General Information or Other (PAR) Event # 42573

Rep Org: GENERAL ELECTRIC COMPANY		**Notification Date / Time:** 05/12/2006 22:36 (EDT)	
Supplier: GENERAL ELECTRIC COMPANY		**Event Date / Time:** 04/24/2006 (EDT)	
		Last Modification: 10/10/2006	
Region: 1		**Docket #:**	
City: WILMINGTON		**Agreement State:** Yes	
County:		**License #:**	
State: NC			
NRC Notified by: JASON POST		**Notifications:** ANTHONY DIMITRIADIS	R1
HQ Ops Officer: MIKE RIPLEY		JAMES MOORMAN	R2
Emergency Class: NON EMERGENCY		RICHARD SKOKOWSKI	R3
10 CFR Section:		OMID TABATABAI-EMAIL	NRR
21.21 UNSPECIFIED PARAGRAPH		JACK FOSTER (EMAIL)	NRR

PART 21 NOTIFICATION - BWR CORE SHROUD TIE ROD UPPER SUPPORT CRACKING

"Summary:
GE Energy, Nuclear (GE) has provided core shroud repairs using tie rods to the US BWR plants identified in Attachment 1 [of the Part 21 notification]. Recently it was discovered during an in-vessel visual inspection (IVVI) that tie rod upper supports at Hatch Unit 1 experienced cracking. The apparent root cause is Intergranular Stress Corrosion Cracking (IGSCC) in the Alloy X-750 tie rod upper support material. Alloy X-750 material is susceptible to IGSCC if subjected to sustained, large peak stress conditions. GE opened an internal evaluation to determine if the potential IGSCC in the X-750 tie rod structural components of other BWR shroud repairs designed by GE could be a reportable condition under 10CFR21.

"GE used the criterion provided in the BWR Vessels & Internals Project (BWRVIP-84) for the IGSCC susceptibility assessment of the X-750 components in the tie rod vertical load path. GE has concluded that it is not a reportable condition for the plants that were found to be within or not significantly exceed the BWRVIP-84 criterion. These US plants are identified as 'NR' in Attachment 2 [of the Part 21 notification]. GE determined that two US plants exceed the BWRVIP-84 criterion for the upper supports (in addition to the Hatch Unit 1 as-found condition). GE has not completed the evaluation for these plants to assess if a substantial safety hazard (SSH) exists. These plants have been provided a 60-Day Interim Report Notification under §21.21(a)(2) and are identified as '60-Day' in Attachment 2 [of the Part 21 notification].

"Safety Basis:
Cracking in the tie rod components made of X-750 may render the tie rod ineffective in maintaining core shroud configuration integrity during postulated accident conditions. Loss of core shroud integrity could impact the ability to maintain adequate core cooling for postulated design basis accident conditions. This condition would be reportable under 10 CFR 21 as a substantial safety hazard.

IE19

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"Corrective Action:
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 (note, these are actions specifically associated with the identified deviation or failure to comply):
1. A preliminary cause evaluation has been performed. The apparent cause of the cracking is Intergranular Stress Corrosion Cracking (IGSCC). A material sample is being shipped to the GE Vallecitos Nuclear Center for examination to confirm the apparent cause. GE will report the results of the examination by August 21, 2006.
2. The issue has been communicated to the industry through the BWR Owners' Group and the Electric Power Research Institute (EPRI)/BWR Vessel and Internals Project (BWRVIP). The NRC was informed in a NRC management meeting with EPRI and the BWRVIP Executive Oversight Committee at the NRC offices, Rockville, on March 15, 2006.
3. GE has completed an evaluation of the susceptibility to IGSCC using the BWRVIP-84 criterion. Determination of whether any possible cracking could lead to a substantial safety hazard (i.e., loss of core shroud configuration integrity during a design basis accident condition) depends upon many factors, including the actual extent of cracking in the repair components. Until inspections are completed, the actual extent of cracking is not known. GE is developing a model to predict the postulated extent of tie rod upper support cracking for tie rods with upper supports made of Alloy X-750. For upper supports that exceed the BWRVIP-84 criteria significantly, the model will be used to postulate the extent of cracking. This prediction will be used to determine if a substantial safety hazard could exist. GE will report the results of the evaluation by October 9, 2006.
4. The original design basis stress reports will be reviewed to assess the available margin in the primary membrane + bending stress intensities of the upper supports with respect to ASME code allowable values. Where reasonable margin exists in the original design basis code evaluation (an existing margin of approximately 25 % will be considered as reasonable margin), the existing margin is deemed adequate to offset any engineering assumptions or judgments used in the original analysis. Where the original margin is less than 25%, further review will be performed (including finite element analysis, if necessary) to confirm that the upper support remains qualified. This review will be completed by October 9, 2006."

