ENCLOSURE 2

MFN 13-034

NEDO-33819, Revision 0

GEH Marathon and Ultra Control Rod Lifetime Surveillance Update

Non-Proprietary Information – Class I (Public)

IMPORTANT NOTICE

This is a non-proprietary version of NEDC-33819P, Revision 0, which has the proprietary information removed. Portions of the document that have been removed are indicated by white space with an open and closed bracket as shown here [[ ]].

HITACHI

GE Hitachi Nuclear Energy

NEDO-33819
DRF Section 0000-0162-0378-R1
Revision 0
July 2013

Non-Proprietary Information – Class I (Public)

GEH Marathon and Ultra Control Rod Lifetime Surveillance Update

PROPRIETARY INFORMATION NOTICE

This is a non-proprietary version of the document NEDC-33819P, Revision 0, which has the proprietary information removed. Portions of the document that have been removed are indicated by an open and closed bracket as shown here [[ ]].

IMPORTANT NOTICE REGARDING CONTENTS OF THIS REPORT

Please Read Carefully

The design, engineering, and other information contained in this document are furnished for the purposes stated in the transmittal letter. The only undertakings of GEH with respect to information in this document are contained in the contracts between GEH and its customers or participating utilities, and nothing contained in this document shall be construed as changing that contract. The use of this information by anyone for any purpose other than that for which it is intended is not authorized; and with respect to any unauthorized use, GEH makes no representation or warranty, and assumes no liability as to the completeness, accuracy, or usefulness of the information contained in this document.

TABLE OF CONTENTS

Acronyms and Abbreviations v
1. Introduction 1
2. Marathon Control Rod Description 2
3. Ultra Control Rod Description 4
4. Inspection Data 7
5. Evaluation 13
6. Planned Inspections 14
7. References 15

TABLES

Table 1. Marathon and Ultra Control Rod Design Comparison 6
Table 2. D/S Lattice* Marathon Control Rod Inspection Results 8
Table 3. C Lattice* Marathon Control Rod Inspection Results 11
Table 4. Ultra MD Control Rod Inspection Results 12
Table 5. Planned Control Rod Inspections 14

FIGURES

Figure 1. Marathon Control Rod Diagram 2
Figure 2. Marathon Control Rod Diagram 3
Figure 3. Ultra Control Rod Diagram 5

ACRONYMS AND ABBREVIATIONS

Term	Definition
BWR	Boiling Water Reactor
CRB	Control Rod Blade
GEH	GE Hitachi Nuclear Energy
HD	High Duty
IASCC	Irradiation Assisted Stress Corrosion Cracking
MD	Medium Duty
NRC	Nuclear Regulatory Commission
SER	Safety Evaluation Report

1. INTRODUCTION

Since the beginning of the Marathon control rod product line, GE Hitachi Nuclear Energy (GEH) has actively maintained a surveillance program consisting of visual inspections of Marathon control rods. This is in accordance with the approved safety evaluation report (SER) for the Marathon control rod (Reference 1). A summary of the status of this surveillance program (Reference 2) was last forwarded to the Nuclear Regulatory Commission (NRC) via MFN 12-091 (Reference 3), and was also provided to the boiling water reactor (BWR) fleet.

GEH has transitioned to the Ultra control rod product line, with the first deliveries made in 2009. Like the Marathon control rod, a surveillance program is in place, consisting of visual inspections, as required for Ultra medium duty (MD) (Reference 4, Marathon-5S Control Rod Assembly) and Ultra high duty (HD) (Reference 5, Marathon-Ultra Control Rod Assembly) control rods.

This report updates Reference 2, including:

- New inspection results for Marathon control rods.
- Results from a new inspection of an Ultra MD control rod.
- A listing of planned inspections.

GEH will continue to provide updates of the Marathon and Ultra control rod surveillance programs on an annual basis.

