



# GE Nuclear Energy

25A5579  
REV. 3

SH NO. 1

EIS IDENT: SHROUD STABILIZER HARDWARE

## REVISION STATUS SHEET

DOCUMENT TITLE SHROUD STABILIZER HARDWARE

LEGEND OR DESCRIPTION OF GROUPS

TYPE: DESIGN SPECIFICATION

FMF: PEACH BOTTOM 2 AND 3

MPL NO: PRODUCT SUMMARY SEC. 7

| - DENOTE CHANGE

THIS ITEM IS OR CONTAINS A SAFETY-RELATED ITEM YES ☒ NO ☐ EQUIP CLASS CODE C

REVISION			
A	RM-01386	9/12/94	
1	J TROVATO	9/24/94	RJA
CONTROL ISSUE			
RM-01502			
CHK BY: J TROVATO			
2	JL TROVATO	11/17/94	RJA
CN01859			
CHK BY: JL TROVATO			
3	L FRENCH	JUN 13 1995	RJA
CN02716			
CHK BY: L FRENCH			
PRINTS TO			
MADE BY		APPROVALS	GENERAL ELECTRIC COMPANY
J.L. TROVATO 8-22-94		M.O. LENZ 9-12-94	175 CURTNER AVENUE
CHKD BY:		ISSUED	SAN JOSE CALIFORNIA 95125
J.L. TROVATO 9-12-94		R.J. AHMANN 9-12-94	
			CONT ON SHEET 2

MS WORD (3/28/94)

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9509260229 950915  
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## 1. SCOPE

1.1 This document defines the design and performance requirements for stabilizers for the core shroud which will functionally replace welds H1 through H7. The assumption of full 360 degree through wall cracking at the H8 weld shall be considered in the design analyses. A sketch of the welds and their nomenclature is given in Figure 1. All ASME Code requirements are given in the document of Paragraph 2.1.1.g. This specification herein contains those requirements that are not ASME Code requirements.

## 2. APPLICABLE DOCUMENTS

2.1 General Electric Documents. The following documents form a part of the specification to the extent specified herein.

### 2.1.1 Supporting Documents

a. Arc Welding of Austenitic Stainless Steel	P50YP102
b. Sensitization Tests for Austenitic Stainless Steel, Modified ASTM A262 Practice E	E50YP13
c. Determination of Carbide Precipitation in Wrought Austenitic Stainless Steel (Modified ASTM A262 Practice A)	E50YP20
d. Examination for Intergranular Surface Attack	E50YP11
e. Age Hardening of NI-CR-FE Alloy X750	P10JYP2
f. Liquid Penetrant Examination	E50YP22
g. Shroud Stabilizers	25A5580
h. Reactor Vessel Thermal Cycles	729E762
i. Seismic Analysis of Peach Bottom 2 Reactor Vessel and Internals	383HA691
j. Peach Bottom 2,3 Power Rate Analysis	NEDC-32230P



2.1.2 Supplemental Documents. Documents under the following identities are to be used with this specification:

- |                         |          |
|-------------------------|----------|
| a. Reactor Components   | 383HA715 |
| b. Essential Components | 22A3041  |

2.2 Codes and Standards. The following documents of the latest issue (or specified issue) form a part of this specification to the extent specified herein.

2.2.1 American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (B&PV) Code

- a. Section III, Appendices, 1989 Edition.
- b. Section IX, Welding and Brazing Qualifications, 1989 Edition.
- c. Section III, Subsection NG, 1989 Edition.
- d. Section XI, Rules for Inservice Inspection, 1980 Edition, Winter 1981 Addenda.

2.2.2 American Society for Testing and Materials (ASTM)

- a. ASTM A-182, Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature.
- b. ASTM A-240, Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.
- c. ASTM A-262, Detecting Susceptibility to Intergranular Attack in Stainless Steel.
- d. ASTM A-479, Specification for Stainless and Heat-Resisting Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels.
- e. ASTM A-480, Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.
- f. ASTM B-637, Specification for Precipitation Hardening Nickel Alloy Bars, Forgings, and Forging Stock for High-Temperature Service.

2.3 PECO Energy Documents

- a. UFSAR, Peach Bottom Units 2 and 3.



### 3. GENERAL DESCRIPTION

3.1 The purpose of the shroud stabilizers is to structurally replace welds H1 through H7. Welds H1 through H6 are all of the circumferential welds in the shroud, as well as the (H7) bimetallic attachment weld of the shroud to the shroud support cylinder. These welds were required to both vertically and horizontally support the core top guide, core support plate, and shroud head; and to prevent core flow bypass into the downcomer region. The core top guide and core support plate horizontally support the fuel assemblies and maintain the correct fuel channel spacing to permit control rod insertion. The design analyses shall consider full 360 degree through wall cracking at the H8 weld. The H8 weld connects the shroud support plate to the shroud support cylinder.

### 4. REQUIREMENTS

#### 4.1 Code

4.1.1 The shroud stabilizer components are not classified as ASME Section III Code components. However, material properties shall be obtained from the document in Paragraph 2.2.1.a, and welding qualification shall be performed in accordance with the document in Paragraph 2.2.1.b. The nomenclature for stress intensity used in this document is the same as that used in the document of Paragraph 2.2.1.c.

#### 4.2 Structural Criteria

4.2.1 All structural analysis shall be performed in accordance with the criteria given in the Peach Bottom UFSAR. All of the load combinations given in Paragraph 4.3.5 shall be shown to satisfy the primary stress limits given in Tables C.5.2 and C.5.6 of the Peach Bottom UFSAR, with values of SFmin as defined in Paragraph 4.3.6. The appropriate SFmin values have been incorporated into the allowable stress intensity values given in Paragraphs 4.2.1.1 and 4.2.1.2.

4.2.1.1 The primary stresses ( $P_m$ ,  $P_1$ , and  $P_1 + P_b$ ) in the existing shroud, during Normal and Upset events, shall be shown to be less than  $S_m$ ,  $1.5S_m$ , and  $1.5S_m$  respectively. During Emergency events, the allowable stresses are increased by a factor of 1.5 times the values for Normal and Upset events. During Faulted events, the allowable stresses are increased by a factor of 2.0 times the values for Normal and Upset events.

4.2.1.2 The stresses ( $P_m$ ,  $P_m + P_b$ , and  $P_m + P_b + Q$ ) in the repair hardware, during Normal and Upset events, shall be shown to be less than  $S_m$ ,  $1.5S_m$ , and  $3.0S_m$  respectively. During Emergency events, the allowable primary stresses are increased by a factor of 1.5 times the values for Normal and Upset events. During Faulted events, the allowable primary stresses are increased by a factor of 2.0 times the values for Normal and Upset events. Secondary stresses are not limited during Emergency and Faulted events.



4.2.2 The values of  $S_m$  and  $S_y$  as well as any other required material property shall be obtained from the document in Paragraph 2.2.1.a (ASME Code, Section III Appendices), except for alloy X-750. The values of  $S_m$  and  $S_y$  for alloy X-750 at operating temperature are 47,500 psi and 92,300 psi respectively. These values must be verified from the Certified Material Test Reports (CMTR's). The value of  $S_m$  must be determined using the method of Appendix III from the document of paragraph 2.2.1.a. If Certified Material Test Reports (CMTR's) are available, the value of  $S_m$  for XM-19, or for stainless steel may be determined using the method in Appendix III of the document in Paragraph 2.2.1.a.

4.2.3 The maximum permanent deflection of any point on the shroud adjacent to either the H2 or the H3 weld shall be less than 2.1 inches divided by  $S_{fmin}$ , during all of the load combinations specified in Paragraph 4.3.5. The maximum permanent deflection of any point on the shroud adjacent to either the H5 or H6 weld shall be less than 0.75 inch divided by  $S_{fmin}$ , during all of the load combinations specified in Paragraph 4.3.5. The maximum transient elastic deflection during the seismic event adjacent to either the H5 or H6 weld shall be less than 1.68 inch divided by  $S_{fmin}$  specified in Paragraph 4.3.6. The allowable deflections are based on test data, and on Tables C.5.1 and C.5.5 of the Peach Bottom UFSAR.

#### 4.3 Design Requirements

4.3.1 General. The shroud repair hardware shall be designed to horizontally support the top guide, core support plate, the fuel assemblies and the shroud head. The shroud repair shall be designed to prevent upward displacement of the shroud. The shroud repair shall be designed for a life equal to the remaining design life of the plant plus possible life extension. The shroud repair shall be removable.

##### 4.3.2 Spring Preload

4.3.2.1 Installation Preload. All of the springs shall be installed with a preload due to bending deflection greater than the deflection resulting from the limiting design upset condition, exclusive of seismic events. The required installation spring bending preload is 0.05 inch for the upper springs and 0.01 inch for the lower springs.

4.3.2.2 Preload Relaxation. The design shall consider an End-of-Life preload relaxation of 5% for the upper springs near the H2 and H3 welds and a relaxation of 5% for the lower springs near the H5 and H6 welds. Potential axial preload relaxation due to a reduction in shroud stiffness resulting from assumed cracking at the H2, H3, H5, and H6 welds shall be considered.

##### 4.3.3 Environmental Conditions

4.3.3.1 Temperature. The design temperature for the repair hardware is 550 degrees F. The operating temperature is 527 degrees F. Operating temperature shall be used for emergency and faulted evaluations.



4.3.3.2 Radiation. The maximum neutron radiation level (flux) at the shroud stabilizers in the shroud vessel annulus is  $4.8E10$  neutrons/cm<sup>2</sup>/sec. This will not affect the properties of the stabilizer materials over the remaining life of the plant.

#### 4.3.4 Physical Interfaces

4.3.4.1 The shroud repair hardware shall restrain the shroud during all of the load combinations in Paragraph 4.3.5. The allowable permanent motion is dependent on the safety significance of the portion of the shroud under consideration. The allowable permanent motion for those portions of the shroud, which affect control rod insertion, is given in Paragraph 4.2.3. For the remaining portion of the shroud below H3, the allowable permanent motion is determined such that the reflooding of the inside of the shroud up to two thirds of core height is assured. For the portion of the shroud above H2, the allowable motion is 2.6 inches, which assures that the core spray lines are not impacted by the shroud.

4.3.4.2 The shroud repair hardware must provide features which facilitate handling during installation. The upper and lower springs shall be movable without removing the tie rod and without welding, in order to permit inspection of the reactor pressure vessel with GERIS 2000.

4.3.4.3 The shroud repair hardware shall be designed and installed such that removal of jet pump inlet mixers can be performed without removal of any of the repair hardware.

4.3.4.4 All parts shall be captured and held in place with a method that will last for the design life given in Paragraph 4.3.1.

4.3.5 Load Combinations. The load combinations that the shroud and shroud repair shall be analyzed for are from the Peach Bottom UFSAR. The limiting Upset event is a Design Basis Earthquake (DBE), plus Normal pressure differences, plus dead weight. The Emergency 1 event is a Maximum Credible Earthquake (MCE), plus Normal pressure differences, plus dead weight. The Emergency 2 event is a main steam line LOCA, plus dead weight. The Faulted event is a Maximum Credible Earthquake (MCE), plus a main steam line LOCA, plus dead weight.

4.3.5.1 The pressure differences for these events are given in the table below. The pressure inside the shroud is higher than that outside of the shroud, and the pressure is higher below the core plate than above the core plate. These values include Power Rerate conditions based on 110% core flow, and 110% original power.

<u>Component</u>	<u>Normal Pressure</u>	<u>LOCA Pressure</u>
Shroud Support Plate	33.03 psi	51.0 psi
Core Plate	23.67 psi	28.0 psi
Upper Shroud	9.35 psi	30.0 psi
Shroud Head	9.41 psi	31.0 psi



4.3.5.2 A new seismic analysis based on the documents in Paragraph 2.3 and 2.1.1.i shall be performed which includes the shroud stabilizers. The shroud stabilizers shall function for the entire continuum from an uncracked shroud to a fully cracked shroud. Therefore, multiple conditions must be analyzed, for both the DBE and the MCE events. As a minimum, the following shroud conditions shall be analyzed: an uncracked shroud with the installed stabilizers, a shroud with a through wall 360 degree crack at the H7 weld with the installed stabilizers, and a shroud with a through wall 360 degree crack at the H6 weld with the installed stabilizers. The limiting seismic loads on the stabilizer are given in the table below:

<u>Component</u>	<u>DBE</u>	<u>MCE</u>
Upper Spring	17,110 lb.	31,390 lb.
Lower Spring	33,440 lb.	92,900 lb.
Set of 4 Tie Rods (each)	75,640 lb.	117,600 lb.

