HITACHI

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M170087

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

Subject: **Part 21 60-Day Interim Report Notification: Control Rod Drive Mechanisms (CRDM) Contaminated with Chlorides**

This letter provides information concerning a 10CFR Part 21 evaluation of the effects of an inappropriate introduction of chlorides into Control Rod Drive Mechanisms (CRDM) during leak rate testing associated with CRDM refurbishments at the GE-Hitachi Nuclear Energy Americas LLC (GEH) Wilmington Field Services Center (WFSC).

GEH will complete all evaluation efforts and provide a determination of Reportability in accordance with 10CFR Part 21 no later than July 14, 2017.

The information required for this GEH 60-Day Interim Report Notification per §21.21(a)(2) is provided in Attachment 2 per the requirements of §21.21(d)(4)(i -ix). The commitment for follow-on actions is provided in Attachment 2, item (vii).

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. US BWR Plants Potentially Affected
2. 60-Day Interim Report Notification Information per §21.21(a)(2)

Enclosures:

1. Description of Evaluation, Non-Proprietary Information – Class I (Public)

cc: J. Golla, USNRC
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PLM Spec 004N2410 R0

Attachment 1
US BWR Plants Potentially Affected

	Utility	Plant
	Constellation Energy	Nine Mile Point 1-2
	Detroit Edison Co.	Fermi 2
	Dominion	Millstone 1
	Energy Northwest	Columbia
	Entergy	Grand Gulf
X	Entergy	River Bend
	Entergy	FitzPatrick
	Entergy	Pilgrim
	Entergy	Vermont Yankee
	Exelon	Clinton
	Exelon	Dresden 2-3
X	Exelon	LaSalle 1-2
	Exelon	Limerick 1-2
	Exelon	Oyster Creek
	Exelon	Peach Bottom 2-3
	Exelon	Quad Cities 1-2
	FirstEnergy Nuclear Operating Co.	Perry 1
	Florida Power & Light	Duane Arnold
	Nebraska Public Power District	Cooper
	PPL Susquehanna LLC	Susquehanna 1-2
	Progress Energy	Brunswick 1-2
	PSEG Services Corp.	Hope Creek
X	Southern Nuclear Operating Co.	Hatch 1 - 2
X	Tennessee Valley Authority	Browns Ferry 1-3
	Xcel Energy	Monticello
	North East Utilities	Millstone

Attachment 2 – 60-Day Interim Report Notification Information per §21.21(a)(2)

(i) Name and address of the individual or individuals informing the Commission.

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(ii) Identification of the facility, the activity, or the basic component supplied for such facility which fails to comply or contains a defect.

See Attachment 1 for a list of potentially affected U.S. plants

(iii) Identification of the firm constructing the facility or supplying the basic component which fails to comply or contains a defect.

GE-Hitachi Nuclear Energy Americas LLC

(iv) Nature of the defect or failure to comply and the safety hazard which is created or could be created by such defect or failure to comply.

The inappropriate addition of chlorinated water from container box desiccants into the CRDMs during leak testing after rebuild could potentially initiate Intergranular Stress Corrosion Cracking (IGSCC) or Transgranular Stress Corrosion Cracking (TGSCC). These two types of SCC could cause a separation of the stop piston or separation of the index tube contained within the CRDM. The stop piston separation could cause a slower scram speed and damage the drive so it could not be withdrawn. An index tube separation could result in a similar type of rod uncoupling event that would have the potential to result in a rod drop accident (RDA). The piston tube located within the CRDM is a reactor coolant pressure boundary (RCPB) and is an ASME component. There is a possibility of cracking causing a RCPB leak. SCC initiation on the Cylinder Tube and Flange (CTF) area of the CRDM could result in a separation that could prevent a scram or normal insertion of a CRDM.

(v) The date on which the information of such defect or failure to comply was obtained.

A Potential Reportable Condition Evaluation in accordance with 10 CFR Part 21 was initiated on February 27, 2017.

(vi) In the case of a basic component which contains a defect or fails to comply, the number and location of these components in use at, supplied for, being supplied for, or may be supplied for, manufactured, or being manufactured for one or more facilities or activities subject to the regulations in this part.

See Table 1, Enclosure 1.

Attachment 2 – 60-Day Interim Report Notification Information per §21.21(a)(2)

(vii) The corrective action, which has been, is being, or will be taken; the name of the individual or organization responsible for the action; and the length of time that has been or will be taken to complete the action.

GEH has initiated a Root Cause Evaluation (RCA) to determine why this event occurred and has implemented process changes to ensure that the condition does not reoccur. Actions to prevent recurrence, such as eliminating the desiccant material and flushing the closed loop water system, will be completed prior to any future shipments.

(viii) Any advice related to the defect or failure to comply about the facility, activity, or basic component that has been, is being, or will be given to purchasers or licensees.

Reports have been issued to River Bend, LaSalle Unit 2, and Hatch Unit 2 providing the results of an evaluation that concludes that the condition will not create a substantial safety hazard or potentially cause a Technical Specification Safety Limit violation for a minimum of one operating cycle. The Browns Ferry Unit 2 drives were shipped but were not installed prior to recall, thus a short-term evaluation for Browns Ferry has not been completed.