2. MARATHON CONTROL ROD DESCRIPTION

As described in Reference 1, the Marathon control rod consists of 'square' absorber tubes, edge welded together to form the control rod wings. The 'lobes' of the square absorber tubes provide both a welding surface area and act as a wear surface. The four wings are welded to central tie rod segments to form a cruciform shape. A cross-sectional view of the control rod absorber section is shown in Figure 1.

The square absorber tubes are filled with capsules containing compacted boron carbide powder, empty capsule plenums, or hafnium rods. [[

]] All absorber contents are sealed within the absorber tubes by welded end plugs. A handle and velocity limiter are attached at the top and bottom respectively to complete the assembly (Figure 1).

[[

]]

Figure 1. Marathon Control Rod Diagram

Figure 2 shows a design modification that was made to the geometry of the D/S lattice 'square' absorber tube. Implementation of this modification began in 2006. Two changes were made:

1. [[

]]

[[

]]

Figure 2. Marathon Control Rod Diagram

In February 2011, GEH issued Reference 6, which reduced the lifetime of all D and S lattice Marathon control rods. This lifetime reduction was done in response to mechanical failures observed as part of the Marathon surveillance program. [[

]]

Current lifetime recommendations for all GEH control rods may be found in Reference 7.

3. ULTRA CONTROL ROD DESCRIPTION

GEH has transitioned to the Ultra MD (licensed as 'Marathon-5S' in Reference 4) and Ultra HD (licensed as 'Marathon-Ultra' in Reference 5) control rods. These control rods use the same basic inner capsule within an outer absorber tube design as the Marathon control rod, but include conservative design features intended to prevent the type of cracking observed in Marathon control rods. The primary difference is the use of a simplified absorber tube geometry, shown in Figure 3. Like the Marathon design, the absorber tubes are laser welded together to form the wings of the control rod assembly, and are filled with boron carbide and empty capsules (Ultra MD and HD), and hafnium rods (Ultra HD only). For the Ultra design, a single full-length central tie rod joins the wings of the control rod, rather than the tie rod segments used in the Marathon design.

[[

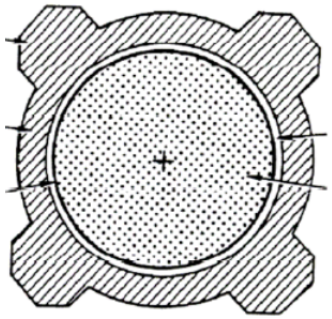
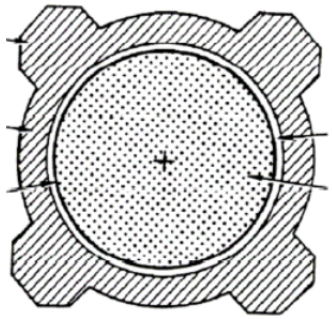
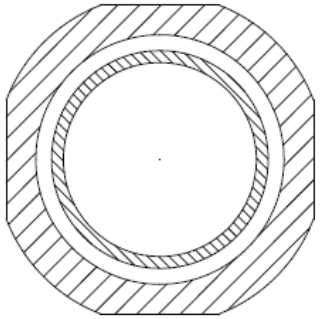
]]

[[

]]

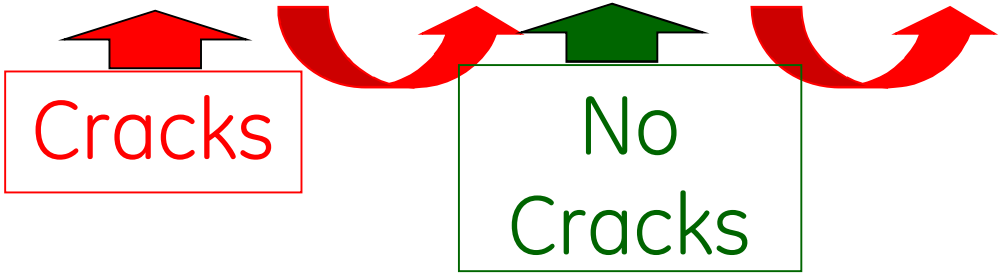
Figure 3. Ultra Control Rod Diagram

Table 1. Marathon and Ultra Control Rod Design Comparison

Parameter	Marathon D/S	Marathon C	Ultra
Absorber Tube			
Local B-10 Depletion at Capsule Contact	[[		
Swelling Induced Strain at 100% Local Depletion			]]

