Edwin I. Hatch Nuclear Plant - Unit 2
Request for Authorization Under the Provision of 10 CFR 50.55a(a)(3)(i) for Modification of the Core Shroud Stabilizer Assemblies

Enclosure 4

GE-NE-000-0080-0259-R2; Hatch 2 Nuclear Plant Shroud Repair Replacement of Upper Support Stress Analysis Report

(Nonproprietary)

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Hatch 2 Nuclear Plant

Shroud Repair Replacement of Upper Support Stress Analysis Report

IMPORTANT NOTICE REGARDING THE

CONTENTS OF THIS REPORT

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This is a non-proprietary version of the document GE-NE-0000-0080-0259-R2, Revision 2, from which the proprietary information has been removed. Portions of the document that have been removed are identified by white space within double square brackets, as shown here [[ ]].

Revision Control Sheet

Revision No.	Date	Description
Rev. 0	Jan 26, 2008	Initial submittal
Rev. 1	June 6, 2008	Report revised to incorporate SNC comments. Major changes are identified below. In addition, some minor/editorial changes were also made. • Throughout the report, "support block" changed to "support" to be consistent with Figure 1 and the title of the drawing (Reference 3.b of Section 8). • **Section 4, Table 4-1** – Stabilizer Support Assembly drawing added. • **Section 5** – Bullets added for the tie rod nut to tie rod threaded-connection FEA, replacement upper support design relative to bulk flow blockage, and stresses in the shroud flange. • **Section 5.1.4** – revised to add the bulk flow blockage assessment. • **Section 5.1.6** - New Section added for the shroud flange stresses evaluation in the modified EDM pocket. • **Section 5.3.3** – New Section added for the replacement tie rod nut/tie rod threaded-connection FEA. • **Section 6** – The stress results section modified to include results of the maximum plastic strains in the tie rod nut and the tie rod threads. • **Section 7** – Modified to include a conclusion of the tie rod nut to the tie rod threaded-connection FEM. • **Section 8** - Stabilizer Support Assembly Drawing (Ref. 3.i) added.
Rev. 2	June 17, 2008	Report revised to incorporate the final SNC comments. Major changes are identified below. In addition, some minor/editorial changes were also made. • **Section 4, Table 4-1** -More detailed material specifications included. • **Section 5.1.4** – Sentence about the transverse stiffness revised.

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1.0 INTRODUCTION AND BACKGROUND

GE-Hitachi Nuclear Energy (GEH) had provided core shroud repairs using tie rods to BWR plants including Hatch 1 and 2 stations. In the spring of 2006 outage at Hatch1 (H1R22), during an in-vessel visual inspection (IVVI), indications were observed in the shroud repair tie rod upper supports made of Alloy X-750 at two of the four shroud tie rod repair locations (Reference 1). The indications emanated from the sharp corner between the horizontal and vertical legs of the upper support and ran outwardly, at approximately 30° to the horizontal. The cracking mechanism was determined by metallographic and Scanning Electron Microscope (SEM) techniques to be Inter-granular stress corrosion cracking (IGSCC). Alloy X-750 material is susceptible to IGSCC if subjected to sustained, large peak stress conditions.

As a result of the cracking at Hatch 1, detailed finite element stress analyses of the Hatch 2 original tie rod repair upper support and the nut, made of Alloy X-750, were also performed by GEH. Although IGSCC susceptibility for the Hatch 2 original upper support was identified based on the maximum calculated stress exceeding the BWRVIP-84 criterion, continued operation was justified for at least one more operating cycle, and documented in the Hatch 2 shroud tie rod repair operability evaluation report (Reference 2). However, as a long-term solution to mitigate the potential for IGSCC, Southern Nuclear Corporation (SNC) decided that the upper support and tie rod nut of the shroud repairs at all four azimuth locations be replaced with new and improved replacement hardware designs that are more robust from the standpoint of IGSCC. This report documents the analyses of the replacement shroud repair hardware to be installed at Hatch 2 station.

2.0 SCOPE

The objective of the stress analysis presented in this report is to demonstrate that the proposed shroud repair replacement hardware (upper support, support, their associated components, and the tie rod nut) depicted in the drawings (Reference 3) satisfies the IGSCC susceptibility criteria and ASME Code requirements of the design specification data sheet (Reference 4). The shroud repair replacement hardware design, criteria for qualification, analysis approach, results and conclusions are presented in the following sections.