(ix) In the case of an early site permit, the entities to whom an early site permit was transferred.

Not Applicable.

ENCLOSURE 1

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Description of Evaluation

Non-Proprietary Information - Class I (Public)

Summary

Based on the evaluations to date for the subject condition, GEH needs additional time to determine whether the subject condition would, or has, created a future Substantial Safety Hazard or Technical Specification Safety Limit violation as it relates to the subject plant applications.

Additional evaluation into crack growth due to either IGSCC and TGSCC on individual Control Rod Drive Mechanism (CRDM or drive) components are required to determine whether a reportable condition exists for extended operation of these CRDMs. This document is a 10CFR Part 21.21(b) 60-Day Interim Notification so that the GEH staff can determine reportability of this condition.

Introduction

The CRDM is a double-acting, mechanically latched hydraulic cylinder, using water as the operating fluid. The CRDM is capable of inserting or withdrawing a control rod blade at a slow controlled rate for normal reactor operation. It also provides a rapid control rod insertion (scram) in the event of an emergency requiring rapid shutdown of the reactor. A locking mechanism in the CRDM permits the control rod to be positioned at 6-inch increments of stroke and to be held in these latched positions until the CRDM is actuated for movement to a new position.

The CRDM contains various components such as the cylinder, tube, and flange (CTF) that consist of an inner cylinder, an outer tube, and a flange. The flange provides a means by which the CRDM is mounted to the CRD housing flange below the vessel. The outer diameter of the cylinder and the inner diameter of the tube form an annulus through which water is applied to the collet piston to unlock the index tube during the withdraw cycle.

The index tube is the moving part of the BWR/6 CRDM that positions the control rod blade and is manufactured of XM-19 material. The piston tube is manufactured using the same material. The older model drives (BWR/2-5) can have either SS 304 or the newer XM-19 material as recommended by SIL 179, "Control Rod Drive Material Improvements," for the index and piston tubes. Both the index tubes and the piston tubes of either material are nitride coated to increase surface hardness for galling prevention. Both the moving piston at the bottom of the index tube and the stop piston located on top of the piston tube contain graphitar seals. These seals prevent leakage for normal operation of the CRDMs and prevent wear from metal to metal contact.

The Control Rod Drive Mechanism (CRDM) functions:

- Some areas of the piston tube assembly are part of the reactor pressure boundary and are ASME components.
- The index tube assembly moves rapidly for insertion of the control rod blade to safely shutdown the reactor during a scram.

- The index tube has notches that will keep it in the full in position after a scram to maintain the reactor in a safe shutdown condition in conjunction with the collet piston.
- The index tube also moves normally during insert/withdraw sequences for reactivity control.

Potentially affected safety functions:

- The ability to scram (safely shutdown the reactor) and maintain it in a safe shutdown condition (CTF, index tube, coupling spud, collet piston and drive/stop pistons).
- The index tube acts in conjunction with the coupling spud to assure coupling to the control rod blade to prevent a Rod Drop Accident. A completely sheared index tube would give indications similar to a non-coupled control rod blade.
- The piston tube assembly is part of the reactor pressure boundary and is an ASME component.

Description of Discovery

During a receipt inspection prior to installation of the CRDMs at Browns Ferry (a BWR/4) the GEH under vessel team observed orange and black crud coming out of the withdraw port of one drive. Borescope visual inspection confirmed other drives had a similar condition and subsequently all onsite refurbished CRDMs (32 drives) were shipped back to the GEH Wilmington Field Services Center (WFSC) to investigate and address the condition.

This issue was caused by inappropriate dumping of chlorinated water from desiccants used in the CRDM storage and transport boxes. The desiccant was a chloride based material (primarily calcium chloride). The accumulated liquid from the desiccant entered the closed loop water used for leak rate testing of the drives by being dumped on the rebuild tables that drained to this closed loop deionized (DI) water supply system. The drives that were subsequently leak tested were contaminated by chlorinated water.

Extent of Condition

GEH has completed an extent of condition review and determined four plants had either receipt accepted or installed CRDMs leak checked with chlorinated water. Those plants are River Bend, LaSalle Unit 2, Hatch Unit 2 and Browns Ferry Unit 2. Browns Ferry Unit 2 CRDMs were not installed in the plant but were accepted at the site and are thus within the evaluation requirements of 10CFR Part 21 (See Table 1).

Safety Significance

The consequences of degraded parts can be logically grouped into four categories of failures. The most likely of these is degradation of the nitride surfaces of the piston and index tubes due to pitting corrosion and/or crevice corrosion. Any damage to the seal surface (e.g., pitting) could reduce sealing effectiveness if any significant pit areas or significant numbers of lesser pitting were involved and the diameter of the pits exceeds the width of the graphitar seals. The increase in surface roughness in the pitted area caused by the corrosion deposits could also accelerate seal wear. The graphitar seals are not attacked by chlorides, but would degrade with increasing surface roughness. The typical consequences of extensive pit formation would be increased seal leakage which would result in operational difficulties (e.g., notching) and degraded buffer performance. However, the scram function of the CRDM would not be affected. These operational issues, if they were to occur, would only result in the necessity of early CRDM maintenance or replacement.

