GE Hitachi Nuclear Energy

Dale E. Porter

GE-Hitachi Nuclear Energy Americas LLC
Safety Evaluation Program Manager

3901 Castle Hayne Rd.,
Wilmington, NC 28401
USA

T 910 819-4491
Dale.Porter@GE.Com

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MFN 10-351

Attn: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: **Update to MFN 10-327: Crack Indications in Marathon Control Rod Blades**

Reference: NEDE-31758P-A, Safety Evaluation Report "GE Marathon Control Rod Assembly"

This letter provides supplemental information concerning an evaluation being performed by GE Hitachi Nuclear Energy (GEH) regarding the identification on crack indications in Marathon Control Rod Blades at a non-domestic BWR/6 plant. As stated herein, GEH has not concluded that this is a reportable condition in accordance with the requirements of 10CFR 21.21(d) and continued evaluation is required to determine the impact and extent of this condition.

GEH is committed to completing the 10CFR Part 21 evaluation no later than February 15, 2011 as previously indicated in MFN 10-327.

If you have any questions, please call me at (910) 819-4491.

Sincerely,

Dale E. Porter
Safety Evaluation Program Manager
GE-Hitachi Nuclear Energy Americas LLC

Attachments:

1. Description of Evaluation
2. US Plants Potentially Affected

cc: S. S. Philpott, USNRC
S. J. Pannier, USNRC
O. Tabatabai-Yazdi, USNRC
J. F. Harrison, GEH
J. G. Head, GEH
P. L. Campbell, GEH Washington
A. A. Lingenfelter, GNF
PRC File
DRF Section No. 0000-0126-0655

Attachment 1 – Description of Evaluation

Background

GE Hitachi Nuclear Energy (GEH) provides Marathon Control Rod Blades (CRB) to BWR's throughout the fleet, inclusive of D lattice, BWR/2-4 plants, S lattice, BWR/6 plants, and C lattice, BWR/4-5 plants, as well as to other reactor vendor plants with similar configurations. GEH maintains a continuous surveillance program to monitor Marathon CRB performance in the BWR fleet as required by the NRC Safety Evaluation (NEDE-31758P-A) for the Marathon Control Rod Blade. This surveillance program primarily consists of visual inspections of highly irradiated near "End-of-Life" Marathon CRBs. The most recent update report for the Marathon surveillance program was provided to the BWR fleet in May 2010; report number 0000-0071-8269-R2. Since that update was released, GEH has completed the planned visual inspection of four-discharged CRBs at an international BWR/6, identified as "Plant O" in the surveillance report. The visual inspection of these assemblies has revealed cracks on all four CRBs. Some of the cracks are larger than those previously observed and reported in the surveillance report. The cracks are more numerous and occur at locations of lower reported local boron-10 depletion than previously documented.

Discussion

Timeline – Failure Analysis

May 2010	Issued Marathon Surveillance Report 0000-0071-8269-R2
8/24/10	Cracks observed in 4 of 4 Marathon control rods inspected at an international BWR ("Plant O").
8/24/10	Initiated GEH Corrective Action process and Part 21 evaluation process. Formed a "War Room" action team.
9/3/10	Issued RICSIL 091.
10/20/10	Issued Safety Communication SC 10-14 as a 60 day Part 21 interim notification.
2/15/11	GEH deadline for completion of failure evaluation and final customer recommendations, and determination of reportability of the Part 21 investigation.

Surveillance Program Status Reported in May 2010

Prior to the "Plant O" inspections in August 2010, GEH released the annual update report for the Marathon surveillance program, 0000-0071-8269-R2. At that time, GEH had completed 93 inspections of irradiated CRBs. Of those inspections, crack indications were observed on 6 CRBs. All of the CRBs with crack indications were D or S lattice configurations, which use the same geometry absorber tube and capsule. No crack indications have been observed on C lattice applications, which use a different geometry absorber tube and capsule. Also, all crack indications were observed on CRBs that were near the end of their nuclear lifetime limits. Counting only D or S lattice CRBs, and only those at near “End-of-Life”, 6 of 19 inspections revealed crack indications.

As noted in the surveillance report, GEH has completed the Post-Irradiation Examination of one of the previous CRBs with crack indications. As a result of this examination, along with failure analyses conducted for each CRB crack observation, the following contributing factors for the cracking were identified:

- Boron carbide swelling
- Design based on nominal dimensions, swelling rates, and material strain capability
- Early Marathon manufacturing processes:
    - Absorber tube annealing
    - Absorber tube straightening
    - Absorber tube ID inspection after weld

Observations from “Plant O”

In August 2010, GEH performed the planned inspection of four near “End-of-Life” CRBs at “Plant O”. The inspection revealed crack indications on all four CRBs. The observed cracks are much more numerous, and have more material distortion than previously observed. Further, the cracks occur at a much lower reported local B-10 depletion than previously observed, with cracking predominantly starting at approximately 40% local depletion, whereas previous inspections observed cracking only above 60% local depletion.

The cracks at “Plant O” are also more severe, in that they resulted in missing capsule tube fragments from two of the inspected CRBs. A lost parts analysis performed for “Plant O” determined that there is no negative affect on plant performance due to the missing tube fragments.

At this point in the investigation, no causal or contributing factors unique to the “Plant O” CRBs, nor their operation, has been identified.

Including the inspections at “Plant O”, GEH has now completed the visual inspection of 97 irradiated Marathon CRBs, with 10 showing crack indications. As “Plant O” is an S lattice design, all crack indications are still confined to D and S lattice applications, with no crack indications on C lattice designs. When considering only D and S lattice applications that are near “End-of-Life” depletion limits, 10 of 23 control rod inspections have revealed crack indications.