Note:

[[ ]]



4. INSPECTION DATA

Tables 2, 3, and 4 contain a summary of [[ ]] visual inspections of Marathon and Ultra control rods that GEH has performed or reviewed to date. Since the 2012 report (Reference 2), [[ ]] additional inspections of Marathon control rods using D/S lattice absorber tubes have been performed at two plants, and are shown in bold in Table 2. In addition, [[ ]] D/S lattice Ultra MD control rod has been inspected, as shown in Table 4.

Tables 2, 3, and 4 show the serial number of each control rod inspected, as well as the year the control rod was delivered to the plant, and the month and year of the inspection. It is noted that in some cases, the same control rod has been inspected during multiple outages as it has been irradiated. For D/S lattice Marathon control rods, Table 2 indicates whether the control rods used the 'old' or 'new' square tube geometry, discussed in Section 2.

The depletion of each control rod is represented using four measures:

- The approximate thermal fluence of the peak ¼ segment, in units of snvt.
- The percent B-10 depletion of the peak ¼ segment, expressed as a percent.
- The peak local B-10 depletion, at the highest depletion node and tube location, also expressed as a percent.
- For control rod inspections with crack indications, the range of local B-10 depletion at which cracks are observed.

Tables 2 and 3 also identify those control rods that are part of the 'etch-affected' population described by Reference 8. For a certain population of Marathon control rods manufactured between 1997 and 2002, an incomplete cleaning operation prior to an annealing process at the absorber tubing vendor left localized locations on the tubes that are potentially sensitized to IASCC. In response, GEH reduced the lifetime of these control rods, and embarked on a campaign of visual inspections to determine the actual effect. Recommended lifetime limits for etch-affected Marathon control rods are contained in References 7 or 8. As noted in Table 2, [[ ]] of the [[ ]] new Marathon control rod inspections are of etch-affected control rods. The effort to acquire additional inspection data for highly irradiated etch-affected control rods is on-going. Ultra control rods are not affected by the etch issue.

Table 2. D/S Lattice* Marathon Control Rod Inspection Results

Plant	Serial Number	Ship Year	Inspection Date	Thermal Fluence (snvt)	¼-Segment B-10 Depletion (%)	Peak Local B-10 Depletion (%)	Crack Indications ?	Local B-10 Depletion at Crack Location (%)	Etch-Affected ?	Square Tube Geometry
Plant A (US BWR/4)	[[									]]

Table 2. D/S Lattice* Marathon Control Rod Inspection Results (Continued)

Plant	Serial Number	Ship Year	Inspection Date	Thermal Fluence (snvt)	¼-Segment B-10 Depletion (%)	Peak Local B-10 Depletion (%)	Crack Indications ?	Local B-10 Depletion at Crack Location (%)	Etch-Affected ?	Square Tube Geometry
Plant D (International BWR)	[[									
Plant E (US BWR/2)										
Plant J (International BWR)										
Plant K (International BWR)										
Plant L (US BWR/6)										
Plant M (US BWR/4)										
Plant N (International BWR)										
										]]

Table 2. D/S Lattice* Marathon Control Rod Inspection Results (Continued)

Plant	Serial Number	Ship Year	Inspection Date	Thermal Fluence (snvt)	¼-Segment B-10 Depletion (%)	Peak Local B-10 Depletion (%)	Crack Indications ?	Local B-10 Depletion at Crack Location (%)	Etch-Affected ?	Square Tube Geometry
Plant O (International BWR/6)	[[									
Plant P (International BWR)										
Plant Q (US BWR/4)										
										]]

Note:

* "D/S" absorber tubes are used for GEH D lattice (BWR/2-4) and S lattice (BWR/6) applications.