4.3.5.3 Two steady state thermal conditions shall be evaluated. The first is Normal operation with the shroud at 539 degrees F, and the stabilizer assembly at 527 degrees F. The second condition is an Upset transient (scram with loss of feedwater pumps) with the shroud at 433 degrees F, and the stabilizer at 300 degrees F. The number of events is defined by 729E762 (document 2.1.1.h).

4.3.5.4 During the recirculation line LOCA event, there is a force applied to the shroud of 169,000 lbs, with a moment of 13.0E6 in-lb acting at the base of the shroud. This is due to asymmetric pressures in the annulus between the shroud and the RPV. This force exists for a sufficient time to be treated as a static force.

4.3.6 Required Safety Factors. The minimum safety factors (SFmin) shall be 2.25 for Normal and Upset events, 1.5 for Emergency events, and 1.125 for Faulted events. These are based on Table C.5.5 of the Peach Bottom UFSAR.

4.4 Materials. ASTM specification material is acceptable for the Shroud Repair. CMTRs are required for all material.

4.4.1 The springs shall be made of nickel-chrome-iron alloy X-750 (UNS N07750). The cobalt content shall be limited to a maximum of 0.10%. Alloy X-750 shall be purchased per ASTM B-637 and age hardened per P10JYP2. Alloy X-750 material shall be tested per E50YP11. In lieu of testing per E50YP11, all finished components may incorporate the removal, after solution heat treatment, of a minimum of 0.030 inches of material from all surfaces of the original raw material form.



4.4.2 The tie rods may be made of either 304, 304L, 316, or 316L material with a maximum carbon content of 0.02%, and annealed at 1900 to 2100 degrees F followed by quenching in circulating water to a temperature below 400 degrees F. The tie rod material shall be tested per E50YP11 and E50YP20. The maximum hardness shall be RB90 for 304 and 304L. The maximum hardness shall be RB92 for 316 and 316L. XM-19 with a maximum carbon content of 0.04% may also be used for fabrication of the tie rods. XM-19 shall be annealed at  $2,000 \pm 50$  degrees F, followed by rapid cooling, and shall be tested per E50YP13, or per ASTM A-262 Practice E.

4.4.3 Other parts shall be made of any of the materials listed in Paragraph 4.4. The filler material for any required weld buildups on 300 series stainless steel shall be Type 308L per P50YP102. All assembly welds shall satisfy P50YP102.

4.5 Leakage Due to Repair. Zero leakage is not required. However, the design shall control the normal operating condition leakage to prevent cavitation of the jet pumps. The leakage after any required load combination shall be limited such that core flooding to 2/3 the height of the core is assured.

4.6 Inspections. Liquid penetrant examination shall be performed on all final machined surfaces of all stabilizer components, and on all structural welds in accordance with the requirements E50YP22A.

#### 4.7 Fabrication

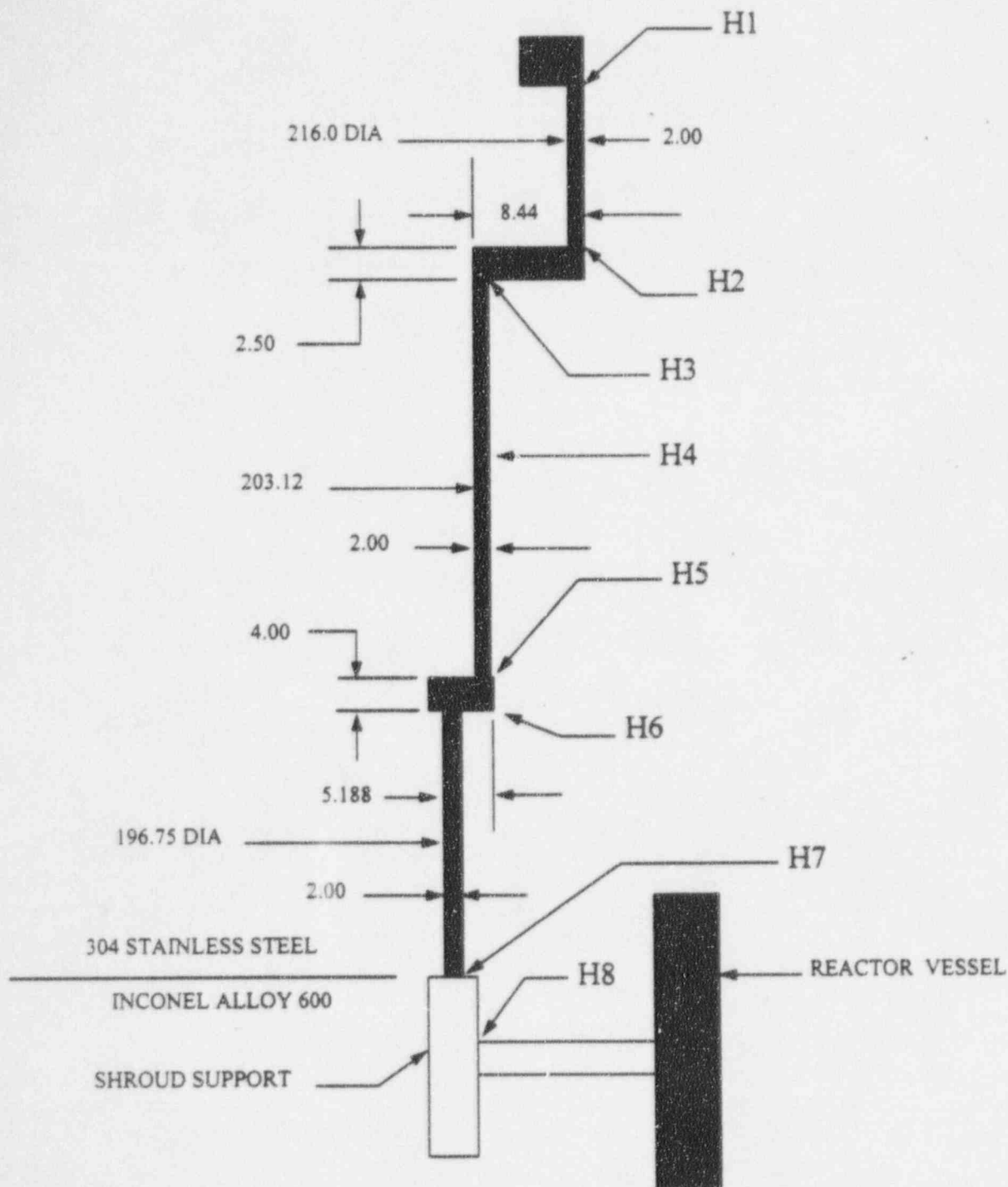
4.7.1 Welder and Weld Procedure Qualification. Welders and weld procedures shall be qualified per the document in Paragraph 2.2.1.b. Welder qualifications shall include limited access similar to the actual welds to be completed.

4.7.2 Root Pass. The root pass of all full penetration single sided stainless steel welded joints shall be made by the GTAW process. Protective gas back-purging is required for all full penetration single sided welded joints until a minimum of 3/16 inch of weld thickness is completed.

4.7.3 Weld Surface Finish. All welds shall have the final outer surface suitable for liquid penetrant examination. The final surface shall meet the hardness requirements of Paragraph 4.4.

### 5. QUALITY ASSURANCE

5.1 The shroud repair hardware components are Safety Related as referenced in Paragraph 2.1.2 b, and design, fabrication, and installation activities shall be controlled per a QA Program which satisfies 10CFR50 Appendix B, in order to assure safe and reliable components.



**HORIZONTAL WELD LOCATIONS**

**FIGURE 1**



**GE Nuclear Energy**

25A5580 SH NO. 1  
REV. 4

EIS IDENT: SHROUD STABILIZERS

**REVISION STATUS SHEET**

DOC TITLE SHROUD STABILIZERS

LEGEND OR DESCRIPTION OF GROUPS

TYPE: CODE DESIGN SPECIFICATION

FMF: PEACH BOTTOM 2 AND 3

MPL NO: PRODUCT SUMMARY SEC. 7

THIS ITEM IS OR CONTAINS A SAFETY RELATED ITEM YES ☒ NO ☐ EQUIP CLASS CODE P

REVISION				C
A	RM-01386 9/12/94			
1	J TROVATO 9/24/94	RJA		
	CONTROL ISSUE RM-O1502 CHK BY: J TROVATO			
2	JL TROVATO	RJA		
	CN01859 CHK BY: JL TROVATO			
3	L. FRENCH 6/13/95	RJA		
	CN02716 CHK BY: L. FRENCH			
4	M. BURT JUN 19 1995	RJA		
	CN02808 ENGR: M.O.LENZ			
PRINTS TO				
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J.L. TROVATO 9-12-94		R.J. AHMANN	CONT ON SHEET 2	

MS-WORD



## 1. SCOPE

1.1 This document defines the ASME Code design requirements for the analysis of the reactor pressure vessel (RPV) as a result of the installation of the shroud stabilizers. The shroud stabilizers function to structurally replace the horizontal shroud welds H1 through H7, and will add new points of application for forces applied to the RPV. In addition, the analysis shall consider the assumption of full 360 degree through wall cracking at the H8 weld between the shroud support plate and the shroud support cylinder.

## 2. APPLICABLE DOCUMENTS

2.1 General Electric Documents. The following documents form a part of this specification to the extent specified herein.

### 2.1.1 Supporting Documents

- |  |                |
|--|----------------|
| a. Reactor Vessel - Power Rerate                   | 25A5341 Rev. 0 |
| b. Reactor Pressure Vessel, Purchase Specification | 71A1111 Rev. 9 |
| c. Reactor Vessel, Purchase Part                   | 886D499 P2     |

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| d. Reactor Thermal Cycles | 729E762 Rev. 0 |
| e. Nozzle Thermal Cycles  | 135B9990       |

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2 - 8

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|---|----------------|
| f. Vessel Flange Bolting                    | 885D911 Rev.2  |
| g. Nozzle End Preparation                   | 107C5305 Rev.2 |
| h. Standard Requirements For Core Structure | 21A3319 Rev.1  |



- i. "Fatigue Evaluation of the Peach Bottom II and III Reactor Vessels", G.E. Report No. GE-NE-523-61-0493, dated May 1993.

2.1.2 Supplemental Documents. Documents under the following identities are to be used with this specification:

- a. Shroud Stabilizer Hardware Design Specification 25A5579

2.2 Codes and Standards. The following documents of the specified issue form a part of this specification to the extent specified herein.

2.2.1 American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code

- a. Section III, 1965 Edition and Addenda through Winter 1965
- b. Section XI, 1980 Edition and Addenda through Winter 1981

2.2.2 Other Documents

- a. UFSAR, Peach Bottom 2 and 3
- b. Shroud Support VPF 1896-064-7
- c. Design Certification VPF 1896-142-1
- d. Design Stress Report VPF 1896-146-1
- e. Final Design Report VPF 1896-148-2

### 3. GENERAL DEFINITION

3.1 The purpose of the shroud stabilizers is to structurally replace all of the horizontal welds (H1 through H7) in the shroud. These welds were required to both horizontally and vertically support the core top guide, core support plate, and shroud head, and to prevent core bypass flow to the downcomer region. The core top guide and core support plate horizontally support the fuel assemblies and maintain the correct fuel channel spacing to permit control rod insertion, as well as having other structural functions. The H8 weld connects the shroud support plate with the shroud support cylinder. The analysis of the RPV shall consider full 360 degree through wall cracking at the H8 weld.

3.2 All of the non ASME Code requirements for the shroud stabilizers are defined in the Document of Paragraph 2.1.2.a. The ASME Code requirements are defined herein.



#### 4. REQUIREMENTS

4.1 The shroud stabilizer construction shall be performed in accordance with a Section XI Replacement Program per the requirements of Article IWA-7000. The core shroud was not supplied as a ASME Code component. However, Section XI requires In Service Inspection (ISI) of the Core Support Structures. The required Replacement Program is different than most Replacement Programs, because the stabilizers are not a direct replacement. Instead, the structural functions of the shroud horizontal welds are replaced by new components. Any defects found in the shroud horizontal welds are acceptable after the installation of the stabilizers.

4.2 The shroud stabilizers shall be constructed to the original Owners Requirements (document of Paragraph 2.1.1.h) for the shroud, as there was no Code of Construction.

4.3 The shroud stabilizers change the points of application of the forces applied to the reactor pressure vessel from the core shroud. These new forces shall be analyzed in accordance with the original Code of Construction (document in Paragraph 2.2.1.a).

4.4 The new forces and their points of application are defined in Figure 1, and in Table 1. The values given in Figure 1, and in Table 1 shall be combined with the forces defined in the Design Specification (documents of Paragraphs 2.1.1.a through 2.1.1.e).

