Edwin I. Hatch Nuclear Plant - Unit 2

Re-review of Subject Information Provided with Respect to 10CFR 2.390 As Requested in NRC Draft SER Letter of February 12, 2009

Enclosure 3

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(Nonproprietary)

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**GEH-Nuclear Energy**

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# Hatch 2 Nuclear Plant

## Shroud Repair Replacement of Upper Support Stress Analysis Report

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## 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.<br>• 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).<br>• **Section 4, Table 4-1** – Stabilizer Support Assembly drawing added.<br>• **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.<br>• **Section 5.1.4** – revised to add the bulk flow blockage assessment.<br>• **Section 5.1.6** - New Section added for the shroud flange stresses evaluation in the modified EDM pocket.<br>• **Section 5.3.3** – New Section added for the replacement tie rod nut/tie rod threaded-connection FEA.<br>• **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.<br>• **Section 7** – Modified to include a conclusion of the tie rod nut to the tie rod threaded-connection FEM.<br>• **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.<br>• **Section 4, Table 4-1** -More detailed material specifications included.<br>• **Section 5.1.4** – Sentence about the transverse stiffness revised. |

| | | |
|---|---|---|
| Rev. 3 | October 17, 2008 | Report revised to incorporate the latest design changes in the geometry of the Upper Support, as reflected in the Rev 1 drawing. Major changes are identified below. In addition, some minor/editorial changes were also made.<br>• **Section 1.0** – Sentence about Revision 3 added.<br>• **Section 5.3.1** – Paragraph about the boundary conditions revised.<br>• **Section 5.3.2** – Sentence describing the contact between the shroud and the upper support modified.<br>• **Section 6.0** - Table 6-1 Max tensile principal stress for the Upper Support revised to 51,551 psi.<br>Table 6-2 Stress intensity values updated.<br>• **Section 8.0** - Reference 3.a updated. |
| Rev. 4 | March 5, 2009 | As a response to SNC comments on Rev. 3 of the report, a minor change was made (labels were added to Figure 2). Also, some labels in the PDF version of Figure 3 were missing. Although, considered editorial changes it was decided to revise the report. Rev. 4 fixes these editorial errors. |

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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 upper support assembly to be installed at Hatch 2 station, as part of the shroud repair hardware. This report also incorporates the latest modification of the upper support design.

## 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 [[ ]] mil 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<br>ASME SB-637, UNS N07750 | 3.a |
| 2 | Support | ASME SA-479, Type XM-19<br>ASME SA-182, Grade F XM-19<br>ASME SA-336, Class F XM-19 | 3.b |
| 3 | Tie Rod Nut | ASME SA-479, Type XM-19<br>ASME SA-182, Grade F XM-19<br>ASME SA-336, Class F XM-19 | 3.c |
| 4 | Top Support Bracket | ASME SA-479, Type XM-19<br>ASME SA-182, Grade F XM-19<br>ASME SA-336, Class F XM-19 | 3.d |
| 5 | Retainer Pin | ASME SA-479, Type XM-19<br>ASME SA-182, Grade F XM-19<br>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<br>ASME SA-182, Grade F XM-19<br>ASME SA-336, Class F XM-19 | 3.g |
| 8 | Dowel Pin | ASME SA-479, Type XM-19<br>ASME SA-182, Grade F XM-19<br>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. Due to this, the vortex shedding frequency remains unchanged with respect to its original value. 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 changed from "U-shaped" to "rectangular" for the replacement upper support design. Consequently, the shroud flange pocket will have to be modified to fit the rectangular shape of the horizontal leg of the replacement upper support. 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 0.6Sy 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 2.5%, 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 | 0.6 $S_y$ | 55,680 psi |
| | XM-19 | Limited by strain | Plastic Strain < 2.5% |

### 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 (2.4$S_m$, 0.7$S_u$) (Austenitic)<br>0.7$S_u$ (Ferritic) | 56,805 | 112,000 |
| | $P_m + P_b$ | Min (3.6$S_m$, 1.05 $S_u$) (Austenitic)<br>1.05$S_u$ (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 |
| | | 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 2$S_m$ | 56,805 | 106,600 |
| | $P_m$+$P_b$ | | Smaller of (3.6$S_m$, 1.05$S_u$); If $S_u$ > 100 Ksi, then 3$S_m$ | 85,208 | 159,900 |
| | Shear Stress | | Smaller of (0.42$S_u$, 0.6$S_y$) | 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 appropriate boundary conditions and the loads as shown below were applied to the finite element model.

**Boundary conditions** (Figure 3)

- The bearing interface of the horizontal arm of the upper support with the shroud flange was modeled using contact elements with [[

  ]]
- 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 solid block 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 shroud and upper support is modeled by the use of solid blocks 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 0.6Sy 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 approximately [[ ]] in the tie rod nut threads (Figure 19) and [[ ]] in the tie rod threads (Figure 20). They meet the strain limit criteria (plastic strain less than 2.5%) 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* | [[ ]] < 0.60 | |
| 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 | ]]< 0.60 | |

[* The value is based on the Code allowable value of Sy. The actual CMTR Sy value is 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 | |
| Dowel Pin | ]] |

## 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


1. GE Indication Notification Report
    a. INR H1R22IVVI-06-03-Rev.1 Tie Rod @135°
    b. INR H1R22IVVI-06-04-Rev.1 Tie Rod @225°
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 1
    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
4. 25A5718AA Rev 0, Hatch-2 Shroud Repair Hardware Modification, Design Specification Data Sheet, Jan 18, 2008.
5. ASME Boiler and Pressure Vessel Code, Section III, Division I, Nuclear Power Plant Components, Subsection NG, Core Support Structures, 2001 Edition through 2003 Addenda.
6. ASME Boiler and Pressure Vessel Code, Section III, Division I, Code Case N-60-5, Material for Core Support Structures.
7. ASME Boiler and Pressure Vessel Code, Section III, Division II, Part D, Materials, 2004 Edition.
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.