3.0 REPLACEMENT HARDWARE DESIGN FEATURES

The replacement hardware (upper supports, support, their associated components and tie rod nut) shown in Figure 1 are fabricated in accordance with Reference 3 drawings. The major load bearing components are the upper support and the tie rod nut. These replacement components incorporate features that improve their ability to resist IGSCC. These features are as follows:

- **Generous Fillet Radius at the Corner and Simplified Design of Upper Support.** The original support design had no stress relief specified between the bottom of the U-shaped horizontal arm that rests on the shroud flange and the vertical arm of the upper support. In the replacement upper support, a generous fillet radius has been incorporated as a stress-relief. This provision reduces the stress concentration and in turn reduces the peak stress. Also, the U-shaped horizontal arm design of the upper support was simplified to a rectangular plate. The finite element analysis of the upper support is consistent with Reference 3.a drawing.

- **Sharp Edges Eliminated on the Upper Support:** Generous fillet radii are specified at interfaces between mating surfaces and cross section variations. This provision reduces the stress concentration, and in turn reduces peak stresses at these locations.
- **Use of IGSCC-Resistant Material:** The tie rod nut and the support are made of XM-19. (References 3.b and 3.c). This mitigates the potential for the nut and the support to IGSCC. Original tie rod nut and support were made of Alloy X-750. Alloy X-750 material is susceptible to IGSCC if subjected to sustained, large peak stress conditions.
- **Generous Root Radius for the ACME Threads in the Tie Rod Nut:** A generous radius of [[ ]] is provided for the replacement tie rod nut ACME threads to reduce peak stress (Reference 3.c). This feature along with the use of XM-19 material greatly mitigates the potential for IGSCC.

4.0 REPLACEMENT HARDWARE MATERIALS AND PROPERTIES

The materials used in the shroud repair replacement hardware (upper supports, support, their associated components, and tie rod nut) and their properties are provided in Table 4-1 and Table 4-2 respectively.

Table 4-1 Components in the Replacement of Upper Support Assembly

No	Description	Material	Reference (Section 8)
1	Upper Support	AMS 5542 Rev. L ASME SB-637, UNS N07750	3.a
2	Support	ASME SA-479, Type XM-19 ASME SA-182, Grade F XM-19 ASME SA-336, Class F XM-19	3.b
3	Tie Rod Nut	ASME SA-479, Type XM-19 ASME SA-182, Grade F XM-19 ASME SA-336, Class F XM-19	3.c
4	Top Support Bracket	ASME SA-479, Type XM-19 ASME SA-182, Grade F XM-19 ASME SA-336, Class F XM-19	3.d
5	Retainer Pin	ASME SA-479, Type XM-19 ASME SA-182, Grade F XM-19 ASME SA-336, Class F XM-19	3.e
6	Retainer Spring	ASME SB-637, UNS N07750	3.f
7	Socket Head Screw Cap	ASME SA-479, Type XM-19 ASME SA-182, Grade F XM-19 ASME SA-336, Class F XM-19	3.g
8	Dowel Pin	ASME SA-479, Type XM-19 ASME SA-182, Grade F XM-19 ASME SA-336, Class F XM-19	3.h
9	Stabilizer Support Assembly	N/A (Assembly Drawing)	3.i

The Design Specification Data Sheet (Reference 4) calls for the use of ASME B&PV Code Section III NB and NG-3000, 2001 Edition through 2003 Addenda (Reference 5), and Code Case N-60-5 (Reference 6). The following material properties are obtained from these references and are used in the evaluations below.

Table 4-2 Material Properties Used in This Evaluation

Property	At Temp	units	Material XM-19	Ref /Table	Material X-750	Ref/Table
Modulus of Elasticity, E	70 °F	psi	28.30E+06	Ref 7, TM-1	30.90E+06	Ref 7, TM-4
	300 °F	psi	27.00e+06	Ref 7, TM-1	29.80E+06	Ref 7, TM-4
	550 °F	psi	25.60E+06	Ref 7, TM-1	28.85E+06	Ref 7, TM-4
Coefficient of Thermal Expansion, α	70 °F	in/in °F	8.20E-06	Ref 7, TE-1	6.70E-06	Ref 7, TE-4
	300 °F	in/in °F	8.70E-06	Ref 7, TE-1	7.20E-06	Ref 7, TE-4
	550 °F	in/in °F	9.10E-06	Ref 7, TE-1	7.70E-06	Ref 7, TE-4
Ultimate Tensile Strength, Su	70 °F	psi	90,000	Ref 7, U	160,000	Ref 6, Tbl C
	550 °F	psi	81,150	Ref 7, U	160,000	Ref 6, Tbl C
Yield Strength, Sy	70 °F	psi	55,000	Ref 7, Y-1	100,000	Ref 6, Tbl B
	550 °F	psi	38,100	Ref 7, Y-1	92,800	Ref 6, Tbl B
Stress Intensity, Sm	70 °F	psi	33,300	Ref 7, 2A	53,300	Ref 6, Tbl A
	550 °F	psi	29,450	Ref 7, 2A	53,300	Ref 6, Tbl A