4.5 The original purchase specification for the reactor pressure vessel (document of Paragraph 2.1.1.b) specified that the boundary of jurisdiction of Section III of the ASME Code (document of Paragraph 2.2.1.a) shall include all attachments to the pressure boundary parts, but does not include the components that are welded to the attachments. Thus, the jurisdiction of the original Code of Construction included all weld build up pads used to attach internal components to the reactor pressure vessel, but did not include the shroud support within the boundary of Code jurisdiction. The boundary of ASME Code jurisdiction is shown in Figure 2.

4.6 The analysis required by this Design Specification shall be Certified.

#### 5.0 PROFESSIONAL ENGINEER CERTIFICATION

To the best of my knowledge and belief, this Design Specification satisfies the requirements of the ASME Boiler and Pressure Vessel Code 1965 Edition with Addenda through Winter 1965.

Signature: \_\_\_\_\_

Date: June 19, 1995

License Number: \_\_\_\_\_

22212



State: California

**ADDITIONAL DESIGN MECHANICAL LOADS**

<u>Force</u>	<u>DBE + Normal Pressure</u>	<u>MCE + Normal Pressure</u>	<u>MCE+LOCA</u>
F <sub>1</sub>	33,400 lbs	92,900 lbs	92,900 lbs
F <sub>2</sub>	17,110 lbs	31,390 lbs	31,390 lbs
F <sub>3</sub>	172,910 lbs	218,500 lbs	372,650 lbs

F<sub>1</sub>, F<sub>2</sub>, and F<sub>3</sub> are discrete loads applied over a small area. At any one point in time, F<sub>1</sub> and F<sub>2</sub> are each applied to one location. At any one point in time, F<sub>3</sub> is applied to 4 locations 90° apart for the installation of four shroud stabilizer assemblies. DBE is a Design Basis Earthquake (OBE). MCE is a Maximum Credible Earthquake (SSE).

For Normal Operation (d-pressure plus thermal loads) without consideration of seismic loads, F<sub>3</sub> = 94,710 lbs.

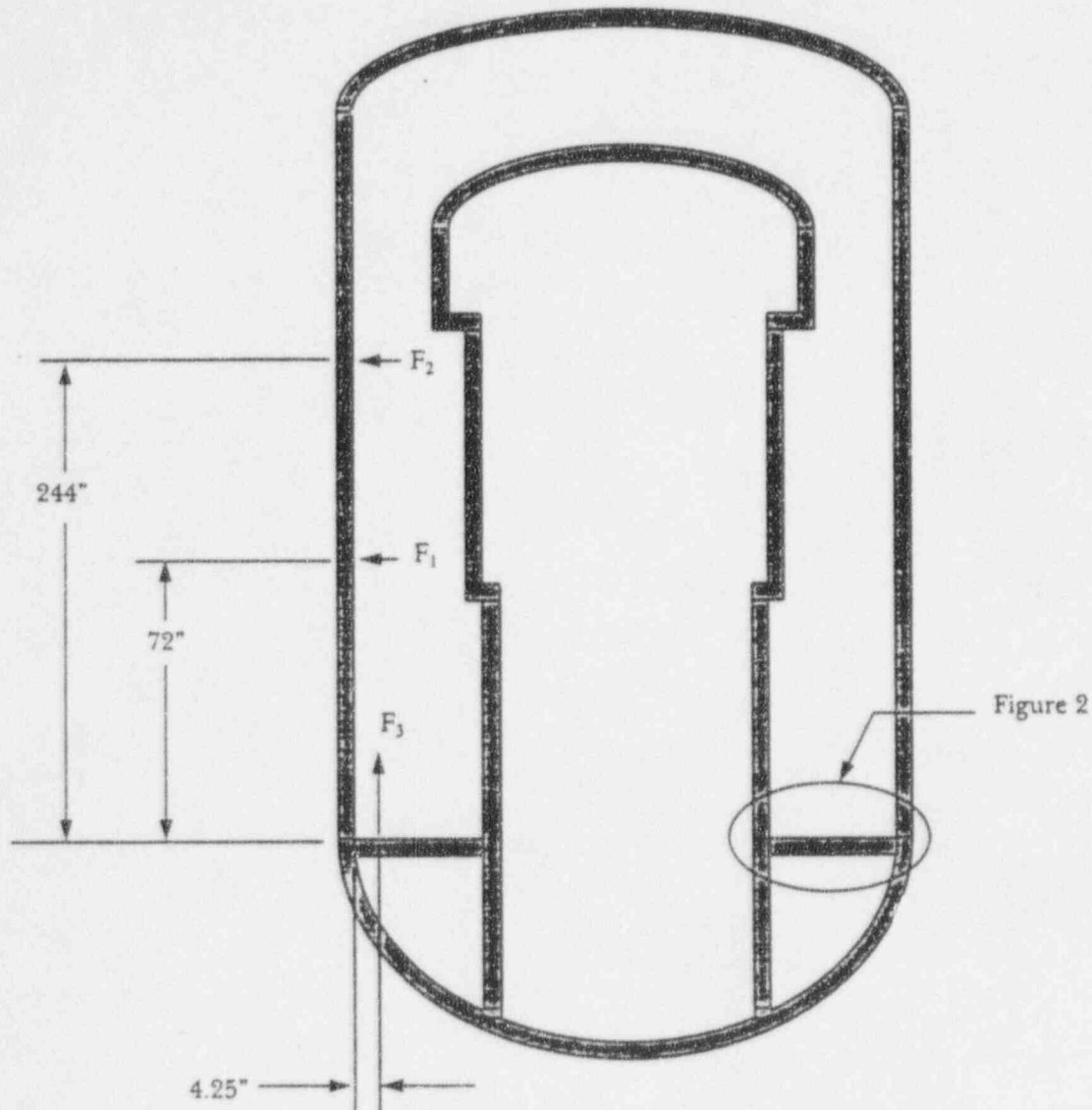
For the limiting Upset thermal transient without consideration of seismic loads, F<sub>3</sub> = 249,985 lbs.

For a Main Steam Line LOCA without seismic loads, F<sub>3</sub> = 248,500 lbs. This must be addressed with the same allowables as the MCE + Normal Pressure load case.

The number of thermal cycles is defined by documents 2.1.1.d and 2.1.1.i.

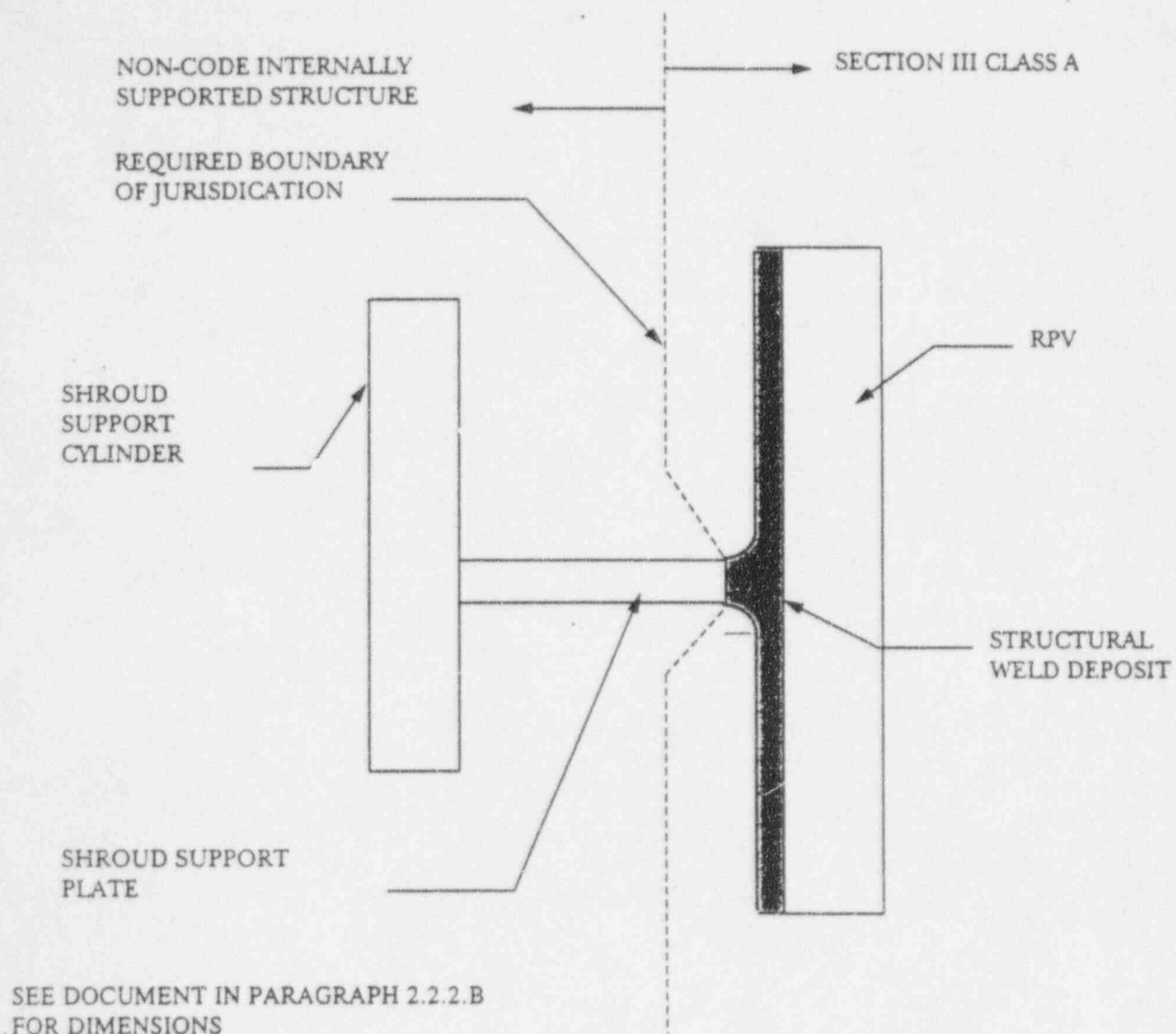
The stress intensities shall meet the stress allowables of the ASME Code, Section III, for the load combinations defined by the Peach Bottom UFSAR. The original Code of Construction did not include Faulted load combinations. Faulted load combinations shall meet the stress allowables as defined by the Peach Bottom UFSAR for the reactor pressure vessel.

**TABLE 1**



APPLICATION OF DESIGN MECHANICAL LOADS

FIGURE 1



**BOUNDARY OF ASME CODE JURISDICTION**

**FIGURE 2**



**GE Nuclear Energy**

25A5581 SH NO. 1  
REV. 2

EIS IDENT:

**REVISION STATUS SHEET**

DOC TITLE STABILIZER INSTALLATION

LEGEND OR DESCRIPTION OF GROUPS

TYPE: INSTALLATION SPEC

- Denotes Changes

FMF: PEACHBOTTOM 2,3

MPL NO: PRODUCT SUMMARY SEC. 7

THIS ITEM IS OR CONTAINS A SAFETY RELATED ITEM YES ☒ NO ☐ EQUIP CLASS CODE P

REVISION			C
0	RM-01490 SEP 24 1994	RJA	
1	C.F. SERMON 5/17/95	RJA	
	CN02668 Added Sections 6.6 and 6.10 Changed section 6.26		
2	M. BURT JUN 19 1995	RJA	
	CN02808 ENGR: M.O.LENZ		
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CHK BY	ISSUED		
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MS-WORD



## 1. SCOPE

1.1 Purpose. This specification provides the engineering requirements for installing stabilizers which replace the H1 through H7 horizontal shroud welds in the Peachbottom reactor assembly.

1.2 If any conflict exists between this document and any other document referenced herein, this document shall govern.

1.3 This document, along with the reactor modification and installation drawing, defines all the engineering requirements for installation of the shroud stabilizers.

1.4 As used herein, the term "Installer" refers to the company or personnel contracted by the Plant Owner to install the shroud stabilizers.

## 2. APPLICABLE DOCUMENTS

2.1 General Electric Documents. The following documents form a part of this specification to the extent specified herein.

### 2.1.1 Supporting Documents

- a. 25A5579, Shroud Stabilizers
- b. 105E1455, Reactor (Modification & Installation)
- c. 21A2040, Cleaning and Cleanliness Control
- d. D50YP5, Nickel-Graphite Thread Lubricant
- e. 112D6355, Contact, Lower
- f. 112D6360, Lower Stabilizer (lower contact assembly)
- g. 112D6357, Contact, Upper
- h. 112D6347, Upper Stabilizer Assembly (upper spring assembly)
- i. 112D6349, Tie Rod Assembly
- j. 112D6351, Spring, Lower
- k. 112D6331, Ring, Mid Support
- l. 112D6358, Tie Rod-Spring Assembly
- m. 112D6356, Support, Mid



- n. 112D6359, Mid Support Assembly
- o. 112D6490, Support, Lower
- p. 112D6495, Toggle Bolt Assembly
- q. 112D6493, Washer, Toggle Bolt
- r. 112D6494 Nut, Toggle Bolt
- s. 112D6505, Pin, Clevis
- t. 112D6348, Stabilizer Support Assembly
- u. 112D6752, Upper Support Spacer
- v. 112D6777, Nut, Tie Rod

#### 2.1.2 Supplemental Documents

- a. NEDC-31735P GE BWR Operator's Manual - Materials and Processes

2.2 Codes and Standards. The following codes and standards of the latest issue (or specified issue) form a part of this specification to the extent specified herein.