Affected US Plants per Attachments 1 and 2 of the Part 21 notification: Clinton, Nine Mile Point 1, Pilgrim, Dresden 2 & 3, Quad Cities 1 & 2, Hatch 1 & 2.

***** UPDATE ON 8/21/06 AT 1614 ET VIA E-MAIL FROM JASON POST TO MACKINNON *****

"GE Energy, Nuclear (GE) has completed the failure evaluation of the cracking discovered in the Hatch Unit 1 core shroud repair tie rod upper supports as committed in Reference 2, (GE Part 21 60-Day Interim Report Notification: Core Shroud Repair Tie Rod Upper Support Cracking, MFN 06-133, May 12, 2006). A preliminary cause evaluation had concluded that the apparent cause of the cracking is Intergranular Stress Corrosion Cracking (IGSCC). A material sample was shipped to the GE Vallecitos Nuclear Center for examination to confirm the apparent cause. GE committed to report the results of the examination by August 21, 2006.

"The fracture was examined by metallographic and scanning electron microscope (SEM) techniques including an analysis of the fracture surface. The examinations revealed the cracking mechanism to be IGSCC. Scanning electron microscopy (SEM) showed the fracture surface had a "rock candy" like appearance, consistent with an IGSCC mechanism. Images of the cross-section of the fracture surface further verified the IGSCC mechanism by showing the path of the crack following the grain boundaries. No hardness or microstrutural anomalies were observed.

"GE continues to work on the other action items that were committed in Reference 2. If you have any questions, on this information, please call me . . . "

R2DO (Mark Lesser) notified. E-mailed to NRR Part 21 (Omid Tabastabai & Jack Foster).

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* * * UPDATE ON 10/09/06 AT 2333 EDT VIA E-MAIL FROM JASON POST TO HUFFMAN * * *

Summary of Part 21 Notification: Completion of GE Evaluation on Core Shroud Repair Tie Rod Upper Support Cracking

Previous correspondence on this subject "identified that GE had concluded that this is not a reportable condition for Hatch Unit 1 and for several other US plants that have core shroud repairs designed by GE. However, GE had not completed the evaluation for two other US plants (Pilgrim and NMP-1). GE committed to complete the evaluation and inform the NRC of the results by October 9, 2006. The purpose of this letter is to inform the NRC of the results of the Pilgrim and NMP-1 evaluations.

"The GE evaluation concluded the following:

"a. All other major Alloy X-750 components in the tie rod assembly vertical load path besides the previously identified upper support brackets for the plants with GE designed tie rod repairs are within the BWRVIP-84 criterion for IGSCC susceptibility. Furthermore, the upper supports remain qualified with respect to ASME code allowable values per the original design basis stress analyses.

"b. It is not a reportable condition for the as found Hatch Unit 1 condition based on the known extent of tie rod upper support cracking.

"c. It is not a reportable condition for plants that do not use X-750 material for the tie rod upper support brackets. This is applicable to Clinton.

"d. It is not a reportable condition for plants that have margin to the BWRVIP-84 IGSCC criterion for the tie rod upper support brackets (or which exceed the criteria by a very small amount). These plants are Hatch 2, Quad Cities 1/2, and Dresden 2/3.

"e. It is not a reportable condition for the plants that exceed the BWRVIP-84 IGSCC criterion for the tie rod upper supports based on a three-pronged composite approach of (1) the shroud repair upper support integrity based on assumed cracking, (2) the shroud horizontal welds integrity, and (3) the previous shroud cracking safety evaluations. These plants are NMP-1 and Pilgrim.