5.0 STRUCTURAL ANALYSIS

Structural analyses of the shroud repair replacement upper support, and the support were performed. Details of the analysis methods, loads and qualification criteria are provided in the following subsections. The results of these analyses are presented in Section 6.0.

- The upper support in engagement with the shroud flange at the top and with the support at its bottom was analyzed using finite element method.
- Other associated components in the replacement upper support assembly, including the tie rod nut were evaluated using hand calculations. These components are non-Alloy X-750 and are more resistant to IGSCC.
- The tie rod nut/tie rod threaded-connection was evaluated using finite element method to determine plastic strains in the threads of the nut and the tie rod for Normal operation tie rod load.

In addition, the following were also addressed:

- Effect of TPO RIPDs on the tie Rod Loads.
- Effect of the replacement upper support stiffness on the tie rod loads.

- Effect of the replacement upper support stiffness on tie rod seismic loads.
- Effect of the replacement upper support stiffness on reactor pressure vessel stresses.
- Effect of the replacement upper support stiffness on flow induced vibration.
- Effect of TPO tie rod loads on the reactor pressure vessel stresses.
- Effect of replacement upper support on the shroud flange.

5.1 Design Basis Loads and Load Combinations

5.1.1 Effect of TPO RIPDs on the Tie Rod Loads

The effects of the changes in RIPDs due to TPO on the tie rod loads were considered in the present evaluations. The load combinations considered for the operating conditions are the same as the original design basis. The tie rod loads due to TPO RIPDs were calculated, and are provided below in comparison with the original design basis tie rod loads. As shown in the Table 5-1 below, the TPO tie rod loads remain essentially the same as the original design basis loads (change < 0.5%)

Table 5-1 Comparison of Original and TPO Condition Tie Rod Loads (lbs/tie rod)

Condition	Normal	Upset-Seismic	Upset-Thermal	Emergency	Faulted
Original	[[				
Current/TPO					]]

5.1.2 Effect of Replacement Upper Support Stiffness on the Tie Rod Loads

The vertical stiffness of the replacement upper support assembly was determined from the finite element model. Using the upper support stiffness, the net combined stiffness of the tie rod assembly was calculated and compared to the original design basis tie rod assembly stiffness. The increase in stiffness of the tie rod assembly with the replacement upper support was found to be < 1%. Also, adequate margins to the ASME Code stresses and conservatism in the IGSCC evaluations exist in the analyses, to offset these small increases in the tie rod loads. Hence, the effect of the increased stiffness on the tie rod loads is deemed to be negligible.

5.1.3 Effect of Replacement Upper Support Stiffness on the Tie Rod Seismic Loads

The tie rod assembly stiffness due to the replacement upper support remains essentially the same as that of the original (< 1% increase). This small increase in the tie rod assembly stiffness has practically no effect on the overall dynamic characteristics of the vessel and internals primary structure model. Hence it is deemed that the seismic load for the tie rod assembly remains unchanged.

5.1.4 Effect of Replacement Upper Support on Flow Induced Vibration and Bulk Flow Blockage

The bulk flow in the annulus area remains unchanged for the TPO condition with respect to the original design basis conditions. [[

]] The calculated value of transverse stiffness of the tie rod is not affected by the replacement upper support since the transverse stiffness is based on the length of the tie rod between the upper and lower springs, and the location and configuration of the mid support.

Therefore, there is no effect of the replacement hardware on the flow-induced vibration characteristics of the tie rod assembly.

The impact of the replacement upper support hardware relative to bulk flow blockage was also assessed. There has been no increase in the cross sectional area of the replacement upper support relative to the original upper support design. Hence, there is no concern for bulk flow blockage with the replacement upper support hardware design.

5.1.5 Effect of the TPO Tie Rod Loads on the Reactor Pressure Vessel Stresses

The tie rod loads in the TPO conditions are essentially the same as the original loads (change < 0.5%). Thus, the effect of this small increase in the loads on the stresses at the reactor pressure vessel walls is deemed to be negligibly small.