#### 2.2.1 American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code

None

### 3. DESCRIPTION

3.1 The purpose of the stabilizer installation is to structurally replace horizontal girth welds H1 through H7 in the shroud; weld designations and the design requirements for the stabilizers are defined in the 2.1.1.a design specification. The installation of the shroud stabilizers involves electric discharge machining (EDM) of some slots and holes in the existing structure, assembling the stabilizer hardware in the reactor, and preloading the threaded fasteners. No structural welding or defect removal by machining are involved.

### 4. RESPONSIBILITIES

4.1 The Installer shall accept full responsibility for his work. The Installer shall comply with the requirements of this document and the supporting documents listed herein.

4.2 The Installer shall take the responsibility for coordination of his work with the work of others including the coordination of work planning and radiation monitoring with the Plant Owner.



4.3 The Installer shall be responsible for providing all specialized handling, alignment, and installation equipment, as may be necessary to perform this work, except as otherwise agreed to by the Plant Owner.

4.4 The Installer, except as otherwise agreed to by the Plant Owner, shall be responsible for machining as specified and limited by the applicable modification drawing.

4.5 The Installer shall supply adequately qualified personnel for supervision and for performing the tasks required to complete the stabilizer installation.

## 5 REQUIREMENTS

### 5.1 General

5.1.1 During installation, the Installer, except as otherwise agreed to by the Plant Owner, shall complete data sheets and quality control check sheets as required by the specifications and instructions listed in this document. The Installer shall also keep log notes, records, etc., for future reference. Video tapes shall be taken of the completed repair. Tabular data entries designated for as-built measurements on the installation drawing shall be recorded.

5.1.2 Procedures and installation equipment shall be developed and designed to minimize the potential of loose parts within the Reactor Pressure Vessel (RPV).

5.1.3 Following completion of the installation of the stabilizers, verification, inspection and signoff shall be performed to ensure that all objects have been removed from the RPV.

5.1.4 All uncontaminated tools shall be stored in an uncontaminated controlled area and brought to the work area only as needed for fit-up and installation.

5.1.5 Refer to Paragraph 2.1.2.a for miscellaneous consumables approved for use in the reactor vessel.

### 5.2 Personnel Safety

#### 5.2.1 Radiation Control

5.2.1.1 All work shall be done with the concurrence of and per the instructions of the authorized site Health Physics Personnel. At no time shall their requirements for dosimeter monitors, protective clothing or devices, time limits, exposure limits, etc., be violated.

5.2.1.2 Machining on contaminated surfaces, as required, shall be done in accordance with Health Physics and Safety Personnel requirements.

5.2.1.3 Radiation control practices shall be used to reduce exposure to workers to levels which are as low as reasonably achievable (ALARA).



### 5.2.2 Safety Precautions

5.2.2.1 Concern for personnel safety shall govern all work operations. All personnel working in hazardous locations shall be under constant surveillance by other personnel. All electric equipment shall be grounded or double insulated. Welding cables and leads shall be in good condition.

5.2.2.2 All work areas shall be kept neat and orderly. Protective measures and devices shall be used to keep all tools, equipment, and materials from inadvertently dropping into the RPV.

5.2.2.3 Care shall be exercised to keep contamination of articles which must enter and leave contamination zones to a minimum. In all cases, site radiation control requirements shall be met.

### 5.3 Cleaning and Cleanliness Control

5.3.1 During this stabilizer installation program, cleaning and cleanliness control shall be in accordance with the document listed in paragraph 2.1.1.c. In addition, no graphite lead pencils are allowed to contact stainless steel and nickel alloys.

### 5.4 Prerequisites

5.4.1 Jet Pump Throat Covers. Prior to the shroud stabilizer installation jet pump throat covers shall be installed as required.

5.4.2 Reactor Temperature. The reactor water temperature shall be less than 100°F, however the RHR shutdown cooling flow must be off whenever the installation activity in progress involves critical remote underwater handling in the annulus area.

## 6. INSTALLATION REQUIREMENTS

6.1 The installation sequence described below is not itself mandatory, so long as all specified installation requirements are accomplished. To assist in evaluating alternative sequences, the intent of some requirements, which are not self evident, are summarized in the step description.

6.2 Shroud head bolt (SHB) lug sets which straddle the 45, 135, 225, and 315 degree azimuths, on the shroud, are specified, on the 105E1455 Modification and Installation drawing, for locating the stabilizer support installation and for machining shroud head flange slots. These SHB lugs shall be determined and independently verified as a

prerequisite to any physical work at each of the four installation locations. Prior to removing the shroud head (SHBs may be unlatched), a common scribe line shall be



made on both the shroud and shroud head at each of the four installation locations, in accordance with the 105E1455 Modification and Installation drawing. This scribe line will then become the datum for locating the slots in the shroud head flange and installing the stabilizer support assemblies on the shroud flange.

6.3 Go-gage checks shall be performed on: the shroud flange and steam dam width for fit-up with the upper support (also checks for possible prior damage to the steam dam), and the jet pump restrainer bracket to RPV inside diameter clearance, 5.4 inch minimum, to allow passage of the lower spring (temporarily ignoring the jet pump restrainer bracket guide plates).

6.4 Install protective shielding for the feedwater sparger and core spray line.

NOTE: The below step is a contingency, which will only be performed if there is insufficient clearance to complete the installation.

6.5 Machine (EDM) the jet pump restrainer brackets, if required, as shown on the 105E1455 Modification and Installation drawing. EDM swarf shall be captured to the maximum extent practical.

6.6 Measure and record the outside-to-outside distance between the SHB lug sets, as shown on the 105E1455 Modification and Installation drawing.

6.7 Measure and record the annulus width at the top guide support ring and at the core support ring elevations as shown on the 105E1455 Modification and Installation drawing. Examine the RPV and shroud contact areas to assure that there are no abrupt discontinuities; if so, EDM spotface these areas flush. The vessel and shroud contact locations of the final stabilizer parts shall be simulated in taking these measurements.

CAUTION: Several piece parts are to be machined based on in-reactor measurements at a specific reactor azimuth. These parts shall then be designated by specific serial number, as recorded on the as-built data table on drawing 105E1455, for that specific azimuth.

6.8 Based on the in-reactor measurements, machine the RPV contact surface of the lower contact, drawing 112D6355, as shown on the 105E1455 Modification and Installation drawing. Assemble the lower contact as shown on the lower stabilizer assembly, drawing 112D6360.

6.9 Based on the in-reactor measurements, machine the RPV contact surface of the upper contact, drawing 112D6357, as shown on the 105E1455 Modification and Installation drawing. Assemble the upper contact as shown on the upper stabilizer assembly, drawing 112D6347.



6.10 Based on the in-reactor measurements of the outside-to-outside distance between the SHB lug sets, and the measurement of the outside dimension of the stabilizer support, machine the contact surface of the upper support spacer, 112D6752, in accordance with the 105E1455 Modification and Installation drawing. Assemble the upper support spacer, 112D6752 on the stabilizer support assembly 112D6348.

6.11 Working in the equipment pool, locate the proper datum on the shroud head flange as shown on the 105E1455 Modification and Installation drawing. Machine (EDM) slots in the shroud head flange as specified on the 105E1455 modification and installation drawing.

6.12 In accordance with the 105E1455 Modification and Installation drawing, machine (EDM) two holes in shroud support plate. EDM swarf shall be captured to the maximum extent practical.

6.13 Hone the holes in the shroud support plate. To assure the removal of microfissures from the EDM hole in the shroud support plate, the hone operation shall remove a minimum of 0.005 inch from the inside surface of the hole while meeting the final hole size requirement on the 105E1455 Modification and Installation drawing.

6.14 Install lower support, 112D6490, over the two shroud support plate holes using two toggle bolt assemblies, 112D6495, and two toggle bolt washers, 112D6493, and two toggle bolt nuts, 112D6493, as shown on the 112D6494 Modification and Installation drawing. Lubricant (D50YP5B) shall be applied to the threaded surfaces. Tension the two toggle bolts to the specified load, and tighten the toggle bolt nuts. Inspect to verify the installation of the lower support. Crimp the toggle bolt nuts, and inspect for proper crimping of the retainers.

6.15. Install the clevis pin, 112D6505, in the mating hole of the lower support in accordance with the requirements of the 105E1455 Modification and Installation drawing.

6.16 Complete the tie rod-spring assembly. Assemble the tie rod, assembly drawing 112D6349, with the lower spring, drawing 112D6351 (Drill pin hole and install lock pin.), and the lower stabilizer, drawing 112D6360 as shown on assembly drawing 112D6358. Lubricant (D50YP5B) shall be applied to the threaded surfaces.

6.17 Temporarily protect the exposed tie rod thread from damage.

CAUTION: Maneuvering of the tie rod-spring assembly must be done with extreme care to avoid damaging reactor hardware such as the jet pump sensing lines.

6.18 Install the tie rod-spring assembly, 112D6358, in accordance with the requirements of the 105E1455 Modification and Installation drawing. Maneuver lower spring clevis over clevis pin and support vertically.



6.19 Position the stabilizer support assembly, 112D6348, over the tie rod. Lower the stabilizer support assembly over the steam dam and locate properly on shroud flange in accordance with the requirements of the 105E1455 Modification and Installation drawing.

6.20 Rotate and position the lower stabilizer assembly, 112D6360, as shown on the 105E1455 modification and installation drawing. Verify that the lower stabilizer assembly latch is engaged in the tie rod slot.

6.21 While forcing the upper end of the tie rod radially inward, taking up clearance (0.25 inch diametrical) in the support block's clearance hole, measure the radial gap from the tie rod to the vessel wall at the mid support elevation. The tie rod itself should not be bowed while taking this measurement. The vessel contact locations of the mid support shall be simulated in taking these measurements. Based on this in-reactor measurement, machine the contact surfaces of the mid support, drawing 112D6356, in accordance with the requirements of the 105E1455 Modification and Installation drawing. Complete the mid support assembly as shown on the mid support assembly drawing, 112D6359.

6.22 Remove the temporary thread protection from the tie rod. Install the tie rod nut and torque in accordance with the requirements of the 105E1455 Modification and Installation drawing; continue to force the upper end of the tie rod radially inward during tensioning. Verify that the tie rod nut is properly locked by its retainers. Lubricant (D50YP5B) shall be applied to the nut threaded surfaces.

6.23 Install the mid support in accordance with the requirements of the 105E1455 Modification and Installation drawing. Verify that the mid support latch is engaged in the tie rod slot.

6.24 Install upper stabilizer (spring) assembly, 112D6347, in accordance with the requirements of the reactor modification drawing. Lubricant (D50YP5B) shall be applied to the 0.50 inch slot areas and the jacking bolt (threaded and moving surfaces). Engage with stabilizer support assembly and adjust the jacking bolt as specified on the 105E1455 Modification and Installation drawing to preload the upper spring. Check that the spring retainers are properly engaged to lock the jacking bolt.

6.25 Remove the protective shielding for the feedwater sparger and core spray line.

6.26 Repeat steps 6.3 through 6.25 for the installation of stabilizer hardware at the remaining azimuth locations. Step 6.11 is envisioned as an independent parallel activity.



## 7. EXAMINATION AND TESTING

7.1 Visual Examination. Visually examine the stabilizer installation preparations to verify that all of the required holes have been machined in the proper locations and that all debris has been removed from the area. Visually examine the installed stabilizers to verify compliance with the 105E1455 Modification and Installation drawing. To minimize inspection time, personnel exposure, and tooling requirements, installation requirements, as indicated on the installation drawing, may be verified by tool design, process control and mockup qualification testing.

## 8. RECORDS AND SUBMITTALS

8.1 Prior to implementation of this stabilizer installation program, the following procedures shall be submitted by the Installer and approved by the Owner.

- a. Installation and inspection procedures including sequence data sheets, measurement data sheets, quality control check sheets, drawings, sketches, instructions, etc.
- b. Cleaning and cleanliness control procedures.
- c. Machining procedures as applicable.
- d. As-built drawing (data required by 105E1455).