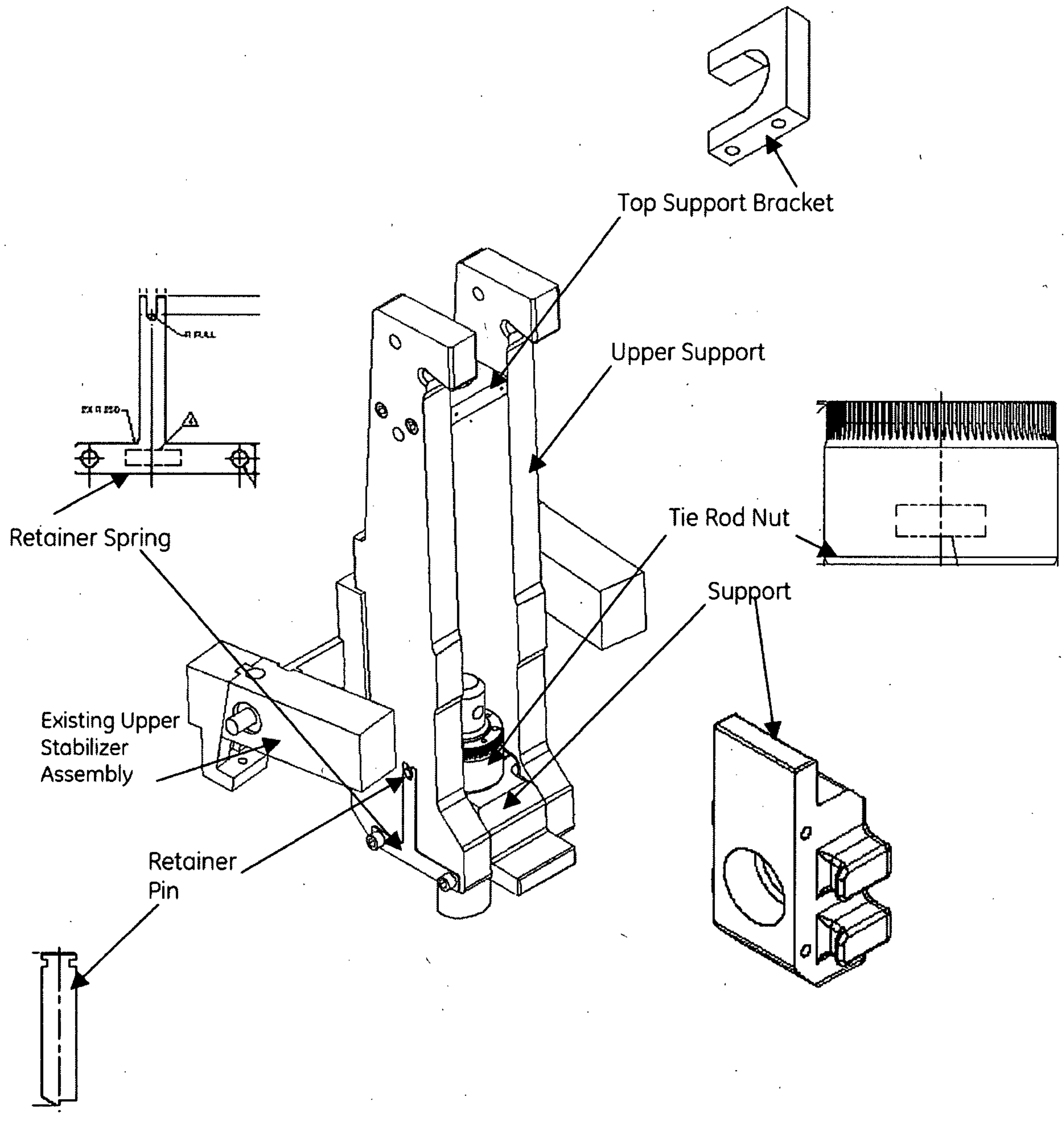


Figure 1. Identification of Replacement Upper Support Components.

[[

]]

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

[[

]]

Figure 3. Upper Support Finite Element Model Boundary Conditions

[[

]]

Figure 4. Support FEM

[[

]]

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

[[

]]

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

[[

]]

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

[[

]]

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

[[

]]

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

[[

]]

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

[[

]]

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

[[

]]

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

[[

]]

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

[[

]]

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

[[

]]

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

[[

]]

Figure 16. Stress Intensity Plot for the Support in the Faulted Loading Condition
(Faulted condition has the least stress margin)

[[

]]

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

[[

]]

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

[[

]]

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. [[ ]]

[[

]]

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, [[ ]]

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

Affidavit for Withholding of Proprietary Information

**GE-Hitachi Nuclear Energy Americas LLC**

**AFFIDAVIT**

I, **James F. Harrison,** state as follows:

(1) I am Vice President, Fuels Licensing, GE-Hitachi Nuclear Energy Americas LLC ("GEH"). I have been delegated the function of reviewing the information described in paragraph (2) which is sought to be withheld, and have been authorized to apply for its withholding.

(2) The information sought to be withheld is contained in GEH letter, JXJ3Z-026, *Hatch 2 Tie Rod Repair, Response to NRC RAIs 1 through 9*, dated March 6, 2009. The proprietary information in Enclosure 1 entitled, *GEH Responses to NRC RAIs 1 through 9*, is identified by a dotted underline inside double square brackets, [[This sentence is an example.{3}]]. In each case, the superscript notation {3} refers to Paragraph (3) of this affidavit, which provides the basis for the proprietary determination.

(3) In making this application for withholding of proprietary information of which it is the owner or licensee, GEH relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC Sec. 552(b)(4), and the Trade Secrets Act, 18 USC Sec. 1905, and NRC regulations 10 CFR 9.17(a)(4), and 2.390(a)(4) for "trade secrets" (Exemption 4). The material for which exemption from disclosure is here sought also qualify under the narrower definition of "trade secret", within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, Critical Mass Energy Project v. Nuclear Regulatory Commission, 975F2d871 (DC Cir. 1992), and Public Citizen Health Research Group v. FDA, 704F2d1280 (DC Cir. 1983).

(4) Some examples of categories of information that fit into the definition of proprietary information are:

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by GEH's competitors without license from GEH constitutes a competitive economic advantage over other companies;

b. Information which, if used by a competitor, would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product;

c. Information that reveals aspects of past, present, or future GEH customer-funded development plans and programs, resulting in potential products to GEH;

d. Information that discloses patentable subject matter for which it may be desirable to obtain patent protection.

The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs (4)a. and (4)b. above.

(5) To address 10 CFR 2.390(b)(4), the information sought to be withheld is being submitted to NRC in confidence. The information is of a sort customarily held in confidence by GEH,

and is in fact so held. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by GEH, no public disclosure has been made, and it is not available in public sources. All disclosures to third parties, including any required transmittals to NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary agreements which provide for maintenance of the information in confidence. Its initial designation as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in paragraphs (6) and (7) following.

(6) Initial approval of proprietary treatment of a document is made by the manager of the originating component, the person most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge, or subject to the terms under which it was licensed to GEH. Access to such documents within GEH is limited on a "need to know" basis.

(7) The procedure for approval of external release of such a document typically requires review by the staff manager, project manager, principal scientist, or other equivalent authority for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside GEH are limited to regulatory bodies, customers, and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or proprietary agreements.

(8) The information identified in paragraph (2) above is classified as proprietary because it contains details of the analysis methods, loads, qualification criteria, and results of GEH stress analysis of replacement shroud support hardware as well as design details of the replacement hardware. Development of the methods, techniques, information, and their application for the stress analysis and the design of the replacement hardware were achieved at a significant cost to GEH.

The development of the analysis methods along with the interpretation and application of the analytical results to design the replacement hardware is derived from the extensive experience database that constitutes a major GEH asset.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GEH's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of GEH's comprehensive BWR safety and technology base, and its commercial value extends beyond the original development cost. The value of the technology base goes beyond the extensive physical database and analytical methodology and includes development of the expertise to determine and apply the appropriate evaluation process. In addition, the technology base includes the value derived from providing analyses done with NRC-approved methods.

The research, development, engineering, analytical and NRC review costs comprise a substantial investment of time and money by GEH.

The precise value of the expertise to devise an evaluation process and apply the correct analytical methodology is difficult to quantify, but it clearly is substantial.