"Corrective/Preventive Actions:

"GE recommends that NMP-1 and Pilgrim replace the tie rod upper supports with an improved IGSCC-resistant design at the next regular scheduled outage.

R1DO (Decker) and R2DO (Krohn) notified. E-mailed to NRR Part 21 (Vern Hodge, Ian Jung, John Thorp).

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GE Energy

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October 9, 2006
MFN 06-374

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

Subject: **Part 21 Notification: Completion of GE Evaluation on Core Shroud Repair Tie Rod Upper Support Cracking**

References:

1. **GE Part 21 60-Day Interim Report Notification: Core Shroud Repair Tie Rod Upper Support Cracking, MFN 06-133, May 12, 2006**
2. **NRC Event Notification Report 42372 (Retracted), Degraded Condition of Shroud Tie Rods, NRC Event Notification Report for April 24, 2006**
3. **GE Update to Part 21 Interim Report Notification: Failure Analysis of Core Shroud Repair Tie Rod Upper Support Crack, MFN 06-292, August 21, 2006**

The Reference 1 letter provided information concerning an evaluation performed by GE Energy, Nuclear (GE) regarding the cracking discovered in the Hatch Unit 1 core shroud repair tie rod upper supports (Reference 2). The condition, the impact on other plants with tie rod repairs by GE, and the recommended actions were presented to NRC management in a meeting with the BWR Vessel & Internals Project (BWRVIP) Executive Oversight Committee at the NRC Rockville, MD offices on March 15, 2006. The Reference 1 letter identified that GE had concluded that this is not a reportable condition for Hatch Unit 1 and for several other US plants that have core shroud repairs designed by GE. However, GE had not completed the evaluation for two other US plants (Pilgrim and NMP-1). GE committed to complete the evaluation and inform the NRC of the results by October 9, 2006. The purpose of this letter is to inform the NRC of the results of the Pilgrim and NMP-1 evaluations.

A description of the evaluation performed by GE for NMP-1 and Pilgrim is provided in Attachment 1. A list of the US plants with GE shroud repairs is provided in Attachment 2. GE previously reported the results of the cause evaluation in Reference 3. This completes the actions committed by GE in the Reference 1 letter.

If you have any questions, please call me at (910) 675-6608.

Sincerely,

Jason Post

Jason. S. Post
Safety Evaluation Program Manager

Attachments:
1. Description of Evaluation
2. US Plants With GE Core Shroud Repair

cc: S. B. Alexander (NRC-NRR/DISP/PSIM) Mail Stop 6 F2
M. C. Hincharik (NRR/DPR/PSPB) Mail Stop O-7D11
C. V. Hodge (NRC-NRR/DIPM/IROB) Mail Stop 12 H2
P. L. Campbell (GE)
M. E. Harding (GE)
J. F. Harrison (GE)
J. F. Klapproth (GE)
A. Lingenfelter (GE)
K. K. Sedney (GE)
G. B. Stramback (GE)
R. J. Marcoot (GE)
PRC File
DRF No. 0000-0059-5417

Attachment 1 -Description of Evaluation

Summary:

GE Energy, Nuclear (GE) has provided core shroud repairs using tie rods to the US BWR plants identified in Attachment 1. Recently it was discovered during an in-vessel visual inspection (IVVI) that tie rod upper supports at Hatch Unit 1 experienced cracking. The root cause was determined to be Intergranular Stress Corrosion Cracking (IGSCC) in the Alloy X-750 tie rod upper support material[3].

GE opened an internal evaluation to determine if the identified condition for BWR shroud repairs designed by GE could be a reportable condition under 10CFR21. GE used the criterion provided in the BWR Vessels & Internals Project (BWRVIP-84) for the IGSCC susceptibility assessment of the Alloy X-750 components in the tie rod vertical load path. GE determined that two US plants exceed the BWRVIP-84 criterion for the upper supports (in addition to the Hatch Unit 1 as-found condition). GE has completed the evaluation for these plants and concluded that a substantial safety hazard (SSH) does not exist.