8.2 After implementation of this stabilizer installation program, all recorded data records, photographs, video tapes, logs, etc., shall be submitted by the Installer to the Owner for file and information within 30 days. The 105E1455 modification and installation drawing shall be updated to incorporate the in-reactor as-built measurements, and the as-built measurements with corresponding serial numbers of the parts machined as part of the installation process. One copy shall be submitted to GENE within 30 days.

## 9. DEVIATIONS AND SUBSTITUTIONS

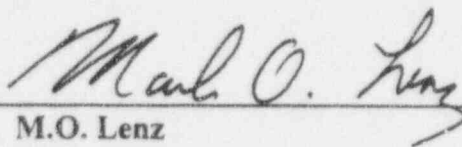
9.1 All deviations, as a result of damaged equipment, nonconforming conditions, or any proposal by the Installer for substitutions, modifications, or relaxation of the specified materials, procedures or design shall be submitted to the Owner for consideration and approval.



DESIGN REPORT FOR THE  
INSTALLATION OF STABILIZERS ON  
THE PEACH BOTTOM 2, 3  
CORE SHROUD

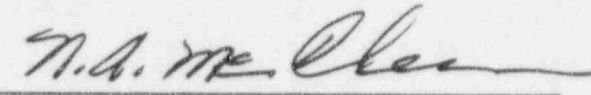
GE NUCLEAR ENERGY

Prepared by:

  
M.O. Lenz

Project Engineer

Verified by:

  
N.A. McClean

Principal Engineer

Approved by:

  
L.E. Tschantre

Project Manager

950705-41 89PP

## **IMPORTANT NOTICE REGARDING**

### **CONTENTS OF THIS REPORT**

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Changes made to the previous revision of this report are indicated by "bars" drawn in the left margin.

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## 1.0 DESCRIPTION OF CHANGE

An in-vessel visual inspection (IVVI) of the horizontal welds in the shroud will be performed at Peach Bottom Unit 2. Based on the results of the weld inspection, shroud stabilizer assemblies, which function to replace cracked horizontal welds in the shroud, may be installed in Peach Bottom Unit 2 during the next refueling outage. In the event that the installation of the stabilizer assemblies is not required for Unit 2, the assemblies will be retained as a contingency for possible later installation, or for installation at Peach Bottom Unit 3. If the stabilizers are installed at Unit 3, replacement of the core spray line repair brackets should be considered, as discussed in Section 1.6.2.

### 1.1 General

Welds H1 through H7 of the core shroud will be structurally replaced by a set of 4 stabilizer assemblies. Figure 1 shows a stabilizer assembly. Each stabilizer assembly attaches to the top of the shroud and to the shroud support plate.

Radially acting stabilizer springs are used to maintain the alignment of the core shroud to the reactor pressure vessel (RPV) during seismic events. The set of stabilizers replace the structural functions of the shroud welds which are postulated to contain cracks. Each stabilizer assembly consists of a tie rod, an upper spring, a lower spring, an upper bracket, a midspan tie rod support, a lower anchor assembly, and other minor parts. The tie rod provides the vertical load carrying ability from the upper bracket to the RPV shroud support plate attachment, as well as support for the springs. The vertical locations of the radial springs were chosen to provide the maximum support for the shroud and fuel assemblies. The upper spring provides radial load carrying ability from the shroud, at the top guide elevation, to the RPV. The lower spring provides radial load carrying ability from the shroud, at the core support plate elevation, to the RPV. The upper bracket provides an attachment feature to the top of the shroud as well as restraint of the upper shroud welds. The midspan tie rod support functions to increase the natural frequencies of the stabilizer assembly.

There are seven horizontal welds (Figure 2) in the Peach Bottom 2, 3 shroud. These welds are identified as H1 through H7, with H1 being the uppermost weld and H7 being the attachment of the shroud to the shroud support cylinder. Each cylindrical section of the shroud is prevented from unacceptable motion by the stabilizers. The motion of the sections above H1, between H1 and H2, and between H2 and H3 are restrained by the upper bracket. The upper bracket contacts the shroud and is radially supported by the upper spring which contacts the RPV. There is a stop

on the upper bracket which prevents unacceptable motion of the shroud section between the H3 and H4 welds. The lower spring contacts the shroud such that it prevents unacceptable motion of the section between the H4 and H5 welds, as well as the section between the H5 and H6 welds. There is also a feature on the lower spring which prevent unacceptable motion of the shroud section between the H6 and H7 welds.

The H8 weld (Figure 2) connects the shroud support shelf to the shroud support cylinder. The assumption of cracking in the H8 weld was also considered in the seismic analysis, the analysis of the stresses in the shroud support plate, and in the systems performance evaluation with the assumption of leakage through the weld cracks.

The primary forces applied to the stabilizers are from seismic events, LOCA differential pressure loads, and differential thermal expansion. The installation of the stabilizer assemblies and the assumption of cracks in the shroud change the seismic response of the reactor internals. Thus, it was necessary to modify the seismic analysis of the reactor to include the assumed cracks and the stabilizers. This dynamic analysis was performed in a iterative manner to determine the appropriate values of the spring constants for the upper and lower springs, as well as the number of stabilizer assemblies required. It was determined that four stabilizer assemblies would be acceptable. Each assembly has an upper spring with a spring rate constant of 20,000 pounds per inch, and a lower spring with a spring rate constant of 150,000 pounds per inch. The midspan tie rod support increases the natural frequency of the rod to prevent unacceptable vibration.

## 1.2 Design

Significant cracking adjacent to the horizontal shroud welds has been observed at several BWRs. If significant cracking is discovered in the horizontal shroud welds at Peach Bottom Unit 2, or at Unit 3, a repair will be implemented. The repair will structurally replace all of the horizontal girth welds in the shroud with a set of shroud stabilizers.

The core shroud is a safety related component. It provides horizontal support for the fuel assemblies, control rods, and incore instrumentation. It provides vertical support for the peripheral fuel assemblies, top guide, and core support plate. It also provides a floodable volume inside the reactor pressure vessel (RPV), which is necessary in the event of a Loss of Coolant Accident (LOCA). Note, however, that welds H1 through H3 are above the floodable volume. In addition, the shroud supports the core spray spargers and the core spray lines.

The stabilizers were designed to the structural criteria specified in the original Peach Bottom 2, 3 UFSAR. The ASME Code, Section III, Subsection NG was used as an analysis guide. The

stabilizers were designed to the requirements of References 4.1 and 4.2. Reference 4.1 is the design specification for the stabilizers, exclusive of ASME Code aspects. Reference 4.2 contains the ASME Code requirements for the interfaces of the stabilizers with the RPV, since the installation of the stabilizers will result in new loads being applied to the RPV. All of the loads and load combinations specified in the UFSAR, that are relevant to the core shroud, are included in the design specifications. The increased operating pressures due to Power Rerate and increased core flow are also included in the design specifications.

The stabilizers are installed with a small vertical mechanical preload, which assures that all components are tight and which provides approximately 3300 pounds of axial load on the 3.5 inch diameter tie rods. The upper support, upper spring, lower spring, and lower anchor assembly are fabricated from alloy X-750, which has a smaller coefficient of thermal expansion than does the 304 stainless steel shroud. Additionally, the tie rods are fabricated from XM-19 stainless steel, which also has a smaller coefficient of thermal expansion than does the shroud. Thus the stabilizer assemblies are thermally preloaded when the reactor is at operating conditions. The spring constant of the stabilizers in the vertical direction was designed to yield a total vertical preload at operating conditions of greater than the net upward applied loads on the shroud. The vertical loads are largely a result of the differential pressures across the shroud head and across the core support plate. Thus, if any or all of the H1 through H7 welds were completely cracked, the stabilizers will vertically restrain the shroud such that no vertical displacement will occur during Normal operation, which minimizes potential leakage through the assumed cracks.

The upper and lower springs are installed with a small radial preload such that they provide radial support for the shroud. During Normal operation, the shroud and springs radially expand due to thermal growth slightly more than the RPV due to both thermal and pressure, which increases the radial preload and assures that the springs provide linear support for the shroud during normal operation.

The vertical location of the upper and lower springs were chosen to provide the maximum horizontal support for the fuel assemblies. The upper springs are at the top guide elevation and the lower springs are at the core support plate elevation. All of the horizontal support for the fuel assemblies is provided by the top guide and the core support plate.

The stabilizer assemblies are designed and fabricated as safety related components, as is the requirement for the shroud. The installation of the stabilizer assemblies will replace the functions of welds H1 through H7.

At the top, each stabilizer assembly fits through two slots, which are machined through the non-safety related shroud head and steam separator assembly. The stabilizer upper bracket contacts the top surface and the inside surface of the shroud flange. It then extends downward to below weld H3. It supports the upper spring, and has a hole through which the tie rod passes. The tie rod is held against the upper bracket with a nut. The tie rod extends downward approximately 165 inches to the lower spring. At the middle of the tie rod there is a support between the tie rod and the RPV. The support is installed such that there is a horizontal preload between the tie rod and the RPV. The midspan support functions to minimize the potential for vibration of the stabilizer assembly. At the bottom, the tie rod threads into the lower spring. The lower spring has a clevis at the bottom, which is attached to the pin in the lower support. The lower support is bolted to the shroud support plate with two toggle bolts.

All pieces of the stabilizer assemblies are locked in place with mechanical devices. Loose pieces can not occur without the failure of a locking device. The stresses in the stabilizer components during Normal plant operation are less than the Normal event allowable stresses. The stabilizers are fabricated from stress corrosion resistant material. Therefore, it is very unlikely that a stabilizer component will fail.

The fast flux levels at the stabilizers are low compared with the values which could result in the degradation of material properties. After 20 years of operation, the maximum fast fluence at the stabilizers will be approximately  $3.0 \times 10^{19}$  n/cm<sup>2</sup>, which is well below the value to cause damage to stainless steel.

### 1.3 Materials

The stabilizers are fabricated entirely from the type 316 stainless steel, XM-19 stainless steel, and alloy X-750. There is no welding required.

The upper and lower springs, upper nut, upper bracket, and lower support are fabricated from Alloy X-750 (Ni-Cr-Fe) material that has been heat treated at  $1975 \pm 25^\circ\text{F}$  followed by an air cool and then age hardened to increase its strength. The annealing and age hardening processes used are essentially the same as those used on the improved jet pump beams for maximum resistance to IGSCC initiation. As a control for intergranular attack (IGA), a minimum of 0.030 inches of material is removed after the last high temperature annealing operation. This material is certified to ASTM B637, Grade UNS N07750. Alloy X-750 was chosen because high strength was required, and it has a coefficient of thermal expansion that is less than that of the shroud.

Alloy X-750 is resistant to IGSCC at the stress levels the components will experience during operation, which is less sustained tensile stress than the jet pump beams experience. Some smaller components are also fabricated from alloy X-750. The cobalt content of all X-750 material was limited to a maximum of 0.09 %.

The tie rods are fabricated from XM-19 stainless steel with a maximum carbon content of 0.04%. The XM-19 rods were solution annealed at  $2000 \pm 50^{\circ}\text{F}$ , and tested for evidence of sensitization and IGA. XM-19 stainless steel was chosen for the fabrication of the tie rods because of its higher strength over that of 300 series stainless steel.

Other components are fabricated from type 316 stainless steel material with a maximum carbon content of 0.02%. The material was annealed at 1900 to 2100 degrees F followed by quenching in circulating water to a temperature below 400 degrees F. All material was tested for evidence of sensitization and IGA.

#### 1.4 System Performance Evaluation

The installation of the four shroud stabilizer assemblies at Peach Bottom Unit 2 or 3 requires the machining of four pairs of holes through the shroud head flange. Each of these holes will have some clearance after the installation of the upper support, which will allow a small amount of leakage flow to bypass the steam separation system. In addition, four pairs of holes will be machined in the shroud support plate, which will also allow a small amount of core flow leakage through the clearance between the holes and the mating bolts. There are seven horizontal welds in the shroud, with two welds below the core plate, and five welds above the core plate. These welds may develop cracks, which will present additional small leakage flow paths for the core flow. In addition, potential leakage through cracks in the H8 weld has been considered. Finally, leakage past the replacement access hole covers in the shroud support shelf has been predicted to be 0.07% of core flow. This section summarizes the performance impact of the total leakage flow for up to 110% of rated power, and 87% to 110% of rated core flow (i.e., potential future power rerate conditions).

Leakage flow past the replacement access hole covers is 0.07% of core flow. Leakage from the machined holes in the shroud head flange is assumed to be two-phase fluid at the core exit quality. The maximum leakage through these eight holes is predicted to be equal to 0.10% of core flow. The steam portion of this leakage will contribute to increasing the total carryunder from the steam separators. The cumulative leakage flow from the shroud support plate holes and

from the assumed weld cracks is conservatively estimated to be 0.21% of core flow. The impact of the total leakage on the performance of the steam separation system, the performance of the jet pumps, the fuel thermal margin, emergency core cooling system (ECCS) performance, and the length of the fuel cycle have been evaluated as summarized in the following subsections.