GEH's competitive advantage will be lost if its competitors are able to use the results of the GEH experience to normalize or verify their own process or if they are able to claim an equivalent understanding by demonstrating that they can arrive at the same or similar conclusions.

The value of this information to GEH would be lost if the information were disclosed to the public. Making such information available to competitors without their having been required to undertake a similar expenditure of resources would unfairly provide competitors with a windfall, and deprive GEH of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing and obtaining these very valuable analytical tools.

I declare under penalty of perjury that the foregoing affidavit and the matters stated therein are true and correct to the best of my knowledge, information, and belief.

Executed on this 6th day of March 2009.

James F. Harrison

James F. Harrison
Vice President, Fuels Licensing
GE-Hitachi Nuclear Energy Americas LLC

Edwin I. Hatch Nuclear Plant - Unit 2

Re-review of Subject Information Provided with Respect to 10CFR 2.390 As Requested in NRC Draft SER Letter of February 12, 2009

Enclosure 6

Nonproprietary Version of December 19, 2008 Submittal

**Southern Nuclear**
**Operating Company, Inc.**
40 Inverness Center Parkway
Post Office Box 1295
Birmingham, Alabama 35201-1295

Tel 205.992.5000

SOUTHERN COMPANY
*Energy to Serve Your World℠*

December 19, 2008

Docket No.: 50-366

NL-08-1897

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D. C. 20555-0001

Edwin I. Hatch Nuclear Plant – Unit 2
Response to NRC Request for Additional Information Regarding
Modification of the Core Shroud Stabilizer Assemblies (TAC No. MD9579)

Ladies and Gentlemen:

By letter dated September 3, 2008, pursuant to 10 CFR 50.55a(a)(3)(i), Southern Nuclear Operating Company (SNC) requested NRC approval of a proposed modification to each of the four core shroud stabilizer assemblies. During the upcoming 2009 Refueling Outage (2RFO23), SNC proposes to replace the Hatch Unit 2 stabilizer assembly upper supports and tie rod top nuts due to their potential for cracking. By letter dated December 8, 2008, the NRC requested additional information regarding this submittal. The SNC responses are enclosed.

This letter contains no NRC commitments. If you have any questions, please advise.

Sincerely,

Mark J Ajluni

M. J. Ajluni
Manager, Nuclear Licensing

MJA/PAH/daj

Enclosure: 1. Response to NRC Request for Additional Information Regarding Modification of the Core Shroud Stabilizer Assemblies

cc: Southern Nuclear Operating Company
Mr. J. T. Gasser, Executive Vice President
Mr. D. R. Madison, Vice President – Hatch
Mr. D. H. Jones, Vice President – Engineering
RTYPE: CHA02.004

U. S. Nuclear Regulatory Commission
Mr. L. A. Reyes, Regional Administrator
Mr. R. E. Martin, NRR Project Manager – Hatch
Mr. J. A. Hickey, Senior Resident Inspector – Hatch

RAI-1) *Section 7.2.2 of Enclosure 1 in September 3, 2008, letter indicates that SNC will inspect the upper support arm inner and outer corner radius locations during the 2001 refueling outage and on a 10-year interval thereafter. The technique used will be VT-1, visual examination, as described in the 2001 Edition of the American Society of Mechanical Engineers (ASME) Code, Section CL, with 2004 Addenda. The upper support is fabricated using Alloy Z-750 material.*

*Section 2, "Background," in Enclosure 1 to the September 3, 2008, letter indicates that the cause of the cracking in the upper supports in the shroud stabilizer assembly was intergranular stress corrosion cracking (IGSCC) of the Alloy X-750 material. Alloy X-750 material is susceptible to IGSCC if subjected to sustained, large peak stress conditions. The Boiling Water Reactor Vessel and Internals Project (BWRVIP) issued letters dated March 29, 2006, and April 3, 2006, requiring plants with core shroud tie rod repairs to inspect their repairs at their next scheduled refueling outage. These letters indicate inspections should include all the same or similar locations were indications were observed at Hatch, Unit 1 (Hatch-1) during the unit's 2006 refueling outage and that consideration should also be given to other locations in the tie rod repair where X-750 material is used and which may experience high-sustained stresses.*

a) *The licensee is requested to identify all Alloy X-750 components, excluding the replacement tie rod upper support, in the primary vertical and horizontal load paths of the core shroud stabilizer assembly.*

**List of all X750 Components, Excluding the Replacement Upper Support**

| |
|---|
| **Tie Rod/Spring Assembly (Figure 1)** |
| Spring, Lower |
| Contact, Lower |
| Latch |
| Spring Extension, Part 1 |
| Spring Extension, Part 2 |
| Bolt, Extension |
| |
| **Collet Assembly (Figure 2)** |
| Collet |
| Clevis Pin |
| Cruciform Spacer |
| Bolt |
| Torque Restraint, Part 1 |
| Torque Restraint, Part 2 |
| Cruciform Spacer, Part 2 |
| Cruciform Rod |
| Latch |
| Torque Restraint, Part 3 |
| Bolt, Torque Restraint |

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| |
|---|
| Latch |
| |
| **Upper Stabilizer Assembly (Figure 3)** |
| Arm, Upper Stabilizer |
| Bracket, Upper Spring |
| Spring, Retainer |
| Block, Upper Stabilizer |
| Bolt, Jack |
| Wedge, Upper Stabilizer |
| Bolt, Upper Stabilizer |
| Spring, Bracket |
| Retainer, Latch |