5.1.6 Effect of Replacement Upper Support on the Shroud Flange

The cross section of the horizontal leg in contact with the shroud flange [[

]] The bearing stresses in the shroud flange pocket for the Normal, Upset, Emergency, and Faulted condition tie rod loads specified in Table 5-1 were computed, and shown to be within the ASME code allowable stress limits.

5.2 Qualification Criteria

5.2.1 IGSCC Criteria for X-750 and XM-19

In accordance with the requirement of the design specification data sheet (Reference 4), the total tensile principal stress (Pm + Pb + Q + F) is compared to the IGSCC criterion of [[ ]] for 40-year life. This criterion is summarized in Table 5-2 and is more restrictive than the BWRVIP-84 criterion of 0.8Sy.

For XM-19 material, no specific criterion for IGSCC is specified in BWRVIP-84. However, the maximum plastic strain is limited to within [[ ]], in accordance with Reference 8.

Table 5-2 IGSCC Allowable Limit for X-750 and XM-19 Components (Ref. 4 and 8)

Total Principal Tensile Stress	Material	Allowable Limit	Allowable value
Maximum Principal stress of the ($P_m + P_b + Q + F$) category due to normal sustained loads	X-750	[[	]]
	XM-19	Limited by strain	Plastic Strain < [[ ]]

5.2.2 ASME Code Allowable Stress Limits

In accordance with the requirement of the design specification data sheet (Reference 4), the Normal, Upset, Emergency and Faulted condition allowable stress limits used in this report are in accordance with the ASME Code (Reference 5). The allowable stress limits of the ASME Code are summarized in Table 5-3 and Table 5-4 below.

Table 5-3 ASME Code Allowable Stress Limits @ 550 °F (Non-Threaded Components)

Service Level	Stress Category	Allowable Limit	XM-19	X-750
Components Other Than Threaded Fasteners (Ref 5, NG-3220)				
Normal & Upset	P_m	S_m	29,450	53,300
	$P_m + P_b$	1.5 S_m	44,175	79,950
	$P_m + P_b + Q$	3.0 S_m	88,350	159,900
	Shear Stress	0.6 S_m	17,670	31,980
	Bearing Stress	S_y	38,100	92,800
		1.5 S_y (away from free edge)	57,150	139,200
	CUF	1.0	1.0	1.0
Emergency	P_m	1.5 S_m	44,175	79,950
	$P_m + P_b$	2.25 S_m	66,263	119,925
	Shear Stress	0.9 S_m	26,505	47,970
	Bearing Stress	1.5 S_y	57,150	139,200
		2.25 S_y (away from free edge)	85,725	208,800
Faulted	P_m	Min (2.4S_m, 0.7S_u) (Austenitic) 0.7S_u (Ferritic)	56,805	112,000
	$P_m + P_b$	Min (3.6S_m, 1.05 S_u) (Austenitic) 1.05S_u (Ferritic)	85,208	168,000
	Shear Stress	0.42 S_u	34,083	67,200
	Bearing Stress	2.0 S_y	76,200	185,600
		3.0 S_y (away from free edge)	114,300	278,400

Table 5-4 ASME Code Allowable Stress Limits @ 550 °F (Threaded Components)

Service Level	Stress Category	Allowable Limit	XM-19	X-750
Threaded Structural Fasteners (Ref 5, NG-3230)				
Normal & Upset	P_m (Mech. Loads)	S_m	29,450	53,300
	P_m (Installation Torque)	Min. (1.08 S_y, 0.8 S_u) at installation temperature.	59,400	108,000
	$P_m + Q_m$	Min. (0.9 S_y, 2/3 S_u)	34,290	83,520
	$P_m + P_b + Q_m + Q_b$	Min. (1.2 S_y, 8/9 S_u)	45,720	111,360
	Threads — Shear	0.6 S_m(Primary)	17,670	31,980
	Threads — Shear	0.6 S_y (Primary + Secondary)	22,860	55,680
	Under bolt head — Bearing	2.7 S_y	102,870	250,560
	Shanks, Threads — CUF	1.0	1.0	1.0
Emergency	P_m	Same as for non-threaded components. If S_u > 100 ksi, then same as Normal, Upset limits for threaded components.	44,175	53,300
	$P_m + P_b$		66,263	111,360
	Shear (Primary)	Same as for Normal Upset limits for threaded components	17,670	31,980
	Shear (Pr +Sec)		22,860	55,680
Faulted	P_m	Smaller of (2.4 S_m, 0.7 S_u); If S_u>100 ksi, then 2S_m	56,805	106,600
	P_m+P_b	Smaller of (3.6S_m, 1.05S_u); If S_u > 100 Ksi, then 3S_m	85,208	159,900
	Shear Stress	Smaller of (0.42S_u, 0.6S_y)	22,860	55,680