#### **1.4.1 Steam Separation System**

The shroud leakage flow includes steam flow, which effectively increases the total carryunder in the downcomer by a maximum of about 0.02% at 110% rated power, and 87% to 110% rated core flow. The total leakage flow also has the effect of slightly decreasing the flow per separator, and slightly increasing the separator inlet quality. The carryunder from the separators is based on the applicable separator test data at the lower limit of the operating water level range. The combined effective carryunder from the separators and from the shroud leakage at 87% and 110% rated core flow is about 0.28% and 0.25% respectively. The specified design value corresponding to 0.25% is slightly exceeded, but is acceptable. The impact of the increased carryunder is evaluated in the following subsections. The carryover from the separators remains within the design limits, so that moisture from the steam dryer meets the plant performance requirement of less than 0.1%.

#### **1.4.2 Jet Pumps**

The increased total carryunder will decrease the subcooling of the flow in the downcomer. This in turn reduces the operating margin to jet pump cavitation. Any increase in flow resistance in the annulus due to the installation of the shroud stabilizer assemblies will be insignificant. The results show that, although that the jet pump cavitation operating margin decreases slightly, it will remain adequate. The change in cavitation operating margin is not significant enough to require a change to a cavitation set point, or to the power flow map.

#### **1.4.3 Anticipated Operational Transients**

The computer code used to evaluate performance under plant transients and to calculate fuel thermal margin includes carryunder as one of the inputs. There will be a slight increase in carryunder due to shroud head installation hole leakage. The increase in carryunder results in an insignificant decrease in subcooling in the downcomer region, with a corresponding decrease in core inlet subcooling. The leakage flow rate via the shroud support plate holes and the shroud weld cracks tends to (insignificantly) reduce the coolant flow rate into the core region. This core flow reduction will slightly decrease the core inlet subcooling. However, the total core flow reduction, and the core inlet subcooling changes are both within the sensitivity range of the

critical power ratio (CPR) calculations. Also, the increased carryunder fraction will tend to reduce (make milder) the response from pressurization transients. Therefore, the fuel thermal limits will not be affected.

#### **1.4.4 Emergency Core Cooling System**

The effect of the shroud and access hole cover leakage flows is to decrease the time to core uncover slightly, and also to increase the time that the core is uncovered. An evaluation of the ECCS performance, conservatively based on the cumulative effect of leakage at the shroud head, at the shroud support plate holes, for five full (360°) shroud weld cracks, and at the access hole covers, was performed. The combined effects have been determined to increase the peak cladding temperature (PCT) for the limiting LOCA event by less than 20°F. This increase is sufficiently small to be judged insignificant, and thus, the licensing basis PCT for the Normal operation condition with no shroud leakage is applicable. In addition, the licensing basis PCT was calculated assuming a 20% reduction in the ECCS flow rates. The effect of the ECCS flow rate reduction bounds the effects of the assumed shroud leakage. The sequence of events remains essentially unchanged for the LOCA events with the shroud leakage.

The conservative ECCS flow rates in the current LOCA analysis significantly bound all potential flow losses resulting from the installation of the shroud stabilizers, and thus the current ECCS-LOCA analysis remains valid. However, even if the current ECCS-LOCA analysis did not use reduced ECCS flow rates, the calculated PCT (1690°F + 20°F) would remain well below the regulatory PCT limit (2200°F), the change in PCT would be less than the 50°F requirement for NRC notification, and a floodable volume to 2/3 core height will be maintained.

#### **1.4.5 Fuel Cycle Length**

The cumulative leakage flow results in an increase in the core inlet enthalpy by about 0.1 Btu/lb, compared with the no leakage condition. The combined impact of the reduced core inlet subcooling and the reduced core flow due to the leakage results in a minor effect (approximately 0.8 days) on fuel cycle length, and is considered negligible.

#### **1.4.6 Leakage through Shroud Cracks and Shroud Support Plate Holes**

The amount of leakage that would pass through an assumed 360° through wall crack at operating conditions is limited by the tie rods, which hold the crack surfaces in contact. If it is conservatively estimated that the crack can be modeled as a 0.001 inch wide smooth slit through the shroud, then the leakage is approximately 145 GPM for all seven welds combined. If the H8

weld is assumed to be cracked, the combined leakage for all eight welds is approximately 170 GPM. All of the leakage below the core plate would be water of the same temperature as the water in the downcomer. All of the leakage between the top guide and the core plate would be water. Only the leakage from H1 and H2 would include any steam. The leakage through the eight machined mounting holes in the shroud support plate will not be more than 525 GPM, calculated at rated power and Increased Core Flow.

#### Summary of Leakage Flows at Uprated Power and ICF

Pressure difference (psi)	
Shroud Head	9.41
Upper Shroud	9.35
Lower Shroud	33.0

Leakage Flow (gpm)	
Repair Holes in Shroud Head	1105
Weld Cracks	170
Repair Holes in Support Plate	525
Access Hole Covers	215

Leakage to Core Mass Flow (%)	
Repair Holes in Shroud Head	0.10
Weld Cracks	0.04
Repair Holes in Support Plate	0.17
Access Hole Covers	0.07

#### **1.4.7 Conclusions**

The stabilizer assemblies will not significantly affect the flow within the downcomer and will not adversely affect the performance of any reactor internal. The water inventory in the downcomer with the stabilizers installed exceeds the volume used in the existing analyses.

The cumulative effects of leakage at the shroud head flange, shroud support plate holes, assumed shroud weld cracks, and access hole covers have been evaluated for degradation in steam separation system performance, jet pump performance, fuel thermal margin, ECCS system performance, and for changes in fuel cycle length. The leakage flows are sufficiently small so that steam separation system performance, jet pump performance, fuel thermal margin, and fuel

cycle length are not significantly affected. Also, the effect on ECCS performance is sufficiently small to be judged insignificant, and thus, the licensing basis PCT for Normal operation with no shroud leakage is applicable.

### 1.5 Seismic Analysis

A seismic analysis of Peach Bottom Unit 2, and 3 has been performed (Reference 4.8). The new seismic model incorporated the installation of the shroud stabilizers. Included in the analysis were the determination of the natural frequencies and mode shapes of the RPV building system for the E-W and N-S direction, computation of the dynamic response to the DBE and MCE time histories, and the calculation of the shears, moments, and displacements. The building model was the 1970 model specified by the architect engineers (Bechtel). The Design Earthquake (DBE) and Maximum Credible Earthquake (MCE) time histories used are based on response spectra in Figures C.3.1 and C.3.2 of the Peach Bottom 2, 3 Updated Final Safety Analysis Report (Reference 4.3). Peak ground accelerations for the DBE and MCE are 0.05g and 0.12g respectively (Reference 4.3).

The model was qualified by achieving excellent agreement with frequencies and mode shapes predicted by the previous GE model of Reference 4.5. The synthetic time history was generated from the design response spectra.

The computer program SAP4G07 (Reference 4.4) was used in this study. Transient response analysis with modal superposition method (NDYN=12) was adapted. A solution time step of 0.002 second was chosen, according to the user's manual for this linear analysis.

The vertical seismic effect was combined directly with the horizontal seismic load (either North-South or East-West). Forces and moments due to vertical loading were calculated as a multiplier of the dead weight. This is based on the approach discussed in the UFSAR (Reference 4.3).

The springs for the stabilizer supports and tie-rods are included in the model. Each stabilizer assembly has a radial spring at both the top guide and at the core support plate elevation. Each radial spring can take only compressive loads. The axial spring constant for the tie-rods was calculated based on the four tie-rods rotating about the shroud neutral axis

In order to determine that the installation of shroud stabilizers does not adversely affect the existing structural integrity with the assumption that no defective welds are present in the shroud, analyses for the uncracked case were performed with the shroud stabilizers in place. The results in this study were compared with those given in Reference 4.5 to insure that all the RPV and internals loads and displacements are within the allowable limits.

An enveloping combination of cracked/uncracked welds has been determined to define the worst situation for the core plate and top guide displacements, in order to insure control rod insertion and plant shut-down. Each cracked weld was postulated to have a 360 degree through wall crack. Seven individual cracked welds as well as several combinations of two cracked welds have been evaluated. Also, an all cracked combination has been evaluated. Each 360 degree through wall crack has been modeled as a hinge or a roller to determine the limiting boundary conditions. The specific load combination that is being analyzed also influences the choice of the boundary condition of hinge or roller. For example, during Normal operation differential thermal tightening of the tie rods prevents upward motion of the shroud. Thus, the tie rods hold the crack surfaces in contact, which assures that a hinge boundary condition is conservative. During a main steam line LOCA, the tie rods will momentarily stretch such that the crack surfaces in the shroud may part. This condition can only exist for a few seconds while the shroud head pressure drop is sufficient to stretch the tie rods. During this short period of time, the assumption of a roller is appropriate. The seismic analysis conservatively assumes that the roller assumption applies during the entire seismic time history.

For the LOCA case with all welds cracked, the uppermost weld (H1) is postulated to be a roller and all the other cracks are postulated as hinges. In this case, to prevent modeling instability, additional torsional and translational springs with small spring rates were inserted at the cracks to stabilize the mathematical model for the all cracked case. In reality, these small torsional springs represent certain degree of resistance from the structure. It was found, through a sensitivity study, that the analysis results were not affected by the small spring rates that were chosen.

The seismic time history analysis considered a total of 21 load cases. They represent combinations of two earthquake events (DBE and MCE), two horizontal directions (North-South and East-West), several cracked weld assumptions, and the two Peach Bottom units.

The maximum deflection of any part of the shroud that is not directly supported by either the upper or lower radial springs is limited to approximately 1.0 inch by mechanical limit stops. These stops do not perform any function unless a section of the shroud, for example the section between the H4 and H5 welds, becomes loose and a combined LOCA plus seismic event occurs.

If this unlikely scenario were to occur, the stops will limit the horizontal displacement of the shroud section to approximately 1.0 inch, which is equal to one half of the shroud wall thickness. These stops do not invalidate the linear seismic analysis. A displacement equal to one half of the shroud wall thickness will not result in post event leakages that prevent core cooling, because the shroud sections still overlap each other by one half (1.0 inch) of the shroud wall thickness.

The original seismic model of the NSSS was revised to incorporate the current core reload and the installation of the shroud stabilizers. This case models the current configuration with an uncracked shroud. The seismic response of this model was then determined using a ground motion input time history equivalent to the Design Response Spectra. A comparison of the results with those from the original seismic analysis showed a close comparison with all resulting loads in NSSS components, which were well below the allowable values. The updated model was then modified to reflect postulated 360 degree through wall cracking at the H1 through H7 shroud welds. Various combinations of postulated cracking locations were investigated in order to identify the bounding combinations and locations. The shroud stabilizers are intended to relieve the shroud seismic overturning moment, and transfer it to the stabilizers and to the RPV. The modeling and the resulting seismic loads in the shroud reflect this design concept, the bending moments in the cracked and stabilized shroud being only 2% of those from the original seismic analysis reported in the UFSAR.

Potential cracking in the H8 weld between the shroud support plate and the shroud support cylinder was also evaluated. Assumed cracking at the H8 weld was determined to have no significant effect on the properties of the seismic model, and thus had no significant effect on the results of the seismic analysis.

## 1.6 Design Evaluation

The results of the structural evaluations per References 4.1 and 4.2 are documented in References 4.6 and 4.7. Reference 4.6 addresses the ASME Code, Section III, RPV and Reference 4.7 addresses the non-code shroud stabilizers, shroud, and shroud support shelf. The stabilizers and affected shroud and RPV components are shown to satisfy the UFSAR structural requirements using the UFSAR load combinations.

The displacements of the core support plate and the top guide are limited to the allowable displacements given in Reference, 4.1 for all load combinations.

### 1.6.1 Load Combinations

The UFSAR requires evaluation of Normal operating loads as well as DBE, MCE, main steam line LOCA, and recirculation line LOCA. The following load combination and their classification were considered:

Normal:	Normal operating pressure differences, temperatures, and weight
Upset 1:	Normal operating weight, temperature and pressures, plus DBE
Upset 2:	Limiting thermal condition, plus Normal pressure differences and weight
Emergency 1:	Normal operating weight, temperature and pressures plus MCE
Emergency 2:	Weight plus main steam line LOCA pressure differences
Faulted 1:	Weight, plus MCE, plus main steam line LOCA pressure differences
Faulted 2:	Weight, plus MCE, plus recirculation line LOCA pressure differences

The values of the individual loads on the shroud stabilizer springs and tie-rod were obtained from the design specifications (References 4.1 and 4.2), which included the seismic analysis of the degraded shroud with stabilizers. The seismic loads in the design specifications are the limiting values of the various assumed cracking conditions.