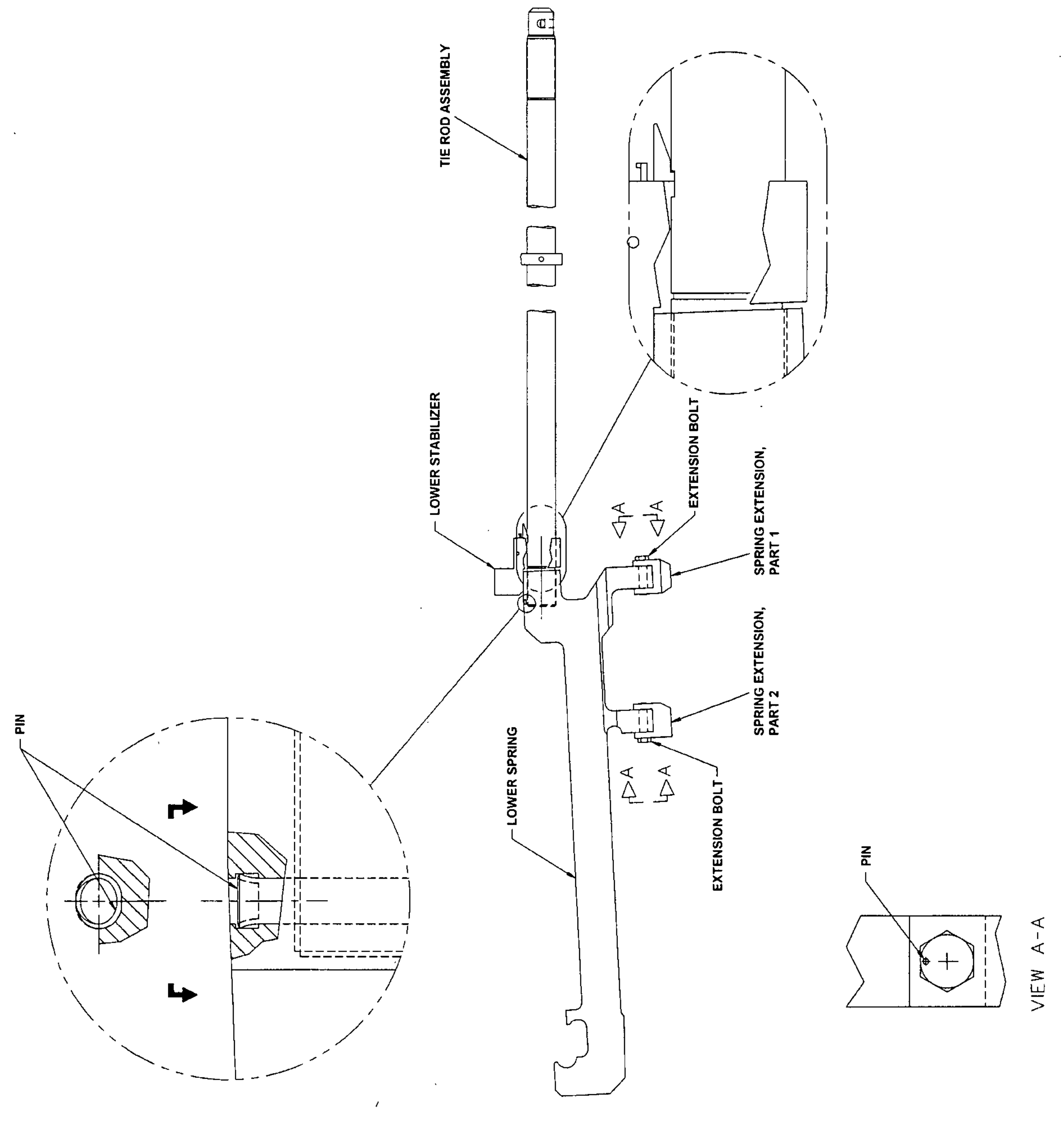



Figure 1 - Tie Rod/Spring Assembly Parts

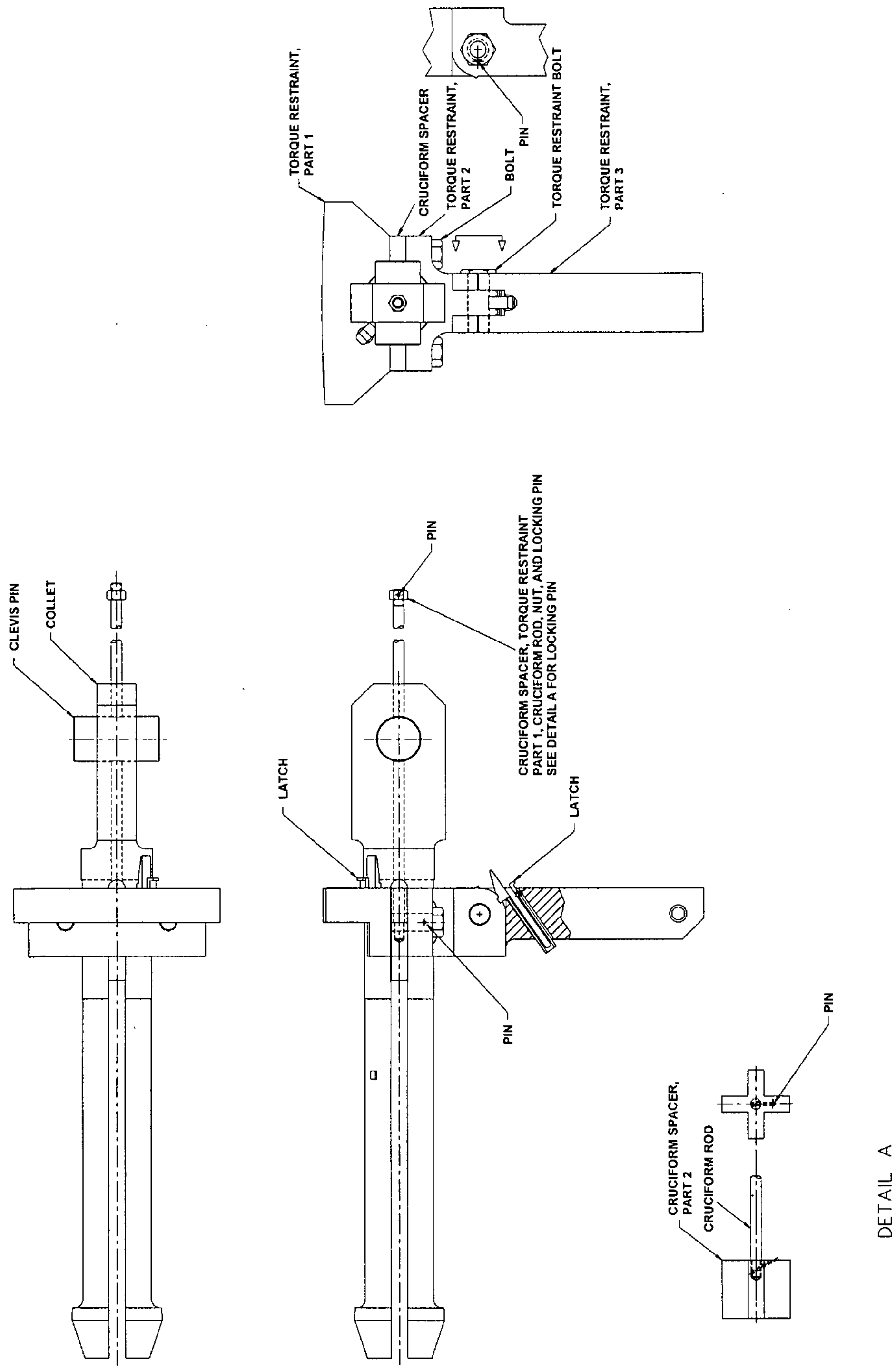



**Figure 2 - Collet Assembly Parts**

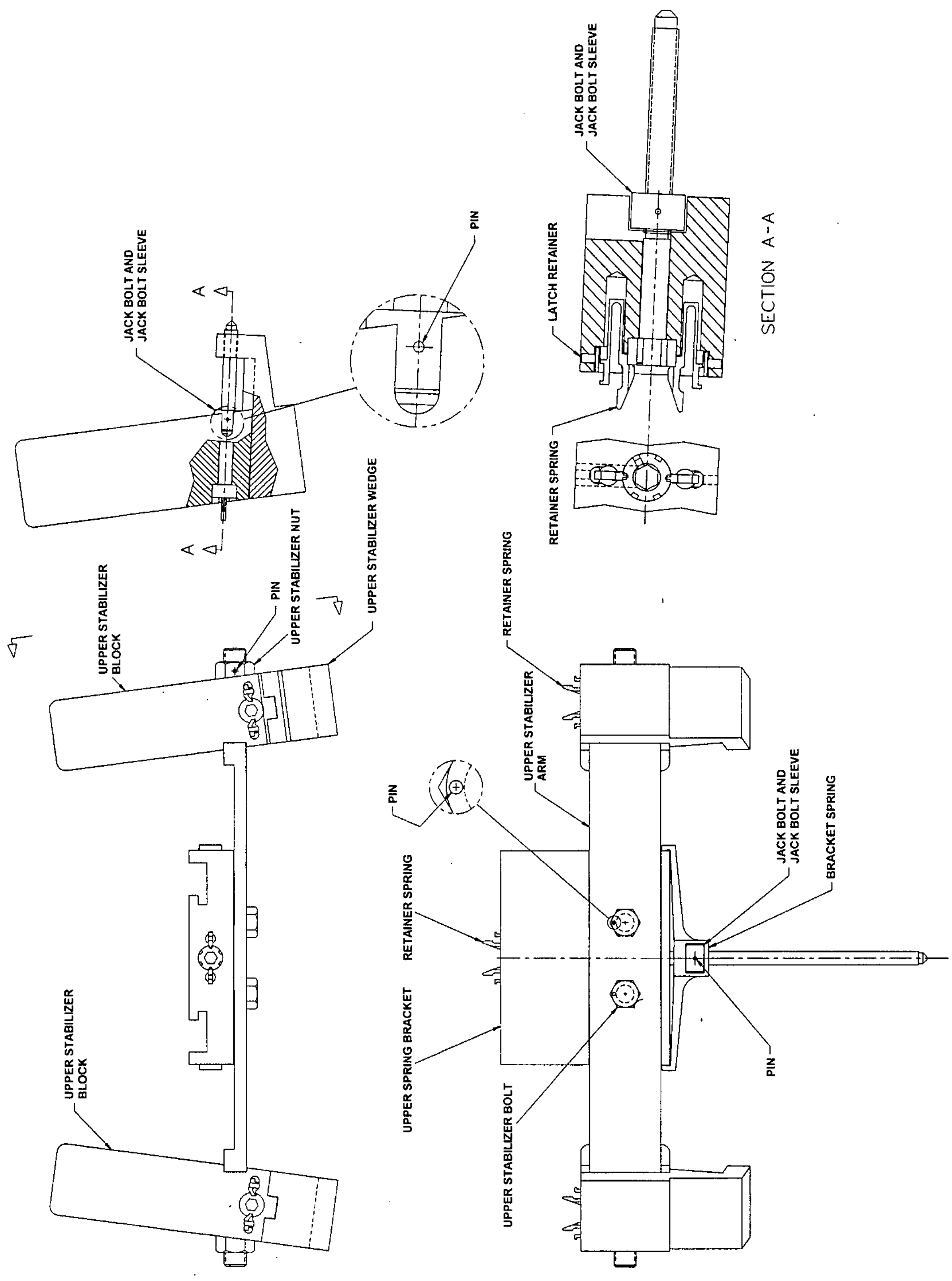



Figure 3 - Upper Stabilizer Assembly Parts

b) *The licensee is requested to identify design changes that are proposed to reduce the total stress in the Alloy X-750 components excluding the replacement tie rod upper support, to reduce their sustained, peak stresses to a value below the IGSCC susceptibility criteria.*

There are no Alloy X-750 components, excluding the replacement tie rod upper support, that have peak sustained stresses above the IGSCC susceptibility criteria of 0.8 Sy.

To facilitate tie rod upper support replacement, the tie rod/lower spring assembly may also be removed. Removal will require fabrication and installation of functionally identical new tie rods and lower supports. The functionally identical new tie rods and lower supports will have stress reducing enhancements such as rounded corners and an increased thread root radius.

*c) The licensee is requested to identify when the components identified in the response to RAI-1a were previously inspected for IGSCC and to identify the results from the inspection.*

Each component listed in the response to RAI-1a was inspected to the extent possible during the Spring 2007 Refueling Outage. Additionally, a tie rod tightness inspection was performed. All inspection results were satisfactory.

*d) The licensee is requested to identify the proposed frequency of inspection for the Alloy X-750 components identified in RAI-1a and what type of inspection will be performed to ensure that potential IGSCC in these Alloy X-750 components will be promptly identified.*

Inspection of each component listed in the response to RAI-1a will be reinspected using the guidance of BWRVIP-76.

*e) The licensee is requested to explain why VT-1 examination was chosen as the inspection method for detecting IGSCC at the upper support arm inner and outer corner radius locations.*

The technique used will be VT-1, visual examination as described in the 2001 Edition of the ASME Section XI Code with 2003 Addenda. The selection of VT-1 is consistent with the Hatch Unit 1 commitment for examination of the shroud stabilizer upper supports. This technique was found acceptable for Hatch Unit 1 in Section 4.1.4 of the NRC staff's evaluation of the Hatch Unit 1 shroud stabilizer submittal dated March 26, 2008 (TAC NO. MD6396).

This technique requires character height recognition (0.044") which is the same as specified for the enhanced visual examinations employed in the latest revision to BWRVIP-03 and is considered adequate for finding IGSCC in the X-750.

