507 (email: jahalfinger@babcock.com).

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VP, Technology Development
B&W NE

JAH/msc

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

D104
NRO

Document No.	Title:
R0003-96-002506 (NP)	B&W mPower™ Reactor- CRDM Design Details and Development Plan Technical Report

Redacted Non-Proprietary Version

babcock & wilcox nuclear energy

B&W mPower™ Reactor

CONTROL ROD DRIVE MECHANISM DESIGN DETAILS AND DEVELOPMENT PLAN TECHNICAL REPORT

R0003-96-002506 (NP)
October 2010

generation *mPower*

B&W *mPower* Reactor Program
Babcock & Wilcox Nuclear Energy, Inc.
109 Ramsey Place
Lynchburg, VA 24501

Confidential Commercial Information Is Enclosed in Square Brackets: and Reasons for Withholding the Identified CCI from Public Disclosure Are Provided in an Accompanying Affidavit

NP-00590-02

Babcock & Wilcox Nuclear Power Generation Group, Inc.
a Babcock & Wilcox company

NUCLEAR EXTERNAL DOCUMENT REVIEW FORM

B&W NPG Contract No.:

Document Source: ☐ Customer ☒ Supplier ☐ Subcontractor ☐ Other

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Document Title: Control Rod Drive Mechanism Design Details and Development Plan Technical Report

Originator Document No.: TR-213 | Revision No.: 0

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NPG Exceptions/ Comments: ☐ Exceptions ☐ Deficiencies ☒ Comments
(Use attachments as needed)
No comments-this document is for informational purposes only to allow for technical discussions between B&W NE and the Nuclear Regulatory Commission.

Signatures

	Printed Name	Signature	Date
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B&W NPG Number Assigned
☒ Yes ☐ No

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Redacted, Non-Proprietary Version

babcock & wilcox nuclear operations group

TR-213

B&W *mPower*™ Reactor

CONTROL ROD DRIVE MECHANISM DESIGN DETAILS AND DEVELOPMENT PLAN TECHNICAL REPORT

October 2010

B&W *mPower* ™ Reactor Program
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Confidential Commercial Information Is Enclosed in Square Brackets; and Reasons for Withholding the Identified CCI from Public Disclosure Are Provided in an Accompanying Affidavit

Babcock & Wilcox Nuclear Operations Group, Inc.

B&W *mPower*™ Reactor
Control Rod Drive Mechanism
Design Details and Development Plan Technical Report

SIGNATURES			
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Approved By:	James F. Fill Department Manager of Engineering	Signature: J F Fill	Date: 10/28/10

RECORD OF REVISION

Revision	Section(s) or Page(s)	Description of Changes
0	N/A	Initial Issue

Table of Contents

1. OVERVIEW

The B&W *mPower*™ reactor is a simplified, passive, modular, light-water-cooled, pressurized water nuclear reactor. It has a rated power output of approximately 125 MWe. The reactor uses an integral arrangement in which the reactor core, steam generator, pressurizer, control rod drive mechanisms (CRDMs) and reactor coolant pumps are combined into a common pressure vessel. Reactor power is controlled by the CRDMs, which also provide a failsafe safety control rod axe man (SCRAM) capability.

The B&W *mPower* reactor uses a common, unique and simple CRDM design that is both different from, and has significantly fewer parts than, conventional light-water reactor CRDMs. This is in part due to the fact that the system and its components are located entirely within the reactor pressure vessel and do not serve as a boundary for reactor coolant. This has certain inherent safety advantages as well as presenting certain challenges, primarily of materials choices for components.

This report provides a detailed description of the B&W *mPower* reactor CRDM design, functionality and operating characteristics. The report also discusses the application of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (References 1 and 2) to the design and structural evaluation of the CRDM, and to the material selection process. Areas where current regulatory guidance poses a challenge in application to the CRDM design are identified, along with proposed courses of action. Additionally, the report describes the CRDM test plan to demonstrate and verify the proper CRDM functionality under normal operational and emergency conditions.

2. MECHANISM FUNCTION AND DESIGN

This section of the report presents a detailed description of the design and function of the B&W *mPower* CRDM, along with operating characteristics and special features. It also identifies key design criteria that serve as the basis for the design and identifies the safety-related and non-safety-related features and functions of the CRDM.

The function of the CRDM is to control reactivity during power operation, to provide a failsafe SCRAM capability and to provide shutdown other than SCRAM. Specifically, during routine operation, the CRDM positions a control rod assembly in response to an electrical signal. Upon receipt of a SCRAM signal or loss of power, the CRDM releases the control rod assembly for free-fall insertion into the fuel assembly.

