ENCLOSURE 2

M240183

NEDO-33856, Revision 10

GEH Marathon and Ultra Control Rod Lifetime Surveillance Update

Non-Proprietary Information

IMPORTANT NOTICE

This is a non-proprietary version of NEDC-33856P, Revision 10, 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 [[ ]].

GE Hitachi Nuclear Energy

NEDO-33856
Revision 10
August 2024

Non-Proprietary Information

GEH Marathon and Ultra Control Rod

Lifetime Surveillance Update

Copyright 2014 - 2024 GE-Hitachi Nuclear Energy Americas LLC

All Rights Reserved

INFORMATION NOTICE

This is a non-proprietary version of NEDC-33856P Revision 10, 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 [[ ]].

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.

Revision Summary

Revision No.	Content
0	2014 Update (Note that all prior updates were issued under different document numbers.)
1	2015 Update
2	2016 Update
3	2017 Update
4	2018 Update
5	2019 Update
6	2020 Update
7	2021 Update
8	2022 Update
9	2023 Update
10	2024 Update

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Acronyms and Abbreviations

Term	Definition
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
SER	Safety Evaluation Report

1. Introduction

GE-Hitachi Nuclear Energy Americas LLC (GEH) actively maintains a surveillance program consisting of visual inspections of Marathon, Ultra MD, and Ultra HD control rods in accordance with the requirements of their respective Nuclear Regulatory Commission (NRC) Safety Evaluation Reports (SERs): Marathon (Reference 1), Ultra MD (Reference 2), and Ultra HD (Reference 3). A summary of the status of this surveillance program was last forwarded to the NRC via M230102 (Reference 4) and was also provided to the Boiling Water Reactor (BWR) fleet via Reference 5.

This report updates Reference 5, including:

- New inspection results for Marathon and Ultra control rods.
- A listing of planned inspections for Marathon and Ultra control rods.

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. [[

]]

In June 2022, GEH issued Reference 7, which reduced the lifetime of Marathon-C+ control rods. This lifetime reduction was issued in response to observed cracking of Marathon-C+ control rods. [[

]]. Current lifetime recommendations for all GEH control rods are found in Reference 8.

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.

[[

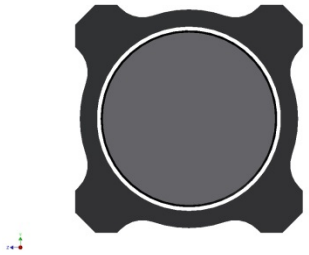
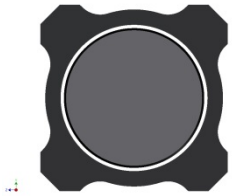
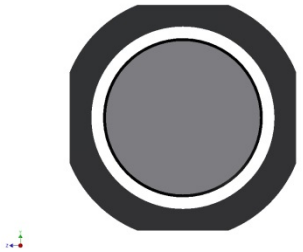
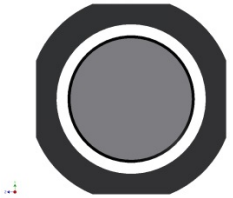
]]

[[

]]

Figure 3: Ultra Control Rod Diagram

Table 1: Marathon and Ultra Control Rod Design Comparison

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

[[ ]]

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 5), [[ ]] additional inspections of D/S lattice Marathon control rods have been performed, which are shown in bold in Table 2. Also, [[ ]] additional inspections of Ultra MD control rods are added to Table 4, and [[ ]] additional inspections of Ultra HD control rods are added to Table 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 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 9. 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 8 and 9. 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 ongoing. Ultra control rods are not affected by the etch issue.

As shown in Table 2, [[
]].

As shown in Tables 4 and 5, [[
]]

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)	[[								
									]]

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

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

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 D (International BWR)	[[								
Plant E (US BWR/2)									
Plant J (International BWR)									
									]]

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

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 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)									
									]]

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

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 P (International BWR)	[[								
Plant Q (US BWR/4)									
Plant T (International BWR/6)									]]

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?	Local B-10 Depletion at Crack Location (%)	Etch-Affected?
Plant B (International BWR)	[[							
Plant C (International BWR)								
Plant F (US BWR/4)								
Plant G (International BWR)								
								]]

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

Table 3: C Lattice* Marathon Control Rod Inspection Results (Continued)

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?
Plant X (US BWR/4)	[[							
								]]

Table 4: Ultra MD Control Rod Inspection Results

Plant	Serial Number	Ship Year	Absorber Tube Size*	Inspection / Discharge 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)							
Plant S (US BWR/5)							
Plant F (US BWR/4)							
							]]

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.