As part of the evaluation, GE created improved finite element models for more accurate predictions of localized stresses. With the improved models, GE re-examined the original design basis stress with respect to ASME Code allowable values for cases with less than 25% margin in the original design basis code evaluation. GE concludes that the shroud repair components remain qualified to ASME Code requirements.

Background

During the H1R22 IVVI examination of Hatch Unit 1 shroud repair upper support, cracks were observed in one of the upper supports, of the shroud repair assemblies at the 135° and 225° azimuth locations. The cracking occurred at the 90° corner of the horizontal and vertical legs of the upper support. These upper supports were made of Alloy X-750 material. The cause for the cracking was determined to be IGSCC, likely caused by large sustained stresses in the Alloy X-750 material during normal operation. The Hatch 1 condition, apparent cause, and recommended action have been communicated to the BWR industry and the NRC by the EPRI and BWRVIP[2].

Evaluation

GE has taken a three-pronged composite approach to this evaluation to account for (1) the shroud repair upper support integrity based on assumed cracking, (2) the shroud horizontal welds integrity, and (3) previous shroud cracking safety evaluations, as a body of evidence that supports a conclusion that a SSH does not exist. This evaluation is summarized for each plant below. These evaluations do not consider plant-specific inspection information that may bolster arguments about shroud repair upper support or shroud weld ligament integrity.

Additionally, the original design basis stress reports were reviewed to assess the available margin in the primary stress intensities of the upper supports and other shroud

repair components with respect to ASME Code allowable values. Where the margin is >25%, the finite element models used in the analyses are adequate to offset any engineering assumptions or judgments used in the original analyses. The margin of 25% was selected as a reasonable basis by comparing the new finite element analysis results of the upper supports of a few plants with those of the original design basis shroud repair stress reports. Where the margin is <25%, adequacy of the margin was supported by further assessment to confirm that the shroud repair components remain qualified to the ASME Code requirements. Based on the above evaluation, GE concludes that the shroud repair components remain qualified to ASME Code requirements.

GE also considered the potential for the upper support of the shroud repair becoming a loose part. It was concluded considering the design features of the upper support that such potential does not exist.

NMP-1

Tie Rod Upper Support Integrity - NMP-1 has 4 tie rods; each tie rod assembly has two upper support brackets. The repair was installed as a contingent pre-emptive repair in 1995. NMP-1 and Hatch Unit 1 have similar geometries at the 90° corner (i.e., no specified radius) and comparable sustained normal operating loads. The NMP-1 upper supports do not exceed the BWRVIP-84 criterion by as much as the upper supports that cracked at Hatch Unit 1. While the duration of operation with Hydrogen Water Chemistry (HWC) and Noble Metal are different for NMP-1 and Hatch Unit 1, the benefit at the upper support location is minimal. All these factors indicate that any cracking at NMP-1 would be no worse than at Hatch Unit 1. However, since the extent of cracking of the upper supports at NMP-1 is unknown, for this evaluation it is assumed that two upper supports in NMP-1 are flawed, one in each of two different tie rod assemblies, just as at Hatch Unit 1. For this evaluation it is assumed that the two upper supports that are postulated to be cracked carry no load, therefore, these two tie rods are each supported by a single uncracked upper support. Normal operating, upset, and faulted conditions were evaluated using a detailed finite element analysis of the upper supports, and taking into consideration the conservatism in the design basis loads. The analysis concluded that:

- For normal operating conditions, the maximum primary membrane plus bending stress in the uncracked upper support is less that the ASME Code allowable stress.

- For upset conditions, the maximum primary membrane plus bending stress in the uncracked upper support is less than the yield stress when using an earthquake load corresponding to the operating basis earthquake (OBE) and normal differential pressure loads.

- For the faulted condition, the maximum primary membrane plus bending stress in the uncracked upper support is less that the ASME Code allowable stress based on a finite element analysis when the main steam line break (MSLB) loads are predicted using TRACG methodology, and combined with the design basis earthquake (DBE) load in a square-root-of-the-sum-of-the-squares (SRSS) summation.