5.3 Analysis Methods

5.3.1 Replacement Upper Support Stress Analysis

A finite element analysis of the upper support was performed using the ANSYS computer program (Reference 9). The components included in the finite element model are shown in Figure 2. Only half of the upper support is modeled due to the symmetry of the geometry about the vertical mid-pane. The model was meshed using ANSYS SOLID 186, 20-noded brick elements. [[

]] The appropriate boundary conditions and the loads as shown below were applied to the finite element model.

Boundary conditions (Figure 2)

- The bearing interface of the horizontal arm of the upper support with the shroud flange was modeled using contact elements with [[
  ]] (per Reference 10). [[
  ]]
- The gap between the upper support and the shroud head flange is conservatively not included in the model. The contact between the top surface of the upper support and the shroud head flange would reduce the stresses in the upper support.
- The shroud flange was modeled as a block, initially in contact with the upper support.
- The lower end of the upper support contacts the outer surface of the shroud. This is simulated by using rigid surface and contact elements (Figure 3).
- At the lower end the upper supports, the 'hooks' on the Support engage into the pockets machined into the upper support. This engagement is modeled in the finite element by merging the nodes.
- Symmetry boundary conditions were applied on the plane of symmetry.

Load Application

- One half of the tie rod loads in the Normal, Upset-Seismic, Upset-thermal, Emergency and Faulted conditions respectively are applied along the axis of the tie rod, on the support as uniformly distributed ring loads on the edge of the circular hole.

The results of the normal condition peak stress and conformance to the IGSCC criterion is summarized in Table 6-1 below.

The stress results for all operating conditions for ASME Code conformance of the upper support are summarized in Table 6-2 below.

5.3.2 Replacement Support Analysis

A finite element analysis of the support was performed using the ANSYS computer program (Reference 9). The finite element model is shown in Figure 4. Only half of the support is modeled due to the symmetry of the geometry about the vertical mid-pane. The model was meshed using ANSYS [[ ]]. The appropriate boundary conditions and the loads as shown below were applied to the finite element model.

- The protrusions/lugs that engage in the machined pockets in the Upper Support are simplified in the model as rectangular blocks.
- The contact between the support and upper support is modeled by the use of rigid surfaces and contact elements.
- Symmetry boundary conditions are applied on the plane of symmetry.
- One half of the tie rod loads in the Normal, Upset-seismic, Upset-thermal, Emergency and Faulted conditions (from Table 5-1) are applied as uniformly distributed ring load around the rim of the circular hole.

Results of the finite element analysis runs for the Normal, Upset Seismic, Upset Thermal, Emergency and Faulted conditions for the upper support and the support are provided in Figure 6 through Figure 17 as stress plots and the actual values are provided in Table 6-3 below.

5.3.3 Replacement Tie Rod Nut/Tie Rod Threaded-connection Finite Element Analysis

The replacement Tie Rod Nut to tie rod threaded-connection was analyzed using FEM to determine the plastic deformation in the threads and by hand calculation for ASME Code evaluation.

FEA of the replacement tie rod nut to tie rod threaded-connection (ACME threads) was performed using the ANSYS computer program (Reference 9).

The axisymmetric FEA model of the Tie Rod Nut and Tie Rod threads interface is shown in Figure 18 with all the available threads in engagement. The model was composed of ANSYS [[

]]

The boundary conditions are as described below, and the loads specified in Table 5-1 were applied to the finite element model.

Boundary Conditions:

The tie rod nut is supported in the vertical direction as shown in Figure 18 using dimensions per Drawings Tie Rod Nut 223D5971 Rev.0 and Support 223D5969, Rev.0.

The tie rod nut and the tie rod are engaged at all the threads. Therefore, contact elements were provided between the threads of the tie rod nut and the tie rod, [[ ]] All the threads in engagement were so modeled in the FEA. The outer edge of the support block-to-nut bearing interface is restrained in the radial direction. It permits the entire nut surface free to slide except at the location where it is restrained radially.

Material Properties:

[[

]]

Load Application:

The Normal condition sustained load specified in Table 5-1 [[ ]] was used to determine the plastic strain in the nut and tie rod threads evaluated based on the elastic-plastic finite element analysis.

The Normal, Upset, Emergency, and Faulted condition loads in Table 5-1 were used for the ASME Code stress evaluation. The ASME Code stresses were evaluated based on hand calculations using elastic analysis methods.