The CRDM is designed to operate inside the reactor vessel in [

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

2.1 Key Design Criteria

The B&W *mPower* reactor CRDM is designed to operate inside the reactor vessel in primary coolant water conditions. [

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

2.2 Description of CRDM Design

[

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

Figure 2.2-1 – Overall CRDM Mechanism, Fully Inserted

[

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

Figure 2.2-2 – Overall CRDM Mechanism, Fully Withdrawn

[

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

2.2.1 [

]

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

Figure 2.2.1-1 – [

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

Figure 2.2.1-2 – [

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

Figure 2.2.1-3 – [

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

Figure 2.2.1-4 – [

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

Figure 2.2.1-5 – [

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

Figure 2.2.1-6 – [

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

Figure 2.2.1-7 – [

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

Figure 2.2.1-8 – [

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

Figure 2.2.1-9 – [

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

2.2.2 [

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

Figure 2.2.2-1 – [

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

Figure 2.2.2-2 – [

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

2.2.3 [

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

Figure 2.2.3-1 – [

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

Figure 2.2.3-2 – [

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

Figure 2.2.3-3 – [

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

Figure 2.2.3-4 – [

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

2.2.4 [

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

Figure 2.2.4-1 – [

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

Figure 2.2.4-2 – [

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

2.2.5 [

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

Figure 2.2.5-1 – [

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

Figure 2.2.5-2 – [

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

Figure 2.2.5-3 – [

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

2.2.6 [

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

]

Figure 2.2.6-1 – [

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

Figure 2.2.6-2 – [Connecting Rod Assembly, Upper End

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

Figure 2.2.6-3 – [Connecting Rod Assembly, Lower End

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

2.2.7 [

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

Figure 2.2.7-1 – [

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

Figure 2.2.7-2 – [

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

2.3 Identification of Safety-Related and Non-Safety-Related Features and Functions

This section summarizes the safety-related (SR) and non-safety-related (NSR) features and functions of the B&W *mPower* reactor CRDM. Although the safety aspects of the CRDM were previously discussed as part of the overall description given in Section 2.2, they are restated here for completeness. The summary, which is provided in Table 2.3-1, includes the component/assembly definition, the safety designation (SR) or (NSR) and a brief description of the rational for the designation.

Table 2.3-1 – Identification of Safety-Related and Non-Safety-Related Attributes of CRDM

[

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

3. DESCRIPTION OF DESIGN CRITERIA AND MATERIAL SELECTION

This section of the report discusses the application of the ASME Code (Reference 1) to the specific component design criteria and to the structural evaluation of the B&W *mPower* reactor CRDM. Also included is a discussion of the material selection process.

3.1 CRDM Component Design Criteria

Footnote 9 of 10CFR50.55a states that guidance for quality group classifications of components may be found in NRC Regulatory Guide 1.26 and in Section 3.2.2 of NUREG-0800 "Standard Review Plan for Review of Safety Analysis Reports for Nuclear Power Plants." Regulatory Guide 1.26 provides guidance for "water-, steam-, and radioactive-waste-containing components" but does not provide guidance for supports or core support structures. Table 3.2.2-1 of NUREG-0800 includes guidance for components such as supports, metal containment components and core support structures.

The CRDM is totally contained within the reactor pressure vessel and is [

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

3.2 CRDM Material Selection

For the majority of the mechanism, and wherever possible, B&W *mPower* reactor CRDM materials are selected from those listed in Tables 2A, 2B, and 4, of the ASME Code, Section II, Part D (Reference 2). In some cases, the technical requirements of the CRDM have made necessary the use of materials other than those listed in the tables. The materials not listed in a table in the Code, or in a Code Case, are addressed as follows:

Non-Listed ASME Structural Materials for Safety-Related Components

Table 3.2-1 identifies the non-listed materials for the safety-related components. It also provides a rationale for their selection and any confirmatory testing that is being considered. The functional performance of the selected CRDM materials will be confirmed during performance verification testing as discussed in Section 4 of this report.

Non-Listed ASME Structural Materials Selected for Non-Safety-Related Components

Table 3.2-2 identifies the non-listed materials for non-safety-related components. It also provides a rationale for their selection, and any confirmatory testing that is being considered. The functional performance of the selected materials will be confirmed during CRDM performance verification testing as discussed in Section 4 of this report.

Table 3.2-1 – Non-Listed ASME Materials Selected for Safety-Related Components

[

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

Table 3.2-2 – Non-Listed ASME Materials Selected for Non-Safety-Related Components

[

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

Table 3.2-2 – Non-Listed ASME Materials Selected for Non-Safety-Related Components (Continued)

[

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

4. MECHANISM TEST PLAN

CRDM testing will be performed [

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

4.1 Description of Planned Sub-Assembly Tests and Objectives

[

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

Table 4.1-1 – [

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

Table 4.1-2 – [

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

Table 4.1-3 – [

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

4.2 Description of Planned Life Tests and Objectives

[

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

Table 4.2-1 – CRDM Life Tests

[

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

5. CONCLUSION AND SUBSEQUENT ACTIONS

All design functionality, material selection, and test plans discussed in this document are subject to change as analysis and test results become available. It is B&W's intention to complete as much of the testing as possible prior to the Design Certification Application submittal but sub-component and CRDM life testing will continue beyond the submittal date. Table 5-1 identifies a high level schedule for performance of planned tests. At this time it is uncertain how many years beyond DCD submittal that the motor tests and CRDM life tests will continue.

Table 5-1: CRDM High Level Test Schedule

[

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

6. REFERENCES

1. ASME Boiler and Pressure Vessel Code, Section III, Division 1, "Rules for Construction of Nuclear Facility Components", Subsection NG, 2007 Edition, 2008 Addenda.

2. ASME Boiler and Pressure Vessel Code, Section II, Part D, "Materials", 2007 Edition, 2008 Addenda.

3. Stein, A.A., and Gennaro, M.S., "Material Specification for Alloy X-750 in LWR Internal Components", EPRI NP-6202, Project 2181-4, January 1989.

4. Gorman, J., "Materials Handbook for Nuclear Plant Pressure Boundary Applications", EPRI, Palo Alto, CA: 2002. 1002792.