*RAI-2) Identify the water chemistry (i.e. hydrogen addition, noble metal addition, etc.) controls that have been instituted, or will be instituted. at Hatch-2 to reduce the susceptibility of Alloy X-750 and austenitic stainless steel to IGSCC. What impact does this water chemistry control have on the susceptibility to IGSCC of the replacement tie rod upper support and tie rod top nuts?*

Hatch Unit 2 primary system water chemistry control for IGSCC mitigation is Hydrogen Water Chemistry with the Noble Metal Chemical Addition process. Hydrogen is added to Unit 2 feedwater at a rate of 10 scfm (0.26 ppm). NobleChem (platinum and rhodium) has been added to the reactor vessel and recirculating water piping twice for Unit 2 (2000 and 2007). During power operation, the Electrochemical Corrosion Potential and the Molar Ratio of Hydrogen to Oxidants in the reactor vessel and primary coolant system are within ranges that yield chemistry conditions that are conducive to the mitigation of IGSCC for stainless steel. However, since the mitigative efficacy is limited or not quantified in the upper regions of the core and annulus for the nickel alloy, no mitigation is assumed for design or reinspection criteria at this location.

*RAI-3) In the licensee's August 14, 2007, letter requesting approval of the Hatch-1 core shroud stabilizer modification, the licensee indicated that its "Post-Modification Inspection Plan, Prior to RPV Assembly," would include an inspection of the support plate gusset and attachment welds. Since the integrity of the support plate gusset and attachment welds are necessary for maintaining tie rod preload, the staff believes inspection of these plates and welds is necessary. Section 7.2.1 of Enclosure 1 to the September 3, 2008, letter does not include inspection of the gusset plate welds and attachment welds. The staff requests that the licensee either include the gusset plate and attachment welds in the reinspection plan or explain why reinspection is not necessary. The licensee is requested to identify its plan for reinspection of the gusset plate and attachment welds at future refueling outages.*

Plant Hatch Unit 2 was constructed with a 8.8" thick shroud support plate fabricated from low alloy steel and clad with Type 304 stainless steel on the bottom (lower plenum side) and alloy 82/182 on the top (annulus side). This thick plate design is unique to Plant Hatch Unit 2 and structurally takes the place of the thinner support plate/gussets or thinner support plate/support leg configurations found in other BWRs. For this reason no gusset plate examinations are specified. The Unit 2 shroud support is exempted from the inspection criteria of BWRVIP-38. Section 2.1.2 of BWRVIP-38 clearly states this and that Code examinations are adequate since the shroud support is low alloy steel and thus not susceptible to IGSCC. A collet/clevis pin assembly was installed in 1995 to provide a lower attachment for each tie rod assembly. These assemblies have no welded components.