Consequences of cracking

From a nuclear standpoint, absorber tube cracking allows water to enter both the outer absorber tube, and the boron carbide capsule, which uses a crimped end cap connection. If the boron has achieved sufficient depletion (50% local depletion or greater), the boron carbide may leach into the reactor coolant. A neutron radiograph of a cracked CRB confirms this leaching effect for CRBs. The neutron radiograph demonstrated partial leaching from boron carbide capsules in locations adjacent to the outer absorber tube cracks. This loss of boron carbide may cause individual control rods to not meet end-of-life reactivity worth requirements.

From a mechanical standpoint, absorber tubes form the main structure of the CRBs. However, the effect of the cracking on the structural strength of an assembly is limited, as the cracking is generally in the axial direction, which is the scram load-carrying direction. An analysis of the CRB design, using worst-case BWR/6 scram loads, indicates that the CRB maintains sufficient structural strength when up to 5 tubes per wing are ignored due to severe cracking.

Interim Recommendations

Based on the crack observations, GEH recommends that BWR plants monitor for indications of absorber material in the coolant through reactor coolant boron and tritium sampling. Experience with original equipment and DuraLife control rod blade cracking has demonstrated that monitoring plant coolant chemistry can identify control rod blade boron carbide leaching. Plant experience indicates that sampling should be at least monthly, or as frequent as weekly if increasing trends are noted, or the onset of leaching indications is suspected. If water chemistry data show indications of increasing trends in boron and/or tritium correlatable with control rod movements, follow-on actions may be needed. Historically, levels of boron greater than approximately 100 ppb, and tritium greater than approximately 1×10^{-2} μCi/ml, have been linked with absorber tube failures. However, some plants have been able to establish clearly increasing trends at levels as much as 50% less than these.

In addition, the presence of lithium in a coolant sample taken after a spike in conductivity has proven effective in determining that a control rod blade crack has occurred.

Additional Guidance

There is a potential that the failure analysis of the “Plant O” CRBs may result in a recommended lifetime reduction for a specific population, or all D and S lattice Marathon control rods blades. GEH has not yet determined what the ¼ segment limit, if any, would be on a potential lifetime reduction. However, the ‘Etch Spot’ reduced lifetime limits, discussed in Safety Information Communication SC 07-02, likely bounds any lifetime reduction for CRB cracking. These ¼-segment lifetime limits are 47% for S lattice applications and 49% for D lattice applications. The 'Etch Spot' lifetime limits are likely bounding, as they are based on assumed cracking at "Beginning-of-Life", and a 50% local B-10 leaching threshold determined from irradiated control rod data.

Based on the information available to date, continued operation of BWRs with installed D or S lattice CRBs is justified if:

- No statistically significant increase in boron and tritium has been observed, or,
- Depletion of all Marathon control rods are less than 'Etch Spot' lifetime limits (S = 47% ¼ segment, D = 49% ¼ segment, Safety Information Communication SC 07-02)

If a D or S lattice BWR observes significant increases in boron and/or tritium, and has installed CRBs above the 'Etch Spot' lifetime limits, GEH recommends that plants:

- Attempt to correlate any boron or tritium increases to the movement of high depletion CRBs or other control rod blades.
- Attempt to correlate any spikes in conductivity and corresponding spikes in lithium to the movement of high depletion CRBs or other control rod blades.
- Perform visual inspections on suspect CRBs during the next refueling outage.
- Make contingency plans to replace CRBs that exceed the 'Etch Spot' lifetime limits.
- Consult with GEH as needed on how to determine the effect on plant shutdown margin for completion of the current cycle.

ABWR and ESBWR Design Certification Documentation Applicability

The issues described above have been reviewed for applicability to documentation associated with 10CFR 52 and it has been determined that there is no affect on the technical information contained in either the ABWR certified design or the ESBWR design in certification.

Attachment 2 – US Plants Potentially Affected

D & S Lattice Plants	C Lattice Plants	Utility	Plant
X		Constellation Nuclear	Nine Mile Point 1
	X	Constellation Nuclear.	Nine Mile Point 2
	X	Detroit Edison Co.	Fermi 2
X		Dominion Generation	Millstone 1
	X	Energy Northwest	Columbia
X		Entergy Nuclear Northeast	FitzPatrick
X		Entergy Nuclear Northeast	Pilgrim
X		Entergy Nuclear Northeast	Vermont Yankee
X		Entergy Operations, Inc.	Grand Gulf
X		Entergy Operations, Inc.	River Bend
X		Exelon Generation Co.	Clinton
X		Exelon Generation Co.	Oyster Creek
X		Exelon Generation Co.	Dresden 2 & 3
	X	Exelon Generation Co.	LaSalle 1 & 2
	X	Exelon Generation Co.	Limerick 1 & 2
X		Exelon Generation Co.	Peach Bottom 2 & 3
X		Exelon Generation Co.	Quad Cities 1 & 2
X		FirstEnergy Nuclear Operating Co.	Perry 1
X		FPL Energy	Duane Arnold
X		Nebraska Public Power District	Cooper
X		Xcel Energy	Monticello
	X	PPL Susquehanna LLC.	Susquehanna 1 & 2
X		Progress Energy	Brunswick 1 & 2
X		Southern Nuclear Operating Co.	Hatch 1 & 2
X		Tennessee Valley Authority	Browns Ferry 1 - 3