In general, the limiting loads in the tie rods occur with different assumed shroud cracks than for the limiting radial loads in the upper and lower springs. It was conservatively assumed that the worst loads on each component in each direction would be combined. The limiting loads in the tie rods occur when it is assumed that there is a 360 degree through wall crack in weld H7 and that crack behaves as a hinge (shear transfer but no moment transfer). If the H7 is assumed to behave as a roller (no shear and no moment transfer), then the loads are reduced in the tie rods. The limiting loads in the radial direction on the upper springs occur when it is assumed that all of the horizontal girth welds in the shroud have 360 degree through wall cracks, with each of these joints modeled as hinges. The limiting radial loads on the lower spring occur with only the H7 cracked, and the joint modeled as a roller. Since the crack surfaces are held in intimate contact, the jagged IGSCC cracks can transmit shear, which is the hinge condition. During a main steam

line break the upward pressure forces are sufficient, for a short period of time, to stretch the tie rods and allow the crack surfaces to separate. For this situation, the roller case was assumed at the joints.

### 1.6.2 Results

The potential for flow induced vibration has been evaluated by calculating the lowest natural frequency of the shroud stabilizer assemblies, and conservatively calculating the highest vortex shedding frequency due to the water flow across the stabilizer tie rods, in the downcomer (RPV-shroud annulus). The lowest natural frequency of the assembly is 45.5 Hertz and the maximum vortex shedding frequency is 5.2 Hertz.

There will be essentially no fatigue usage for any of the stabilizer components.

References 4.6 and 4.7 document that all structural limits have been satisfied for the shroud, shroud support plate, shroud stabilizers, and the reactor pressure vessel. The analysis of the shroud support plate considered cracking at the H8 weld. The predicted worst case transient deflections of the core plate is 0.87 inch for a load combination of a MCE with the H7 weld cracked plus a main steam pipe LOCA. The allowable transient displacement for this Faulted event is 1.49 inch. All calculated stress intensities in the lower radial spring meet the UFSAR allowables. The predicted worst case transient displacement of the top guide is 2.20 inches for a MCE with an all cracked shroud. The allowable permanent deflection of the top guide for this Emergency event is 1.40 inch. The 2.20 inch displacement is a momentary value which occurs during the MCE, and is not permanent. The stresses in the lower radial spring meet the UFSAR allowables for an Emergency event with sufficient margin such that the spring remains elastic, and the permanent displacement is zero. The predicted deflections of both the top guide and the core plate for all load combinations are within the allowables defined in the design specification, which are based on test results and the criteria of the UFSAR.

The Peach Bottom 2, 3 core spray lines were analyzed for the increase in seismic loads and anchor movements which may result from the assumption of a worst case cracked shroud, with the installation of the shroud stabilizers. The non-ASME Code, Safety Related, core spray lines were conservatively analyzed using the rules for Class I piping in the ASME Code Section III, NB-3600, as an analysis guide. It was determined that the Peach Bottom core spray lines as originally designed meet the ASME Code allowables for stress and fatigue usage for Normal / Upset, Emergency, and Faulted conditions, and thus remain functional with the assumption of a

cracked shroud, and the installation of the shroud stabilizers. The allowable stress limits are in accordance with Tables C.5.2 and C.5.5 of the Peach Bottom UFSAR.

Each core spray line attaches to the reactor pressure vessel at the  $120^{\circ}$  or the  $240^{\circ}$  core spray nozzle. Each line branches into a 6.0" schd. 40 horizontal header, with two vertical downcomers that are welded to elbows in the upper shroud. The increase in loads on the core spray lines are largely a result of the increase in movement of the assumed worst case cracked shroud during a seismic event, or loss of cooling accident (LOCA). The shroud displacements are documented in Reference 4.8. The core spray lines with the mounting brackets, and appropriate boundary conditions were modeled with the ANSYS Revision 4 finite element computer program.

The load combinations addressed were as follows:

<u>Service Level</u>	<u>Load Combination</u>	<u>Stress Type</u>
N / U	Weight + $DE_{Inertia}$	Primary
N/U	Thermal + $DE_{Inertia}$ + $DE_{Anchor Movement}$	Primary + Secondary
E	Weight + $MCE_{Inertia}$	Primary
F	Weight + $MCE_{Inertia}$	Primary

All calculated stresses in the core spray piping met the ASME Code stress allowables. The maximum 40 year fatigue usage was calculated to be less than the Code allowable of 1.0. The Normal / Upset condition for primary plus secondary stress included the existing thermal stresses due to thermal expansion and thermal anchor movements, as well as seismic inertia and seismic anchor movements.

It should be noted that, per NB-3217-2, the stresses resulting from piping anchor point motions are considered to be secondary, and are not required to be evaluated for Emergency and Faulted conditions (one time load application), in accordance with the requirements of NB-3600. However, as a functional check on the core spray lines during the anchor movement resulting from a Faulted Condition main steam line LOCA combined with a maximum credible earthquake (MCE) event, the maximum strain in the piping was calculated. This was found to be less than 1.0%, which is well below the minimum allowable strain at failure of 25% for ASTM A-312

conditions (one time load application), in accordance with the requirements of NB-3600. However, as a functional check on the core spray lines during the anchor movement resulting from a Faulted Condition main steam line LOCA combined with a maximum credible earthquake (MCE) event, the maximum strain in the piping was calculated. This was found to be less than 1.0%, which is well below the minimum allowable strain at failure of 25% for ASTM A-312 TP304 stainless steel piping, thus demonstrating the functionality of the core spray line after a Faulted event. The displacement of the shroud during a recirculation line LOCA was not found to be significant.

Repair brackets were installed on the core spray lines at Peach Bottom Unit 3 in 1985 (Reference 4.12) after the discovery of cracking in the 240° core spray line header near the connection of the pipe with the tee-box. The brackets are welded to the tee-box and to each header pipe, with one bracket mounted above the tee-box, and one mounted below. The core spray lines and repair brackets were also modeled and analyzed with the assumption of a 360 degree crack in each header pipe. The core spray piping was determined to meet the allowables for stress and fatigue usage in accordance with the requirements of NB-3600. The repair brackets and attachment welds to the piping were analyzed in accordance with the requirements of NB-3200. The stresses in the repair brackets and attachment welds were determined to meet ASME Code primary stress allowables for all load cases.

Although the ASME Code Primary and Primary plus Secondary stress criteria is satisfied, the fatigue usage in a local area of the bracket to pipe weld for one of the two repair brackets was calculated to be 2.0, which is in excess of the Code allowable of 1.0. The fatigue usage for the second repair bracket was found to be acceptable. The main contribution to the calculated fatigue usage was due to the relative displacement of the shroud during 10 full amplitude cycles of a design earthquake (DE) event. A stress concentration factor of 4.0 was assumed for the fillet welds between the repair brackets and the core spray piping.

The analysis of the core spray line header tee-box repair brackets described above does not support the plant design basis of 50 DE earthquake cycles, as indicated in Section C.5.3.6 of the Peach Bottom UFSAR, with the core shroud horizontal welds postulated to be fully cracked and the core shroud stabilizers installed (Modification P00435). Therefore, PECO Modification P00541 has been initiated to provide a revised analysis which demonstrates that the repair brackets are acceptable with Modification P00435 installed, or to provide replacement brackets that meet the design requirements. Modification P00541 will be installed prior to, or during the implementation of the core shroud stabilizer modification.

## 2.0 REASON FOR CHANGE

Cracks have been observed in the core shrouds of several BWRs. The NRC has issued a generic letter, Reference 4.9, which required inspection or repair. This report discusses the installation of shroud stabilizers that will functionally replace horizontal welds H1 through H7 in the Peach Bottom 2 and 3 shroud. At this time it is not known if there are any actual cracks in the shroud. This report is based on the assumption that all of the horizontal girth welds (H1-H7) have significant cracking. However, there is no degradation of function if the stabilizers are installed in the absence of cracks in the shroud welds.

## 3.0 DESIGN AND LICENSING DOCUMENTATION REVIEW

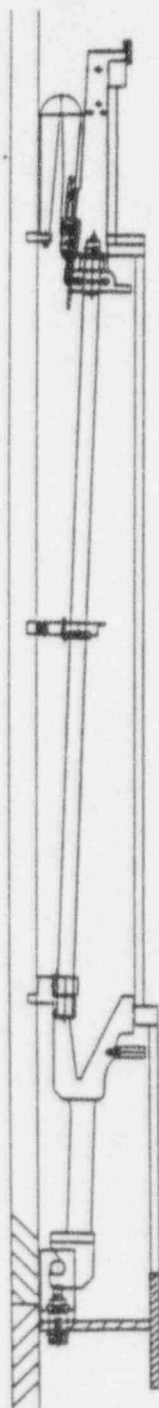
The Peach Bottom 2, and 3 UFSAR (Reference 4.3) was reviewed. The results of that review are as follows. The numbers in ( ) are the paragraph numbers from which the information was extracted.

(3.3.4.1.1)	Gives a brief description of the shroud
(3.3.5.1.2)	Defines the pressure differences for Normal operation
(3.3.5.2)	Defines recirculation line LOCA pressure differences
(3.3.5.3)	Defines main steam line LOCA pressure differences
(Table 4.2.1)	Defines RPV material
(Table C.5.9)	Defines the damping values to be used in seismic analysis
(Figures C.3.1, C.3.2)	Seismic response spectra
(C.5.3.2.3)	Internal seismic analysis methodology
(Table C.5.5)	Defines the required load combinations and required safety factors
(Table C.5.1)	Defines the allowable deflections
(Table C.5.2)	Defines stress limits

(Table C.5.6)	Defines load combinations and stress limits
(C.5.3.2)	States that ASME Section III was used as a guide in the design of the reactor internals.
(Appendix K)	RPV summary stress report