The stress results of this analysis are presented in Section 6.0 .

5.4 Other Components in the Replacement Upper Support Assembly

The other components in the Replacement Upper Support Assembly (Items 3, 4, 5, 6, 7, and 8 of Table 4-1) are analyzed by hand calculation and the stress results are provided in Table 6-4 below. These components (except the retainer spring) are made of XM-19 material, which is more IGSCC-resistant compared to Alloy X-750. For these components the ASME code stresses are of primary importance.

5.5 Fatigue Analysis Of Replacement Upper Support Assembly

Cumulative usage factor (CUF) was evaluated for the replacement components in accordance with the provisions of the Code, and using the cycles per Reference 11. The number of cycles considered is [[ ]] cycles for plant start up and shut down, (normal load combination) [[ ]] cycles for seismic (upset-seismic load combination) and [[ ]] cycles for thermal (upset-thermal load combination). Table 6-5 summarizes the Cumulative Usage Factors for the components in the replacement assembly.

6.0 STRESS/STRAIN RESULTS

The replacement hardware components (upper support, support, tie rod nut and other associated upper support components) were evaluated for their susceptibility to IGSCC and ASME Code stresses, consistent with the acceptance criteria of the Reference 4 design specification data sheet. The maximum tensile principal stress (Pm + Pb + Q + F) for all Alloy X-750 components satisfies the [[ ]] requirement for IGSCC.

The XM-19 components (the replacement tie rod nut and tie rod threads) become plastic under the sustained load. The maximum total strain (which includes the elastic and plastic strain) is [[ ]] the tie rod nut threads (Figure 19) and [[ ]] in the tie rod threads (Figure 20). They meet the strain limit criteria [[ ]] specified in Table 5-2.

The ASME requirements for the stress and fatigue usage are satisfied for all components in the replacement upper support assembly.

Table 6-1 Maximum Tensile Principal Stresses (psi) and Strains in the Normal Sustained Conditions for IGSCC Criteria

Component	Material	Fig	Max Tensile Principal Stress, S1 (Pm+Pb+Q+F)	Yield Strength SY	IGSCC S1/SY	Strain $= \frac{S1}{25.6 \times 10^6}$
Upper Support, at large radius	X-750	Figure 5	[[	92,800*	[[	
Support	XM-19			38,100		All XM-19 components remain in the elastic range. Hence, the strain limit in Table 5-2 is satisfied.
Tie Rod Nut, threads	XM-19			38,100		
Top Support Bracket	XM-19			38,100		
Retainer Spring	X-750			92,800		
Retainer Pin	XM-19			38,100		
Soc Head Cap Screws	XM-19			38,100		
Dowel Pin	XM-19			38,100		
Upper Support, at the Internal threads at Socket Head Cap Screws	X-750		]]	92,800	]]	

[* These values are based on the Code allowable values of Sy. The actual CMTR Sy values are expected to be higher, yielding better margin against IGSCC].

Table 6-2 Stress Intensity for Upper Support – ASME Code Compliance

Service Level*	Governing stress intensity (psi)				Remark
	Stress Category	Max Stress intensity	Allowable Stress	Stress Ratio	
N	P_m	[[	53,300	[[	See Figure 6, 7
	P_m+P_b		79,950		See Figure 6, 7
U1	P_m		53,300		See Figure 8, 9
	P_m+P_b		79,950		See Figure 8, 9
U2	P_m+P_b+Q		159,900		See Figure 10, 11
E	P_m		79,950		See Figure 12, 13
	P_m+P_b		119,925		See Figure 12, 13
F	P_m		112,000		See Figure 14, 15
	P_m+P_b	]]	168,000	]]	See Figure 14, 15

Table 6-3 Stress Intensity Values for Support – ASME Code Compliance

Service Level*	Governing stress intensity (psi)			
	Stress Category	Max Stress intensity	Allowable Stress	Stress Ratio
Normal	P_m	[[	29,450	[[
	P_m+P_b		44,175	
Upset-Seismic	P_m		29,450	
	P_m+P_b		44,175	
Upset Thermal	P_m+P_b+Q		88,350	
Emergency	P_m		44,175	
	P_m+P_b		66,263	
Faulted	P_m		56,805	
	P_m+P_b	]]	85,208	]]