*RAI-4) Section 4.0 in Enclosure 3 to the September 3, 2008 letter indicates that several components (i.e., tie rod nut, support, etc.) in the Hatch-2 core shroud stabilizer modification will be fabricated using Alloy XM-19 austenitic stainless steel material (these components in the Hatch-1 core shroud stabilizer modification were fabricated using Alloy X-750 and Type 316 austenitic stainless steel material). Section 6.3 of Enclosure 1 in the September 3, 2008, letter indicates that surface cold work in austenitic stainless steel material was addressed by controlling machining in accordance with demonstrated procedures or solution annealing of the component subsequent to machining. For all components fabricated using austenitic stainless steel material, the licensee is requested to identify the heat treatment and surface cold work limitations for machining that were instituted to prevent IGSCC. Describe the tests performed to demonstrate that the heat treatment and surface cold work limitations will prevent IGSCC.*

The Type XM-19 austenitic stainless steel material for the modification is required to be supplied in the solution annealed condition, with a minimum solution annealing temperature of 1950°F. Machining is controlled by limiting the final machining passes to a maximum of 0.010 inches per pass, consistent with the requirements of BWRVIP-84, Paragraph C9.6.7. For further discussion of the IGSCC resistance of the material and associated test data, see the response to NRC RAI-5.

*RAI-5) Section 5.2.1 in Enclosure 3 to the September 3, 2008 letter indicates that no specific criterion for prevention of IGSCC in Alloy XM-19 material is specified in BWRVIP-84, "BWR Vessel and Internals Project Guidelines for Selection and Use of Materials for Repair to BWR Internal Components," however, General Electric-Hitachi Nuclear Energy (GEH) has specified a maximum plastic strain limit to assure the materials are not susceptible to IGSCC. Provide data and analyses that demonstrate that the maximum plastic strain limit for Alloy XM-19 material will assure that the Alloy XM-19 material is not susceptible to IGSCC.*

Type XM-19 is considered highly resistant to IGSCC. As stated in the response to RAI-4, the material is procured in the solution annealed condition and the machining process limits the amount of material removal during the manufacturing process. This complies with BWRVIP that contains the generic criteria for owners to use that minimizes susceptibility to IGSCC. Although BWRVIP-84 does not include additional service limits to preclude IGSCC, SNC has elected to extend the 2.5% strain limit to normal operating loads to provide additional margin.

The limits were based on GEH experience as described below.

Specifically, the alloy was thoroughly evaluated by GE Nuclear Energy prior to its application in several Control Rod Drive components where it is viewed as having superior IGSCC resistance as compared to low carbon Type 304 and Type 316 stainless steels. As part of internal GE Nuclear Energy and Licensee assessments, studies were made of material with cold work levels well above the 2.5% limit. These included slow strain rate tests and constant load tests performed in high temperature oxygenated water. None of these tests led to IGSCC. Another set of long term exposure tests, conducted in autoclaves at an operating BWR, also demonstrated the IGSCC resistance of XM-19 at several stress levels including stresses above the material's yield strength which in turn produced strained material well beyond 2.5%. All of these tests on XM-19 are consistent with tests performed on solution annealed Type 304 that also support the 2.5% strain limit.

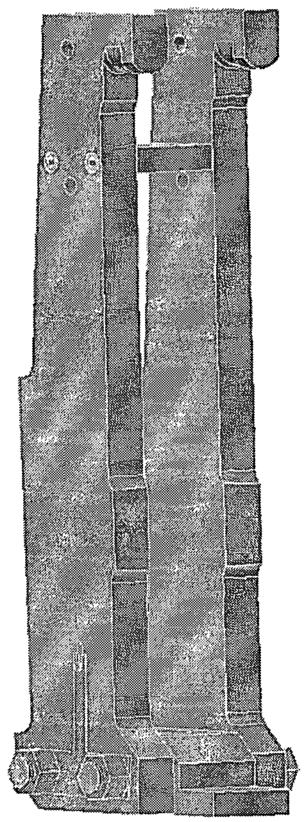
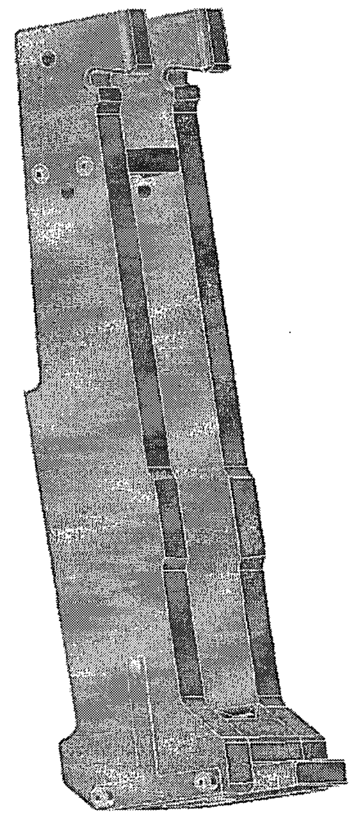
In addition to the different small specimen tests, there is a large experience base of use of XM-19 in CRD components. These have shown excellent behavior. XM-19 has been used in several other BWR components and repairs designed and installed by GEH in the BWR fleet. Specifically, XM-19 has been used in the repair clamps for a jet pump riser pipe RS-1 weld repair, shroud head bolt nuts since the late 1980s, and various other repair bolting applications. GEH is not aware of any IGSCC-related failures in a Type XM-19 component used in the base design or used in a repair component.

In summary, there exists both laboratory test data available from GEH as well as extensive BWR application experience that substantiate that Alloy XM-19 is highly resistant to IGSCC. This data includes test conditions of high stress along with local plastic strain. Based on this information, the Hatch 2 XM-19 tie rod components are not considered susceptible to IGSCC when designed using current criteria.