Table 3. C Lattice* Marathon Control Rod Inspection Results

C Lattice Visual Inspection Data Plant	Serial Number	Ship Year	Inspection Date	Thermal Fluence (snvt)	¼-Segment B-10 Depletion (%)	Peak Local B-10 Depletion (%)	Crack Indications ?	Etch-Affected?
Plant B (International BWR)	[[							
Plant C (International BWR)								
Plant F (US BWR/4)								
Plant G (International BWR)								
								]]

Note:
* "C" absorber tubes are used for GEH C lattice (BWR/4,5) applications.

Table 4. Ultra MD Control Rod Inspection Results

Plant	Serial Number	Ship Year	Inspection Date	Thermal Fluence (snvt)	¼-Segment B-10 Depletion (%)	Peak Local B-10 Depletion (%)	Crack Indications ?
Plant M (US BWR/4)	[[						
Plant N (Int'l BWR)							
Plant R (Int'l BWR/4)							]]

Several observations are made based on the crack statistics.

- [[

]]

5. EVALUATION

[[

]]

6. PLANNED INSPECTIONS

In accordance with the Marathon SER (Reference 1), GEH is continuing to pursue visual inspections of high depletion Marathon control rods in order to confirm the new lifetime limits contained in References 6 and 7. For Ultra control rods, visual inspections of lead depletion control rods are planned in accordance with the requirements of the Reference 4 and 5 safety evaluations. Table 5 shows a listing of planned inspections.

Table 5. Planned Control Rod Inspections

Plant	Absorber Tube Type*	Control Rod Type	Planned Inspection Date	Number of Control Rod Blades (CRBs) to be Inspected	Thermal Fluence (snvt)	¼-Segment B-10 Depletion (%)	Peak Local B-10 Depletion (%)
Plant M (US BWR/4)	D/S/N	Ultra MD	[[				
Plant N (Int'l BWR)	D/S/N	Ultra HD					
Plant N (Int'l BWR)	D/S/N	Ultra MD					]]

Note:

* "D/S/N" absorber tubes are used for GEH D lattice (BWR/2-4), S lattice (BWR/6), and N lattice (ABWR) applications. "C" absorber tubes are used for GEH C lattice (BWR/4,5) applications.

7. REFERENCES

1. GE Nuclear Energy, "GE Marathon Control Rod Assembly," NEDE-31758P-A, October 1991.
2. GE Hitachi Nuclear Energy, "GEH Marathon Control Rod Lifetime Surveillance Update," NEDC-33769P, Revision 0, July 2012.
3. Letter from James F. Harrison (GEH) to Document Control Desk (NRC), "Marathon and Ultra Control Rod Assembly Surveillance Program Update," MFN 12-091, July 30, 2012.
4. GE Hitachi Nuclear Energy, "Licensing Topical Report: Marathon-5S Control Rod Assembly," NEDE-33284P-A, Revision 2, October 2009.
5. GE Hitachi Nuclear Energy, "Licensing Topical Report: Marathon-Ultra Control Rod Assembly," NEDE-33284 Supplement 1P-A, Revision 1, March 2012.
6. Safety Communication, "Part 21 Reportable Condition Notification: Design Life of D and S Lattice Marathon Control Blades," SC 11-01, February 2011.
7. GE Hitachi Nuclear Energy, "GEH BWR Control Rod Lifetime," NEDE-30931P, Revision 14, March 2012.
8. Safety Communication, "Update: Etch Indications on Marathon Control Rod Blade Absorber Tubes," SC 07-02, January 2007.