

## ENCLOSURE 2

MFN 14-050

NEDO-33856, Revision 0

GEH Marathon and Ultra Control Rod Lifetime Surveillance  
Update

Non-Proprietary Information – Class I (Public)

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**GE Hitachi Nuclear Energy**

NEDO-33856  
Revision 0  
August 2014

*Non-Proprietary Information – Class I (Public)*

## **GEH Marathon and Ultra Control Rod**

### **Lifetime Surveillance Update**

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**Acronyms and Abbreviations**

<b>Term</b>	<b>Definition</b>
ABWR	Advanced Boiling Water Reactor
B-10	Boron-10
BWR	Boiling Water Reactor
GEH	GE-Hitachi Nuclear Energy Americas LLC
IASCC	Irradiation Assisted Stress Corrosion Cracking
NRC	Nuclear Regulatory Commission
RPIS	Rod Position Indication System
SER	Safety Evaluation Report

## 1. Introduction

In accordance with the requirements of the following Nuclear Regulatory Commission (NRC) Safety Evaluation Reports (SERs), GE-Hitachi Nuclear Energy Americas LLC (GEH) actively maintains a surveillance program consisting of visual inspections of Marathon (Reference 1), Ultra MD (Reference 2), and Ultra HD (Reference 3) control rods. A summary of the status of this surveillance program (Reference 4) was last forwarded to the NRC via MFN 13-034 (Reference 5), and was also provided to the Boiling Water Reactor (BWR) fleet.

This report updates Reference 4, including:

- New inspection results for Marathon control rods.
- New inspection results for Ultra MD control rod.
- The first inspection results for Ultra HD control rods.
- 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 2) and Ultra HD (licensed as Marathon-Ultra in Reference 3) 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 ([ [ ]]), and hafnium rods ([ [ ]]). 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.

[ [

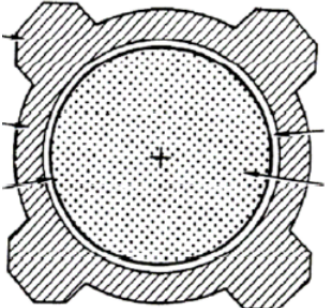
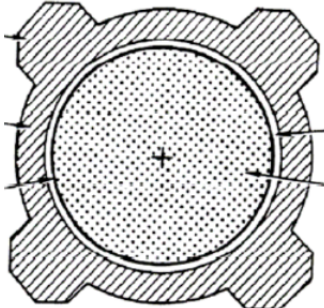
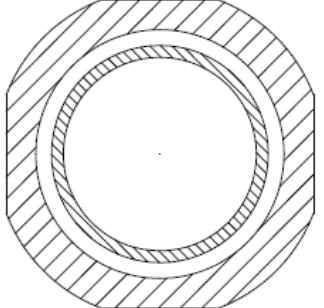
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**Figure 3: Ultra Control Rod Diagram**

**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			]]

[[

]]

#### 4. Inspection Data

Tables 2 through 5 contain a summary of [[ ]] visual inspections of Marathon and Ultra control rods that GEH has performed or reviewed to date. Since the previous annual report (Reference 4), [[ ]] 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 and [[ ]] D/S lattice Ultra HD control rods have been inspected, as shown in bold in Tables 4 and 5.

Tables 2 through 5 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, as discussed in Section 2.

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

- The percent B-10 depletion of the peak  $\frac{1}{4}$  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 Boron-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	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	1/4-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	<sup>1</sup> / <sub>4</sub> -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**

Plant	Serial Number	Ship Year	Inspection Date	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	Absorber Tube Lattice Type	Inspection Date	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)						]]	

**Table 5: Ultra HD Control Rod Inspection Results**

Plant	Serial Number	Ship Year	Absorber Tube Lattice Type	Inspection Date	¼-Segment B-10 Depletion (%)	Peak Local B-10 Depletion (%)	Crack Indications ?
Plant N (Int'l BWR)	]]						
							]]

As shown in Tables 2 through 5, [[

]]

## 5. Evaluation

[[

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The lead depletion Ultra MD control rods continue to accumulate B-10 depletion. As shown in Table 4, these control rods continue to perform well, with no crack indications.

Table 5 shows the first visual inspections of irradiated Ultra HD control rods. Although these inspections are not required by the NRC SER in Reference 3, the inspection results also show good performance.

## 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 2 and 3 SERs. Table 6 shows a listing of planned inspections, with estimates of planned depletions at the time of inspection.

**Table 6: Planned Control Rod Inspections**

Plant	Type	Number	Absorber Tube Size	Ship Year	Planned Inspection Date	¼-Segment B-10 Depletion (%)	Peak Local B-10 Depletion (%)
Plant N (International BWR)	[[						
Plant M (US BWR/4)							
Plant S (US BWR/5)							
Plant N (International BWR)							]]

**Note:**

\* “D/S/N” absorber tubes are used for GE D lattice (BWR/2-4), S lattice (BWR/6), and N lattice (Advanced Boiling Water Reactor (ABWR)) applications. “C” absorber tubes are used for GE C lattice (BWR/4,5) applications.

Figure 4 tracks lead depletion Ultra MD control rods, since the first installation in 2009. [[

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[[

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**Figure 4: Ultra MD Control Rod Inspections**

## 7. References

1. GE Nuclear Energy, “GE Marathon Control Rod Assembly,” NEDE-31758P-A, October 1991.
2. GE Hitachi Nuclear Energy, “Licensing Topical Report: Marathon-5S Control Rod Assembly,” NEDE-33284P-A, Revision 2, October 2009.
3. GE Hitachi Nuclear Energy, “Licensing Topical Report: Marathon-Ultra Control Rod Assembly,” NEDE-33284 Supplement 1P-A, Revision 1, March 2012.
4. GE Hitachi Nuclear Energy, “GEH Marathon and Ultra Control Rod Lifetime Surveillance Update,” NEDC-33819P, July 2013.
5. Letter from James F. Harrison (GEH) to Document Control Desk (NRC), Subject: Marathon and Ultra Control Rod Lifetime Surveillance Update, MFN 13-034, July 9, 2013.
6. Safety Communication SC 11-01, “Part 21 Reportable Condition Notification: Design Life of D and S Lattice Marathon Control Blades,” February 2011.
7. GE Hitachi Nuclear Energy, “GEH BWR Control Rod Lifetime,” NEDE-30931P, Revision 14, March 2012.
8. Safety Communication SC 07-02, “Update: Etch Indications on Marathon Control Rod Blade Absorber Tubes,” January 2007.