Table 6-4 Stress Intensities for other Components in the Replacement Assembly

Component Name (material)	Service Level*	Governing Stress Intensity, psi			Stress Ratio
		Stress Category	Max Stress Intensity	Allowable Stress	
Tie Rod Nut – (XM19)	N	Shear	[[	17,670	[[
		P_m		29,450	
	U1	Shear		17,670	
		P_m		29,450	
	U2	Shear		17,670	
		P_m		29,450	
	E	Shear		17,670	
		P_m		44,175	
	F	Shear		22,860	
		P_m		56,805	
Top Support Bracket, Socket Head Screw Caps (XM-19)	Instln	P_m		59,400	
	N	Shear		17,670	
		P_m		29,450	
	U1	Shear		17,670	
		P_m		29,450	
	U2	Shear		17,670	
		P_m		29,450	
	E	Shear		17,670	
		P_m		44,175	
	F	Shear		22,860	
		P_m		56,805	
Retainer Pin (XM-19)	All	--		--	
Retainer Spring (X-750)	Instaln	P_m+P_b		79,950	
Dowel Pins – (XM19)	All	Shear	]]	17,670	]]

* (N – Normal, U1 – Upset Seismic; U2-Upset Thermal, E – Emergency and F – Faulted)

Table 6-5 Cumulative Usage Factors

Component	Cumulative Usage Factor
Upper Support, at the large radius	[[
Upper Support, at Socket screw threads	
Tie Rod Nut	
Support Block	
Top Support Bracket	
Retainer Pin	
Retainer Spring	
Socket Head Screw Cap	
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7.0 CONCLUSION

Based on the structural evaluation documented in the preceding sections, the shroud repair replacement upper support hardware (upper support, support, their associated components and tie rod nut) as depicted in the referenced drawings are structurally qualified in accordance with the design specification data sheet for IGSCC and ASME Code requirements. The plastic strains in the nut and tie rod threads are also within strain limit specified in Table 5-2.

8.0 REFERENCES

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2. GE-NE-0000-0051-8783-R1, Edwin I. Hatch Nuclear Plant – Unit 2, Shroud Tie Rod Repair – Operability Evaluation, March 2007.
3. Replacement Upper Support Assembly Drawings
    a. Upper Support, 223D5968 Rev 0
    b. Support, 223D5969 Rev 0
    c. Tie Rod Nut, 223D5971 Rev 0
    d. Top Support Bracket, 223D5970 Rev 0
    e. Retainer Pin, 147C2846 Rev 0
    f. Retainer Spring, 147C2847 Rev 0
    g. Socket Head Screw Cap, 147C2850 Rev 0
    h. Dowel Pin, 147C2852 Rev 0
    i. Stabilizer Support Assembly, 223D5967, Rev.0
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6. ASME Boiler and Pressure Vessel Code, Section III, Division I, Code Case N-60-5, Material for Core Support Structures.
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8. GENE-0000-0063-5939, Assessment of SCC Crack Initiation in Hatch-2 and Pilgrim Type XM-19 Tie Rods, Feb 22, 2007.
9. ANSYS Finite Element Computer Code, Version 10.0, ANSYS Incorporated, 2004.
10. 22A4052, GE Design Specification for Core Support Structure, Reactor System.
11. 761E246 Rev 1, Hatch-2 Reactor Vessel Thermal Cycles.