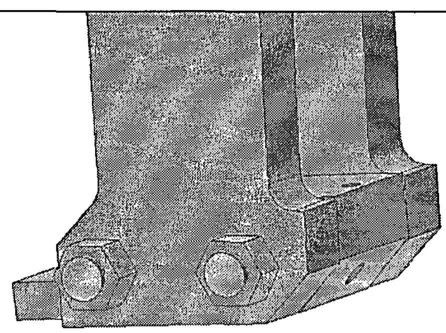
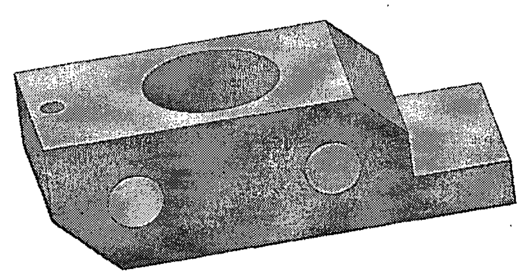
**RAI-6**

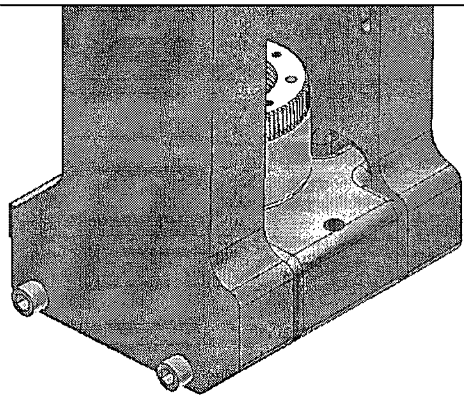
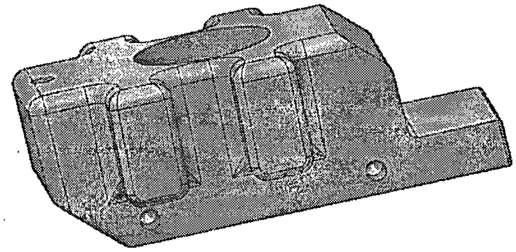
*Section 3 of Enclosure 3 and Section 3.3 of Enclosure 1, show the replacement upper support components and contain a brief description of the components that will be repaired/replaced. Provide a drawing (or pictorial) that illustrates the differences between the original and the proposed replacement upper components for comparison. Also identify dimensionally, the proposed changes to the shroud head flange.*

Enclosure 1
Log: MP-08-1900

| | |
|---|---|
|  |  |
| Hatch 2 Original Upper Support Assembly | Hatch 2 Replacement Upper Support Assembly |

The upper supports will be replaced in their entirety. The primary difference between the original and the replacement is the shape of the contact surface that interfaces with the shroud flange pocket. The original upper support has a circular surface, while the replacement upper support has a flat surface as well as a larger fillet radius at the horizontal to vertical transition.

| | |
|---|---|
|  |  |
| Hatch 2 Original Upper Support Assembly | Hatch 2 Original Support |

| | |
|---|---|
|  |  |
| Hatch 2 Replacement Upper Support Assembly | Hatch 2 Replacement Support |

The other difference between the original and the replacement is the support to upper support connection. The replacement support has integral tabs or arms that engage pocket in the upper support, which provides a direct load path between the support and upper support (instead of the Alloy X750 thru bolts used in the original upper support assembly). This allows the support to be made from Type XM-19 material instead of Alloy X750. See Figure 6-2.

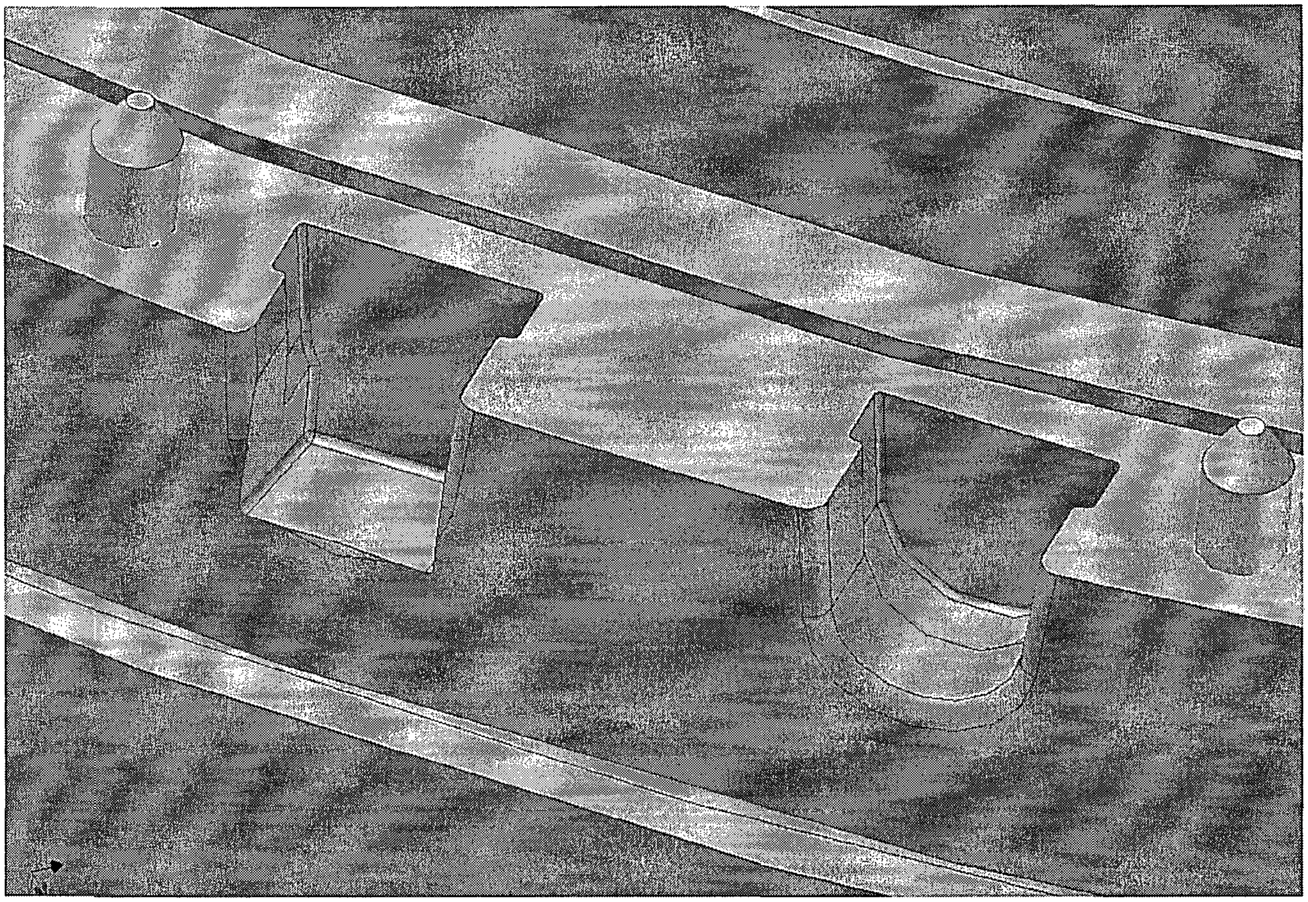
There are no proposed changes to the shroud head flange. The changes to the shroud flange are discussed in the response to EMCB RAI 3 a)

*RAI-7*
*a) Section 4.1.1.2 of Enclosure 1 states (in two places) that details of the GE structural analysis and results are provided in Attachment 2. Confirm that the GE structural analysis is contained in Enclosure 3 of the application and not Attachment 2 or provide Attachment 2.*

The GE structural analysis is contained in Enclosure 3 of the application.

*b) Section 4.1.1.2 of Enclosure 1 also states that Structural Integrity Associates, Inc. performed an independent third party review of the GE analysis and developed a separate ANSYS finite element analysis, the results of which compared favorably to the GE results. Provide a comparison of the results of the two analyses for the replacement upper support assembly parts for staff's review.*

Independent reviews were performed for the purpose of vendor oversight and are not considered formal calculations. The maximum principle tensile stress variation between the two calculations was within 0.5%.
<u>*RAI-8*</u>
*a) Describe in detail the proposed changes to the core shroud.*



The figure above shows a comparison of the existing versus the proposed changes to the shroud flange slots. The slot on the right is the existing slot. The slot on the left is the modified slot. The proposed change flattens the bottom of the slot over a width of 2.90" at an angle of 15 degrees to horizontal.
SNC Scope.

