

ENCLOSURE 2

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NEDO-33769, Revision 0

GEH Marathon and Ultra Control Rod Lifetime Surveillance
Update

Non-Proprietary Information – Class I (Public)

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GEH Marathon and Ultra Control Rod

Lifetime Surveillance Update

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Acronyms and Abbreviations

Term	Definition
BWR	Boiling Water Reactor
GEH	GE-Hitachi Nuclear Energy Americas LLC
IASCC	Irradiation Assisted Stress Corrosion Cracking
NRC	Nuclear Regulatory Commission
SER	Safety Evaluation Report

1. Introduction

Since the beginning of the Marathon control rod product line, GE-Hitachi Nuclear Energy Americas LLC (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 Nuclear Regulatory Commission (NRC) via MFN 11-184 (Reference 3), and was also provided to the Boiling Water Reactor (BWR) fleet.

GEH has introduced 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 MD (Reference 4) and Ultra HD (Reference 5) control rods.

This report updates Reference 2, including:

- New inspection results for Marathon control rods, including the first visual inspections of Marathon control rods using the ‘new’ square absorber tube geometry introduced in 2006.
- The first inspection results for Ultra MD 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 2001, 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 introduced the Ultra MD (licensed as Marathon-5S in Reference 4) and Ultra HD (licensed as Marathon-Ultra in Reference 5). These control rods use the same 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.

[[

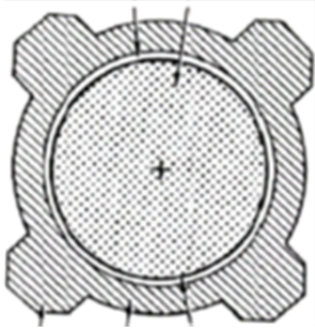
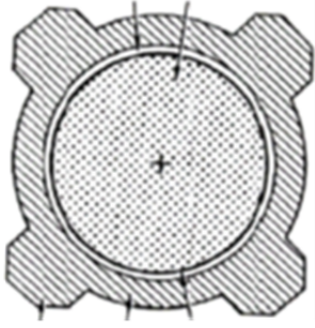
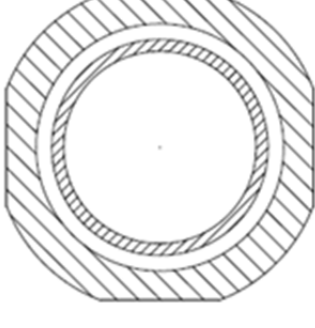
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Figure 3: Ultra Control Rod Diagram

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]]

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 Revision 3 of this report (Reference 2), [[]] additional inspections of D and S lattice Marathon control rods have been performed at four plants, and are shown in bold in Table 2. In addition, [[]] D/S lattice Ultra MD control rods have been inspected at two plants, 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 $\frac{1}{4}$ segment, in units of snvt.
- 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 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, none of the [[]] new Marathon control rod inspections are of etch affected control rods. However, 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)	[[
	Plant D (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 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)										
Plant O (International BWR/6)										
Plant P (International BWR)										
Plant Q (US BWR/4)										
]]

Note:

* “D/S” square 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)	¹ / ₄ -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” square 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)							
]]

Figures 4 and 5 show the results of Marathon visual inspections plotted against the year that the control rods were manufactured and shipped to the plant. The vertical axis is peak local depletion, which is the B-10 depletion at a particular axial node, and in a particular absorber tube. The local B-10 depletion is chosen as the figure of merit [[

]] For inspections with no observed crack indications, a single point is identified showing the peak local B-10 depletion for the entire control rod. For inspections with observed crack indications, the range of local B-10 depletions at which cracks are observed is shown by a vertical bar.

[[

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Figure 4: D/S Lattice Visual Inspection Results by Year Shipped

[[

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Figure 5: C Lattice Visual Inspection Results by Year Shipped

Several observations are made based on the crack statistics.

- [[

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5. Evaluation

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Figure 6: D/S Lattice Marathon Control Rod Location Survival Plot

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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 References 4 and 5 safety evaluations. Table 4 shows a listing of planned inspections.

Table 4: Planned Marathon Control Rod Inspections

Plant	Square Tube Lattice*	Control Rod Type	Planned Inspection Date	Number of CRBs to be Inspected	Thermal Fluence (snvt)	1/4-Segment B-10 Depletion (%)	Peak Local B-10 Depletion (%)	Square Tube Geometry
Plant A (US BWR/4)	D/S	Marathon	[[
Plant R (Int'l BWR/4)	D/S	Ultra MD (Marathon-5S)						
Plant M (US BWR/4)	D/S	Ultra MD (Marathon-5S)						
Plant N (Int'l BWR)	D/S	Ultra MD (Marathon-5S)]]

Note:

* “D/S” square tubes are used for GEH D lattice (BWR/2-4) and S lattice (BWR/6) applications. “C” square 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,” 0000-0071-8269-R3-P, June 2011.
3. Letter from James F. Harrison (GEH) to Document Control Desk (NRC), Subject: Marathon Control Rod Assembly Surveillance Program Update, June 16, 2011, MFN 11-184.
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 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.