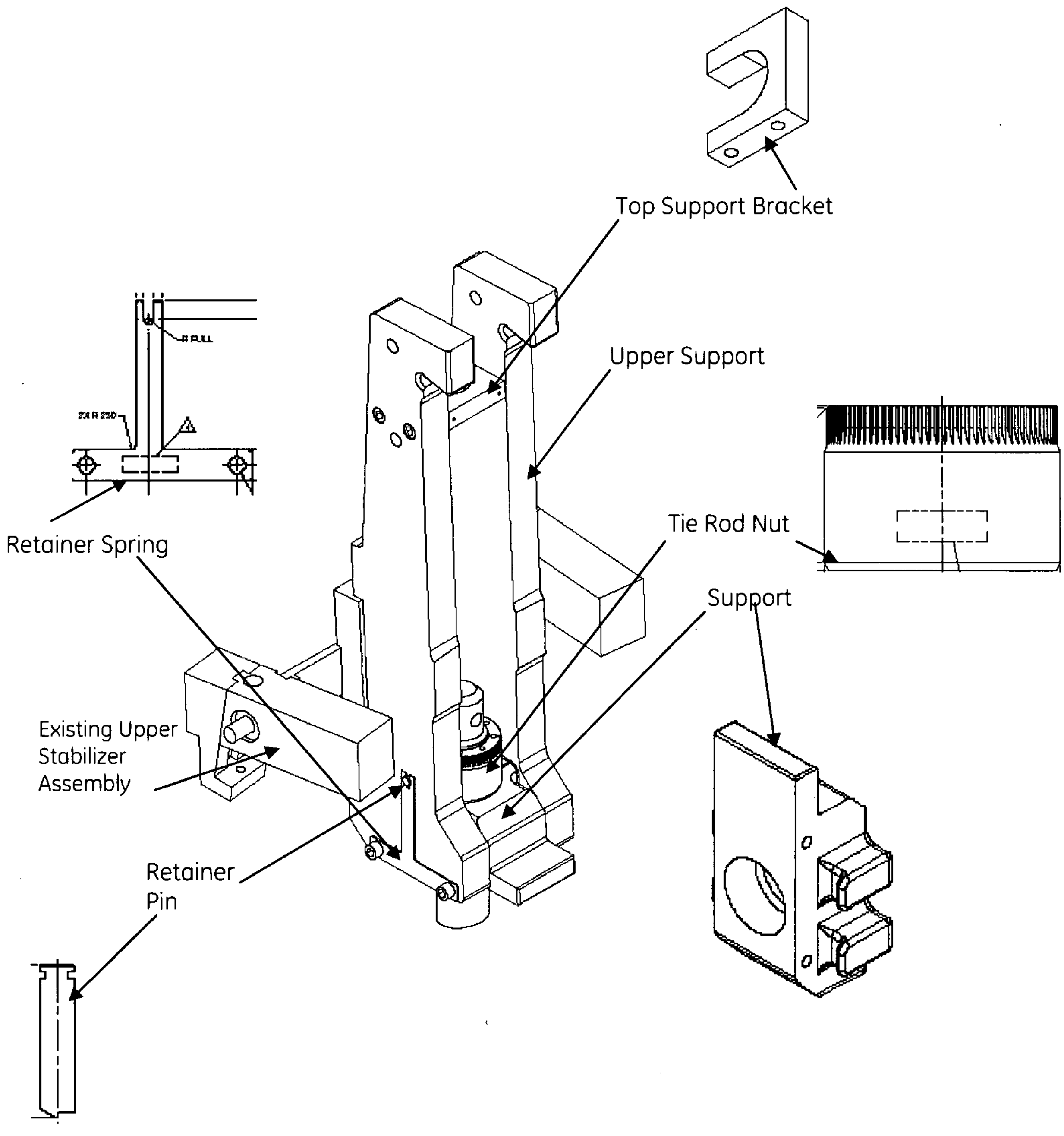

Figure 1. Identification of Replacement Upper Support Components.

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Figure 2. Finite Element Model of the Upper Support Including the Lower Support.

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Figure 3. Upper Support Finite Element Model Boundary Conditions

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Figure 4. Support FEM

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Figure 5. Maximum Tensile Principal Stress Plot for Upper Support Normal Loading Conditions

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Figure 6. Stress Intensity Plot for Upper Support Normal Loading Condition

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Figure 7. The linearization paths for Upper Support Normal Condition Loads

(The governing Pm occurred on the 45 deg path and the governing (Pm+Pb) occurred along the vertical path).

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Figure 8. Stress Intensity Plot for the Upper Support Upset Seismic Loading Condition

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Figure 9. Replacement Upper Support - Linearization Plots for the Upset Condition Loads

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Figure 10. Stress Intensity Plot for Upper Support Upset Thermal Loading Condition

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Figure 11. Replacement Upper Support – Linearization Plots for Upset Thermal Condition

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Figure 12. Stress Intensity Plot for Upper Support Emergency Loading Condition

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Figure 13. Replacement Upper Support – Linearization Plot for Emergency Condition

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Figure 14. Stress Intensity Plot for Upper Support Faulted Loading Condition

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Figure 15. Replacement Upper Support - Linearization Plots for Faulted Condition

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Figure 16. Stress Intensity Plot for the Support in the Faulted Loading Condition

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Figure 17. Linearization Plot for the Support in the Faulted Condition

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Figure 18. Tie Rod Nut / Tie Rod Threaded Connection- Finite Element Model

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Figure 19. Replacement Tie Rod Nut/Tie Rod Threaded Connection – Plot of Maximum Total Tensile Principal Strain in the Nut Threads for Normal Loading Condition, [[ ]]

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Figure 20. Replacement Tie Rod Nut/Tie Rod Threaded Connection – Plot of Maximum Total Principal Strain in the Tie Rod Threads for Normal Loading Condition, [[ ]]