Shroud Horizontal Weld Integrity - Previous safety evaluations for NMP-1 determined that the minimum shroud weld ligament required to demonstrate structural integrity is approximately 10% of the wall thickness for 360° circumferential cracking. Significant industry data exists on the extent of core shroud cracking. This data shows that considerable core shroud integrity is likely to be maintained to date. Fleet-wide data shows that many individual shroud welds have little cracking. Even in plants with significant cracking in one or more welds, some welds have little or no cracking. The generic fleet-wide bounding estimate of core shroud wall cracking in August 1994 was 80% of the shroud wall thickness. Based on this industry data and the earlier observed cracking in the NMP-1 shroud welds, and considering possible crack growth for the reactor chemistry at NMP-1, a reasonable basis exists to conclude that the NMP-1 core shroud horizontal welds have not degraded to the shroud repair design assumption of 360° thru-wall cracking.

Previous Shroud Cracking Safety Evaluations - A safety evaluation was previously performed for NMP-1 without the shroud repair as part of the response to Generic Letter (GL) 94-03. The safety evaluation concluded that plant retained the ability to operate and safely shutdown even with assumed 360° thru-wall cracking of the H1-H7 welds. The ability of NMP-1 to operate and safely shutdown is enhanced relative to this conclusion with the shroud repair even if there is postulated cracking in the tie rod upper supports.

<u>Pilgrim</u>

Tie Rod Upper Support Integrity - Pilgrim has 4 tie rods; each tie rod assembly has a single (larger) upper support bracket. The repair was installed as a contingent pre-emptive repair in 1995. Pilgrim and Hatch Unit 1 have similar geometries at the 90° corner (i.e., no specified radius) and the sustained normal operating load for Pilgrim is within 10% of the Hatch Unit 1 loads. The Pilgrim upper supports do not exceed the BWRVIP-84 criterion by as much as the upper supports that cracked at Hatch Unit 1. While the duration of operation with HWC and Noble Metal are different for Pilgrim and Hatch Unit 1, the benefit at the upper support location is minimal. All these factors indicate that any cracking at Pilgrim would be no worse than at Hatch Unit 1. However, since the extent of cracking of the upper supports at Pilgrim is unknown, for this evaluation it is assumed that the same fraction of upper supports in Pilgrim are flawed (25%) as at Hatch Unit 1. Thus one of the four Pilgrim upper supports is assumed to be cracked with the same average flaw size as the cracking of the upper supports at Hatch Unit 1. Normal operating, upset, and faulted conditions were evaluated using a detailed finite element analysis of the upper support, and taking into consideration the conservatism in the design basis loads. The analysis concluded that:

- For normal operating conditions, the primary membrane plus bending stress in the cracked upper support is less that the ASME Code allowable stress.
- For upset conditions, the primary membrane plus bending stress in the cracked upper support is less than the ASME Code allowable stress.
- For the faulted condition, the primary membrane plus bending stress in the cracked upper support is less that the ASME Code allowable stress when the

MSLB loads are predicted using TRACG methodology, and combined with the safe shutdown earthquake (SSE) load in a SRSS summation.

Shroud Horizontal Weld Integrity - Previous safety evaluations for Pilgrim determined that the required minimum shroud weld ligament to demonstrate structural integrity is less than 5% of the wall thickness for 360° circumferential cracking. Significant industry data exists on the extent of core shroud cracking. This data shows that considerable core shroud integrity is likely to be maintained to date. Fleet-wide data shows that many individual shroud welds have little cracking. Even in plants with significant cracking in one or more welds, some welds have little or no cracking. The generic fleet-wide bounding estimate of core shroud wall cracking in August 1994 was 80% of the shroud wall thickness. Using an estimated bounding crack growth rate for the reactor chemistry at Pilgrim, the estimated total depth of cracking by the scheduled Spring 2007 outage is 93% of the wall thickness, with at least a 7% wall thickness remaining. This exceeds the minimum weld ligament requirement of 5% of the shroud wall thickness for Pilgrim to ensure shroud structural integrity even when assuming 360° circumferential cracking.

Previous Shroud Cracking Safety Evaluations - A safety evaluation was previously performed for Pilgrim without the shroud repair as part of the response to Generic Letter (GL) 94-03. The safety evaluation concluded that plant retained the ability to operate and safely shutdown even with assumed 360° thru-wall cracking of the H1-H9 welds. The ability of Pilgrim to operate and safely shutdown is enhanced relative to this conclusion with the shroud repair even if there is postulated cracking in the tie rod upper supports.