The second category of degradation is stress corrosion cracking in the base metal of the index or piston tube. This category is less likely to occur than the potential pitting or crevice corrosion noted above. If these cracks extended through the wall of either tube it may result in increased internal CRD leakages. The consequence of this leakage, if significant, would be operational anomalies such as notch-in and notch-out and degraded buffer performance. Significant leakage which invariably causes operational problems may also result in a slightly slower scram time on the affected CRDM. In no case would the CRDM scram capability be significantly degraded, and in no case would this potential CRDM cracking affect the vessel pressure boundary integrity. Also, this type of degradation would necessitate early CRDM maintenance. In the case of some of the Hatch Unit 2 CRDMs that have index and piston tubes manufactured from highly SCC resistant XM-19 material, it is highly unlikely this would occur for that material. However, there are also index and piston tubes manufactured from 304 stainless steel (SS) in the rebuilt population of the Hatch Unit 2 drives where this type of cracking may be possible. The index and piston tubes of River Bend, LaSalle Unit 2, and Browns Ferry Unit 2 are manufactured from XM-19 material. Further long term evaluation is continuing for the XM-19 material.

The third category and the least likely type of CRDM part failure is sufficient cracking leading to complete separation of either the piston or index tube. In the unlikely event of a piston tube separation, the most probable location for this to occur is at the top of the piston tube. A failure at this location would likely result in a slower scram time, followed by an inability to withdraw the CRDM. In the case of the index tube, if the cracking resulted in separation at the upper end near the coupling spud, it would be equivalent to the coupling failure previously analyzed in the Rod Drop Accident (RDA) analysis. This case is also highly unlikely due to the use of XM-19 material in

the CRDMs where it exists. Index and piston tubes manufactured of 304 SS are more susceptible to cracking. However, in this case the potential for a crack to develop and propagate to a point of tube failure within one cycle has been evaluated to not exist.
A fourth category would consist of a separation of the CTF as described in SIL 139, "Control Rod Drive Collet Retainer Tube Cracking." This issue is still under evaluation for IGSCC and TGSCC concerns for long term use. For short term the chloride concentration was not enough to cause an issue for one operating cycle. The Browns Ferry CTF short term evaluation was not performed since the drives were not installed.

Of the four categorizations of failure, the only one GEH deems credible within one operational cycle is pitting and crevice corrosion of the nitride surfaces of the piston and index tubes. This conclusion is based on the relatively low chloride concentration the drives were exposed to, the short time of exposure, and the drive materials used, particularly for the components that are required for completing the scram function. Where present, the XM-19 index and piston tube material is resistant to chloride attack initiating any SCC. The indicator tube located within the piston tube is manufactured from 316 SS. This material is more resistant to SCC than 304 SS and would mitigate the indicator tube from leaking due a through wall crack and developing a reactor pressure boundary leak. However, those tubes manufactured from 304 SS are susceptible to SCC. The initial GEH evaluation concludes these cracking failure issues will not occur on the XM-19 or 304 SS material during the current operating cycle. The long term (>1 operating cycle) potential for SCC which may result in through wall cracking and separation of either the 304 SS piston tube or index tube remains under evaluation.

GEH determined a fracture mechanics allowable flaw size based on upset scram conditions of a failed buffer at reactor temperature. The likely cracking areas of the piston and index tube were chosen based on historical cracking areas of 304 SS as described in SIL 179 S1. This conservative bounding flaw size was then compared to a crack growth rate in 304 SS to verify the crack will not exceed the maximum flaw length during a two-year operating cycle. The assumed crack growth rate was conservatively based on the initial presence of a through wall crack, prior to exposure to the chlorinated water; which there was no evidence of for the rebuilt CRDMs.

Long term crack growth rates in 304 SS and XM-19 CRDM materials are under further evaluation.

ABWR and ESBWR Design Certification Documentation Applicability

Not applicable.

Recommendations

No additional trending or monitoring of CRDMs is recommended at this time.

Corrective/Preventive Actions

1. WFSC has stopped the use of the desiccants.
2. The WFSC closed loop water system was cleaned and successfully sampled.
3. A Root Cause Evaluation (RCA) was initiated to determine the cause of the issue and further actions needed to prevent reoccurrence.

Table 1

Plant Description	Customer Name	Shipped Date	Shipped Quantity	Part Description	Safety Class	Customer PO Number
River Bend	Entergy	2017	15	CRDM	Q	10478763
LaSalle Unit 2	Exelon	2017	24	CRDM	Q	00414787-66
Hatch Unit 2	Southern Nuclear	2017	15	CRDM	Q	SNG50295-0001 SNG50295-0002
Browns Ferry Unit 2	TVA	2017	32	CRDM	Q	2424171