*b) Clarify whether the proposed modification impacts the existing shroud stress analysis and how it has been documented.*

NL-08-1301, Enclosure 3, Section 5.1.6 describes the impact of the changes to the core shroud and how it is documented.

*c) Provide a summary of the stresses in the shroud flange due to analyzed loading conditions and due to the proposed geometry changes to the shroud head flange, along with a comparison to ASME code allowable values.*

The bearing stress at the upper support / shroud head flange interface is the predominant stress category of the shroud flange for the analyzed loading conditions.

A summary of the stresses compared with the ASME code values for the shroud head flange is presented below.

**Table 1 - Governing Stresses for the Shroud Head Flange**

| | Shroud Head Flange (304L) | | | | | |
|---|---|---|---|---|---|---|
| **Service Level*** | **Stress Category** | **Max Stress (psi)** | **Allowable Limit** | **Allowable Stress (psi)** | **Stress Ratio** | **Remark** |
| N | Bearing | [[ | $S_y$ | 20,500 | [[ | - |
| U1 | Bearing | | $S_y$ | 20,500 | | - |
| U2 | Bearing | | $S_y$ | 20,500 | | - |
| E | Bearing | | 1.5 $S_y$ | 30,750 | | - |
| F | Bearing | ]] | 3.0 $S_y$ | 61,500 | ]] | Away from free edge |

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

*d) Confirm that, with the exception of the proposed modification to the shroud head flange, there are no other contact areas between the upper core shroud support assembly and core shroud that have been changed.*

With the exception of the proposed modification to the shroud flange discussed in the response to RAI-8a, there are no changes to the contact areas between the upper support assembly and the core shroud.

*RAI-9*

*Section 5.3.1 of the stress analysis report (Enclosure 3) states that: "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."*

*a) Confirm that this is the vertical gap between the upper support and the shroud head flange.*

The referred statement is addressing the vertical gap between the top surface of the upper support and the shroud head flange.

*b) Verify that the statement, that the contact between the top surface of the upper support and the shroud head flange would reduce the stresses in the upper support refers to the rotation of the upper support arms.*

For the condition, that the vertical gap between the upper support and flange head is closed, the contact between the top surface of the upper support and the shroud head flange is expected to limit the rotation of the upper support arms. As a result, the stresses in the critical large radius of the upper support would be reduced.

*c) Explain under what conditions is this gap expected to close and why a horizontal force due to upper head shroud area thermal expansion against the upper support arms has not been considered.*

The nominal vertical gap between the top surface of the upper support and the shroud head flange is 0.105", per Hatch 2 Mod Drawing (105E4558). The gap is not a controlled parameter and varies, based on the height of the upper support leg and the depth of the shroud flange pocket. Considering the tolerances, the gap varies from 0.035" to 0.175".

The maximum vertical displacement at the free edge of the upper support (as a result of the rotation of the upper arms) is calculated from the FEA as 0.002" for the Normal (sustained) loading, and as 0.015" for the Faulted condition (see Figures 4 and 5). Hence, the gap between the top surface of the upper support and the shroud head flange remains open for all loading conditions.

It is deemed that no potential exists for a generation of a significant horizontal force at the upper support, resulting from the normal (sustained) loading condition. The thermal expansion of the shroud against the upper support arms builds similar thermal radial displacements at the upper and lower tie rod assembly sections, which remain continuously in contact with the shroud.

[[

]]

**Figure 4– Upper Support Vertical Displacement Under Normal (Sustained) Load**

[[

]]

{3}]]

**Figure 5 – Upper Support Vertical Displacement Under Faulted Load**

Edwin I. Hatch Nuclear Plant - Unit 2

Re-review of Subject Information Provided with Respect to 10CFR 2.390 As Requested in NRC Draft SER Letter of February 12, 2009

Enclosure 8

Nonproprietary Version of January 8, 2009 Submittal

**Southern Nuclear**
**Operating Company, Inc.**
Post Office Box 1295
Birmingham, Alabama 35201-1295
Tel 205.992.5000

January 8, 2009

SOUTHERN COMPANY
*Energy to Serve Your World*℠

Docket No.: 50-366

NL-09-0024

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D. C. 20555-0001

Edwin I. Hatch Nuclear Plant – Unit 2
Revision to Response to NRC Request for Additional Information Regarding
Modification of the Core Shroud Stabilizer Assemblies (TAC No. MD9579)

Ladies and Gentlemen:

By letter dated December 19, 2008 pursuant to 10 CFR 50.55a(a)(3)(i), Southern Nuclear Operating Company (SNC) responded to the December 8, 2008 NRC requests for additional information concerning the proposed modification to core shroud stabilizer assemblies during the upcoming 2009 Refueling Outage (2RFO23). Subsequently, General Electric – Hitachi (GEH) advised that there was an error in Table 1, "Governing Stresses for the Shroud Head Flange." For Service Level N, the column titled "Stress Ratio" should be changed from 0.17 to 0.33. This revised value was discussed with Mr. R. E. Martin, Plant Hatch Licensing Project Manager, and other members of the NRC staff in a telephone conversation on January 7, 2009. A revised table is enclosed.

This letter contains no NRC commitments. If you have any questions, please advise.

Sincerely,

Mark J Ajluni

M. J. Ajluni
Manager, Nuclear Licensing

MJA/PAH/daj

Enclosure: 1. Revision to Table 1, Governing Stresses for the Shroud Head Flange

cc: Southern Nuclear Operating Company
Mr. J. T. Gasser, Executive Vice President
Mr. D. R. Madison, Vice President – Hatch
Mr. D. H. Jones, Vice President – Engineering
RTYPE: CHA02.004

U. S. Nuclear Regulatory Commission
Mr. L. A. Reyes, Regional Administrator
Mr. R. E. Martin, NRR Project Manager – Hatch
Mr. J. A. Hickey, Senior Resident Inspector – Hatch

**Edwin I. Hatch Nuclear Plant – Unit 2**
**Response to NRC Request for Additional Information Regarding**
**Modification of the Core Shroud Stabilizer Assemblies (TAC No. MD9579)**

**Enclosure 1**

**Revision to Table 1, Governing Stresses for the Shroud Head Flange**

**Table 1 - Governing Stresses for the Shroud Head Flange**

| Service Level* | Shroud Head Flange (304L) | | | | | |
|---|---|---|---|---|---|---|
| | Stress Category | Max Stress (psi) | Allowable Limit | Allowable Stress (psi) | Stress Ratio | Remark |
| N | Bearing | [[ | $S_y$ | 20,500 | [[ | - |
| U1 | Bearing | | $S_y$ | 20,500 | | - |
| U2 | Bearing | | $S_y$ | 20,500 | | - |
| E | Bearing | | 1.5 $S_y$ | 30,750 | | - |
| F | Bearing | ]] | 3.0 $S_y$ | 61,500 | ]] | Away from free edge |

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