Safety Basis

Loss of core shroud integrity could impact the ability to maintain adequate core cooling for postulated design basis accident conditions and would be reportable under 10 CFR 21 as a substantial safety hazard. This evaluation has concluded that a substantial safety hazard does not exist as a result of the identified concern.

Conclusion

The GE evaluation concluded the following:

a. All other major Alloy X-750 components in the tie rod assembly vertical load path besides the previously identified upper support brackets for the plants with GE designed tie rod repairs are within the BWRVIP-84 criterion for IGSCC susceptibility. Furthermore, the upper supports remain qualified with respect to ASME code allowable values per the original design basis stress analyses.
b. It is not a reportable condition for the as found Hatch Unit 1 condition based on the known extent of tie rod upper support cracking.
c. It is not a reportable condition for plants that do not use X-750 material for the tie rod upper support brackets. This is applicable to Clinton.

d. It is not a reportable condition for plants that have margin to the BWRVIP-84 IGSCC criterion for the tie rod upper support brackets (or which exceed the criteria by a very small amount). These plants are Hatch 2, Quad Cities 1/2, and Dresden 2/3.
e. It is not a reportable condition for the plants that exceed the BWRVIP-84 IGSCC criterion for the tie rod upper supports based on a three-pronged composite approach of (1) the shroud repair upper support integrity based on assumed cracking, (2) the shroud horizontal welds integrity, and (3) the previous shroud cracking safety evaluations. These plants are NMP-1 and Pilgrim

Corrective/Preventive Actions

GE recommends that NMP-1 and Pilgrim replace the tie rod upper supports with an improved IGSCC-resistant design at the next regular scheduled outage.

Attachment 2 – US Plants With GE Core Shroud Repair

SC	Utility	Plant
X[1]	AmerGen Energy Co.	Clinton
	AmerGen Energy Co.	Oyster Creek
X[2]	Constellation Nuclear	Nine Mile Point 1
	Constellation Nuclear.	Nine Mile Point 2
	Detroit Edison Co.	Fermi 2
	Dominion Generation	Millstone 1[3]
	Energy Northwest	Columbia
	Entergy Nuclear Northeast	FitzPatrick
X[2]	Entergy Nuclear Northeast	Pilgrim
	Entergy Nuclear Northeast	Vermont Yankee
	Entergy Operations, Inc.	Grand Gulf
	Entergy Operations, Inc.	River Bend
X[1]	Exelon Generation Co.	Dresden 2
X[1]	Exelon Generation Co.	Dresden 3
	Exelon Generation Co.	LaSalle 1
	Exelon Generation Co.	LaSalle 2
	Exelon Generation Co.	Limerick 1
	Exelon Generation Co.	Limerick 2
	Exelon Generation Co.	Peach Bottom 2
	Exelon Generation Co.	Peach Bottom 3
X[1]	Exelon Generation Co.	Quad Cities 1
X[1]	Exelon Generation Co.	Quad Cities 2
	First Energy Nuclear Operating Co.	Perry 1
	FPL Energy	Duane Arnold
	Nebraska Public Power District	Cooper
	Nuclear Management Co.	Monticello
	PPL Susquehanna LLC.	Susquehanna 1
	PPL Susquehanna LLC	Susquehanna 2
	Progress Energy	Brunswick 1
	Progress Energy	Brunswick 2
	PSEG Nuclear	Hope Creek
X[1]	Southern Nuclear Operating Co.	Hatch 1
X[1]	Southern Nuclear Operating Co.	Hatch 2
	Tennessee Valley Authority	Browns Ferry 1[4]
	Tennessee Valley Authority	Browns Ferry 2
	Tennessee Valley Authority	Browns Ferry 3

Notes:
1. Previously notified of GE conclusion that it is Not Reportable
2. 60-Day Interim Report Notification cleared: GE has concluded that it is Not Reportable
3. Plant has been shutdown.
4. Plant is in an extended shutdown