Table 5: Ultra HD Control Rod Inspection Results

Plant	Serial Number	Ship Year	Absorber Tube Size*	Inspection / Discharge Date	¼-Segment B-10 Depletion (%)	Peak Local B-10 Depletion (%)	Crack Indications?
Plant N (Int'l BWR)	[[						
Plant P (Int'l BWR)							
Plant J (Int'l BWR)							
							]]

Table 5: Ultra HD Control Rod Inspection Results (Continued)

Plant	Serial Number	Ship Year	Absorber Tube Size*	Inspection / Discharge Date	¼-Segment B-10 Depletion (%)	Peak Local B-10 Depletion (%)	Crack Indications?
Plant U (US BWR/6)	[[						
Plant O (Int'l BWR/6)							
Plant V (US BWR/4)							
Plant W (US BWR/3)							
Plant F (US BWR/4)							]]

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.

5. Evaluation

[[

]] GEH continues to pursue inspection data for irradiated Marathon control rods to confirm these cracking thresholds.

GEH also continues to gather inspection data for irradiated Ultra MD and Ultra HD control rods, exceeding the surveillance requirements of References 2 and 3. As shown in Tables 4 and 5, good performance has been observed, with no crack indications identified to date.

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 8. Currently, there are no planned inspections for Marathon control rods.

For Ultra control rods, visual inspections of lead depletion and permanently discharged control rods are planned in accordance with the requirements of the Reference 2 and 3 SERs. Table 6 shows a listing of planned Ultra control rod inspections.

Table 6: Planned Ultra Control Rod Inspections

Plant	Type	Quantity	Absorber Tube Size[1]	Ship Year	Inspection / Discharge Date	¼-Segment B-10 Depletion (%)	Peak Local B-10 Depletion (%)
Plant M-A (US BWR/4)	[[						
Plant M-B (US BWR/4)							]]

Notes:

1. Control rod was discharged at Plant M-A in Fall 2022. Inspection is currently planned for Fall 2024.
2. Control rod will be discharged at Plant M-B in Fall 2023. Inspection is currently planned for Fall 2024.

Figures 4 and 5 track lead depletion Ultra MD and Ultra HD control rods, respectively. Since the prior annual report, the world-wide lead depletion Ultra HD control rods were inspected at Plant W (Table 5), with no crack indications.

Per the surveillance program requirements of References 2 and 3, the first 12 discharged Ultra MD and 12 Ultra HD control rods of each lattice type must be inspected, with no more than 4 from any single unit. Table 7 summarizes the status of the number of permanently discharged Ultra control rod inspections.

Table 7: Inspections of Permanently Discharged Ultra Control Rods

Control Rod Type	D/S/N Lattice	C Lattice
Ultra MD	**Completed = 6** • Plant M-A (Fall 2020) – 3 • Plant M-B (Fall 2021) – 3 **Planned = 2** • Plant M-A (discharge Fall 2022) – 1 • Plant M-B (discharge Fall 2023) – 1	**Completed = 3** • Plant F (discharge Spring 2023) - 3 **Planned = 0**
Ultra HD	**Completed = 11** • Plant O (Fall 2020) – 4 • Plant U (Fall 2019) – 3 • Plant W (Fall 2022) – 2 • Plant U (discharge Fall 2021) - 2 **Planned = 0**	**Completed = 3** • Plant V (Spring 2022) – 2 • Plant F (discharge Spring 2023) - 1 **Planned = 0**

[[

]]

Figure 4: Ultra MD Control Rod Inspections

[[

]]

Figure 5: Ultra HD Control Rod Inspections

7. References

1. GE Nuclear Energy, “GE Marathon Control Rod Assembly,” NEDE-31758P-A, October 1991.
2. GE Hitachi Nuclear Energy, “Marathon-5S Control Rod Assembly,” NEDE-33284P-A, Revision 2, October 2009.
3. GE Hitachi Nuclear Energy, “Marathon-Ultra Control Rod Assembly,” NEDE-33284 Supplement 1P-A, Revision 1, March 2012.
4. Letter from Michelle Catts (GEH) to Document Control Desk (NRC), Subject: Marathon and Ultra Control Rod Lifetime Surveillance Update, M230102, August 4, 2023.
5. GE Hitachi Nuclear Energy, “GEH Marathon and Ultra Control Rod Lifetime Surveillance Update,” NEDC-33856P, Revision 9, July 2023.
6. Safety Communication SC 11-01, “Part 21 Reportable Condition Notification: Design Life of D and S Lattice Marathon Control Blades,” February 2011.
7. Safety Communication SC 22-03, “Updated Lifetime Limits for Marathon-C+ Control Rods,” June 2022.
8. GE Hitachi Nuclear Energy, “GEH BWR Control Rod Lifetime,” NEDE-30931P, Revision 21, February 2024.
9. Safety Communication SC 07-02, “Update: Etch Indications on Marathon Control Rod Blade Absorber Tubes,” January 2007.