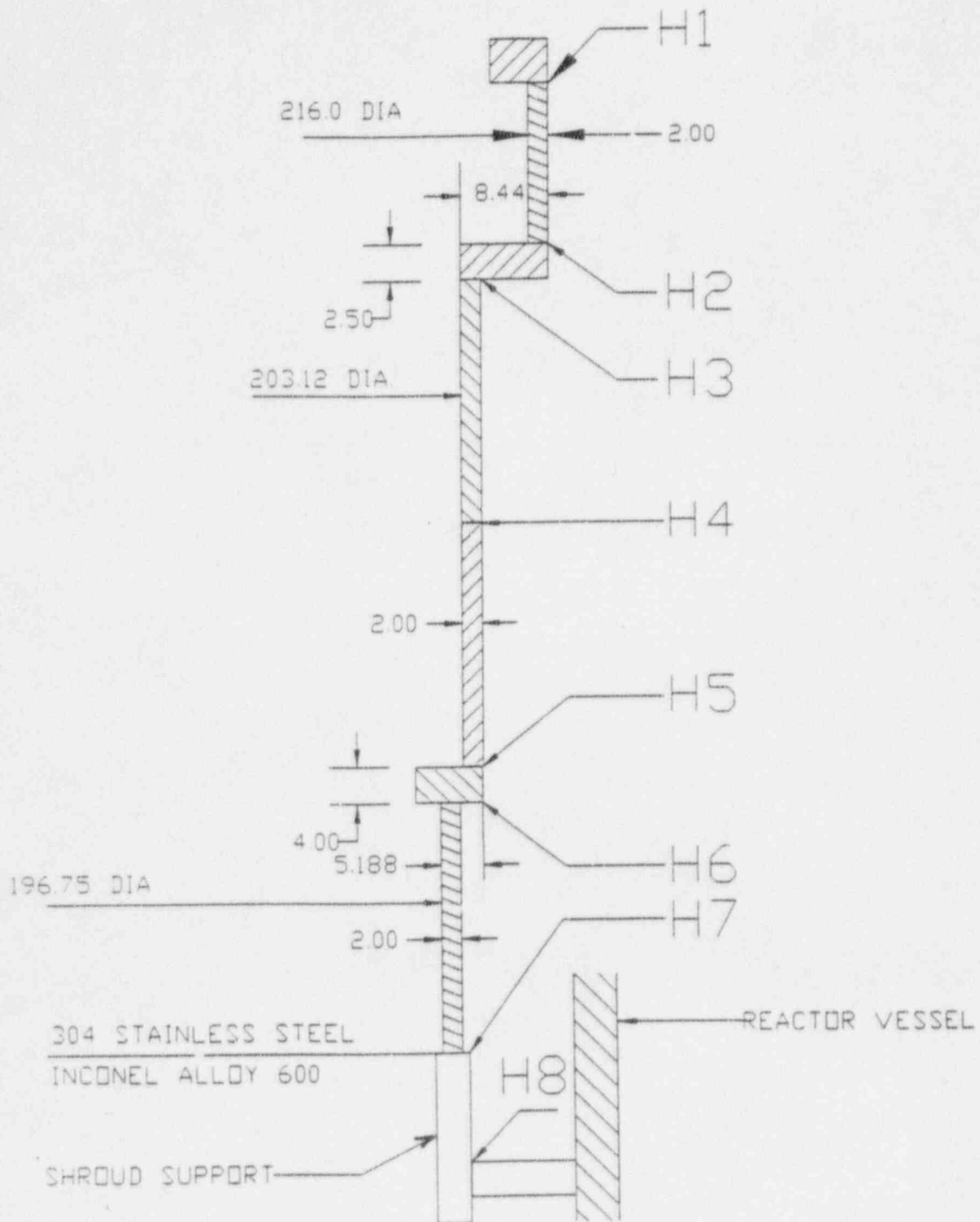
#### 4.0 REFERENCES

- 4.1 25A5579 Rev. 3 "Shroud Stabilizer Hardware; Design Specification".
- 4.2 25A5580 Rev. 4 "Shroud Stabilizer; Code Design Specification".
- 4.3 Peach Bottom Units 2 and 3 UFSAR, Rev. 12.
- 4.4 SAP4G07 Computer Program.
- 4.5 383HA691 Rev. 0; "Seismic Analysis of Peach Bottom 2 Reactor Vessel and Internals".
- 4.6 25A5607 Rev. 4; "Reactor Pressure Vessel; Code Stress Report".
- 4.7 GENE-771-58-0994 Rev. 4; "Shroud and Shroud Stabilizer Hardware Stress Analysis".
- 4.8 GENE-771-60-0994 Rev 2; "Peach Bottom Seismic Analysis, Shroud Mechanical Repair Program".
- 4.9 NRC Generic Letter 94-03, July 25, 1994, "Intergranular Stress Corrosion Cracking of Core Shrouds in Boiling Water Reactors".
- 4.10 10CFR50.59 Review, Rev.0, for Mod P00435; "Installation of Stabilizers on Core Shroud In Peach Bottom Atomic Power Station Units 2 & 3".
- 4.11 105E1455 G001; Reactor Modification Drawing
- 4.12 797E551 G001; Core Spray Line Repair (Unit 3)



STABILIZER ASSEMBLY

FIGURE 1



# WELD NOMENCLATURE

FIGURE 2

**GE RESPONSES  
TO NRC QUESTIONS  
FOR  
PEACH BOTTOM SHROUD REPAIR**

June 1995

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## SHROUD SEPARATION AND THERMAL UPSET CONDITIONS

### 1. Introduction

The purpose of this document is to describe the analyses performed which evaluate the axial loading between the Peach Bottom shroud and the shroud repair stabilizers. The specific concerns to be addressed here are that of the potential of shroud separation during normal operating conditions with a shroud having all of the horizontal welds completely cracked and that of the potential for loss of preload due to plastic deformation of the stabilizers during a thermal transient event.

The method used to evaluate the axial loads in the stabilizer system was to determine the axial stiffness of the various components of the stabilizers and the axial stiffness of the various shells and rings of the shroud and to combine these using a finite element model with the effects of the appropriate temperatures, pressure differences and component weights. The resulting load balance of stabilizer tension and shroud compression demonstrates that the stabilizer tie rods maintain compressive loads at all of the shroud horizontal welds for the cracked shroud condition thereby assuring that the shroud rings and shells are held together and no separation occurs at the cracked horizontal welds. Additionally, the stabilizer components are shown to remain elastic and thus no loss of preload will occur for the axial loads in the stabilizer components which result from the uncracked shroud during a thermal transient event.

### 2. Description of the Analytical Model

This section presents a description of the analytical model and the inputs to the model which produce the axial load distributions in the stabilizer assemblies and shroud for the cases of normal operation with normal temperature and pressures and the case of a thermal transient with the corresponding temperature and pressures. The model is schematically shown in Figure 1. The model consists of a system of collinear two-dimensional beams, each beam representing the length and stiffness of a major component of the stabilizer assembly and shroud. Direct inputs to the beam elements of Modulus of Elasticity, coefficient of thermal expansion, temperature, distributed axial loading and point loads appropriately addressed the effects of component stiffness, temperature differences, pressure differences, component weights and mechanical preload of the tie rods. The ASIST computer program was used to solve the system of beam elements and produce the resulting load distributions.

## 2.1 Component Stiffness

The axial stiffness of each of the major components of the stabilizer and shroud system was determined by various methods depending upon the complexity of the individual structure. The stiffness was input to the beam elements of the ASIST model by means of an effective area that combined with the component's actual Modulus of Elasticity and length would produce the correct stiffness.

### 2.1.1 Stabilizer Axial Stiffness:

The axial stiffness of the lower stabilizer spring assembly and the upper support assembly were determined by finite element analysis. The tie rod axial stiffness was determined by a simple hand calculation of a beam in tension. The values used are shown in Figure 2.

### 2.1.2 Shroud Axial Stiffness:

The axial stiffness of the shroud was determined by a combination of finite element analysis and theoretical ring stiffness calculations. The axial stiffness of the shroud shell members, shroud support ring and struts were determined by finite element analysis. The resulting axial stiffnesses are shown in Figure 2.

The axial stiffness of the shroud shell to ring welded connection was determined using the method of analysis and equations from Section III, ASME B&PV Code, 1965 Edition, Appendix I, Article 1-2. This method was used for the ring axial stiffness between welds H2-H3 and H5-H6. The stiffness was determined for both the case of intact welds and fully cracked welds. The fully cracked welds were assumed to be through wall at the top of the weld fillet as schematically shown in Figure 3. Values of the axial stiffnesses used for the cracked and uncracked condition are shown in Figure 2.

## 2.2 Pressure Loads

The axial forces acting on the shroud due to reactor internal pressure differences were input to the ASIST model as point loads at the appropriate node location. Figure 4 shows the various pressure induced forces that were calculated. The force values are tabulated for both the normal operation and upset event pressure differences in Table 1.

## 2.3 Component Weights

The weights of the various components that provide axial loads on the shroud including the shroud weight itself were corrected for the effects of buoyancy and input to the ASIST model as either point loads or distributed axial loads along the beam elements. The values of the weights of the various components is summarized in Table 2.

## **2.4 Mechanical Preload**

The mechanical preload that the tie rods exert on the shroud due to the initial installation torque of the tie rod nuts is directly accounted for in the ASIST model. The temperature value input to the tie rod beam member was adjusted to produce a length difference between the stabilizer assembly and the shroud at installation. The resulting length difference stretched the tie rod member the appropriate amount to produce the initial tie rod tension of 3346 Lb per tie rod.

## **3. Load Calculations**

A sequence of five load cases was made with the ASIST model to produce the loads of interest. The sequence begins with the initial installation of the stabilizer assemblies onto a shroud that has all welds intact. Using the larger shroud stiffness for uncracked shroud welds will produce the maximum tie rod loads and stresses for the thermal transient condition. The shroud welds are then assumed to be fully cracked which reduces the shroud stiffness which produces a reduction in mechanical preload due to the stiffness change and produces the condition most likely to have shroud separation. The load values presented for each load case are the tie rod tension and the compressive load at shroud weld H6.

### **3.1 Load Case 1 - Stabilizer Assembly**

The first load case is for the stabilizer assembled onto an uncracked shroud in the cold condition. Uncracked shroud stiffnesses are used, pressure forces are zero, all weights except the shroud head are applied and all temperatures are set to 70 °F. The tie rod temperature is then artificially reduced which creates tension in the tie rod system equivalent to the tension produced by the initial torque of the tie rod nut during assembly. The tie rod tension value is 3346 Lb and the compressive load at shroud weld H6 is 156,057 Lb.

### **3.2 Load Case 2 - Shroud Head Installation**

This load case is identical to Load Case 1 except the shroud head weight is included as downward force. The net effect is to increase the compressive load at H6 to 277,657 Lb and reduce the initial tension in the tie rod to 962 Lb.

### **3.3 Load Case 3 - Normal Operation with Uncracked Shroud**

This load case considers the uncracked shroud and stabilizer system in the hot operating condition with normal temperatures and pressures. Uncracked shroud stiffnesses are used, normal operation pressure forces from Table 1 and weights from Table 2 are input to the ASIST model. The temperature of the stabilizer components and shroud support members below H5 was set to 527 °F and the temperature of the shroud members above H5 was input as 539 °F. The resulting

tie rod load was 94,708 Lb and the compression load at shroud weld H6 was 65,564 Lb.

### **3.4 Load Case 4 - Thermal Transient Event with Uncracked Shroud**

This load case considers the uncracked shroud and stabilizer system in the operating condition with upset pressures and temperatures from a thermal transient event combined to produce large tie rod tension in the stabilizer system. Uncracked shroud stiffnesses, upset pressure forces from Table 1, and weights from Table 2 were input to the ASIST model. The temperature of the stabilizer components was set to 300 °F and all members of the shroud and shroud support were input as 433 °F. The resulting tie rod load was 249,985 Lb and the compression load at shroud weld H6 was 500,112 Lb.

Each component of the stabilizer / shroud system was evaluated for stresses resulting from the 249,985 Lb axial load. The stress in each of the components was shown to be less than the material yield strength at the appropriate temperature thus assuring an elastic system with no loss of preload resulting from the thermal transient event.

### **3.5 Load Case 5 - Normal Operation with Cracked Shroud**

This case is identical to Load Case 3 except the cracked shroud stiffnesses are used. The significant reduction in the stiffness of the system reduces the tie rod tension and compressive load at the shroud H6 weld, however, the shroud is maintained in compression by the tie rod stabilizers and no shroud separation occurs. The resulting tie rod tension was 79,343 Lb and the compressive load at shroud weld H6 was 4081 Lb.

**Table 1**  
**Pressure Forces Inputs to ASIST Model**

Location	Normal $\Delta P$ , Psi	Transient $\Delta P$ , Psi
Lower Shroud	33.03	35.68
Upper Shroud	9.35	14.03
Core Plate	23.68	26.32

Force Location (Figure 4)	Normal $\Delta P$ Force (Lb)	Transient $\Delta P$ Force (Lb)
F1	109,150	117,910
F2	96,430	104,160
F3	423,910	457,920
F4	12,180	12,190
F5	130,140	130,280
F6	39,630	59,460
F7	12,570	18,870
F8	6,260	9,390
Shroud Head	336,310	504,630

**Table 2**  
**Weight Inputs to ASIST Model**

Component	Weight in Cold Water (Lb)	Weight in Hot Water (Lb)
Shroud Head	131,136	136,042
Shroud	99,761	103,494
Core Spray	1,751	1,817
Top Guide	18,118	18,796
Core Plate	27,182	28,199
Peripheral Fuel Supports	231	240
Peripheral Fuel Bundles	13,272	13,728

ASIST Model  
Peach Bottom Shroud / Stabilizer

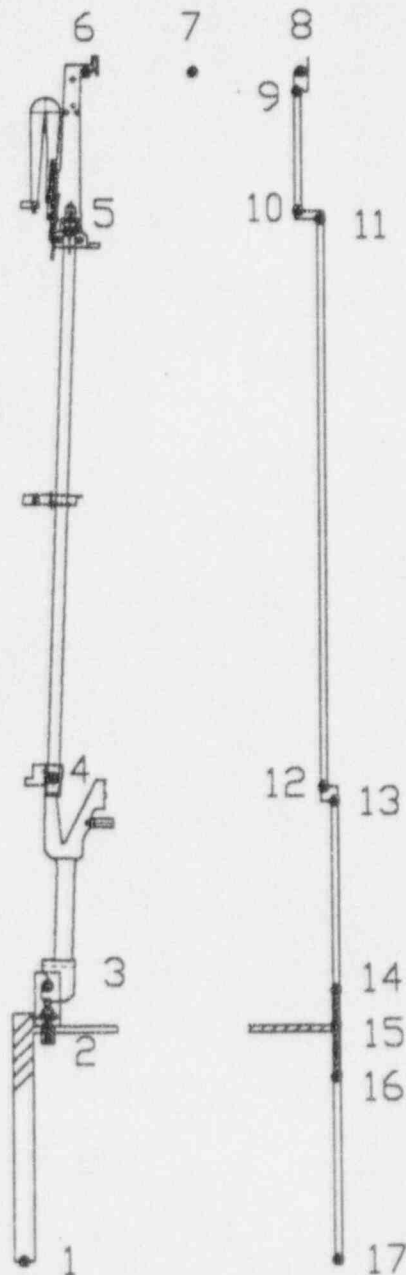


Figure 1. Peach Bottom Shroud / Stabilizer ASIST Model Definition

# ASIST Model

## Peach Bottom Shroud / Stabilizer

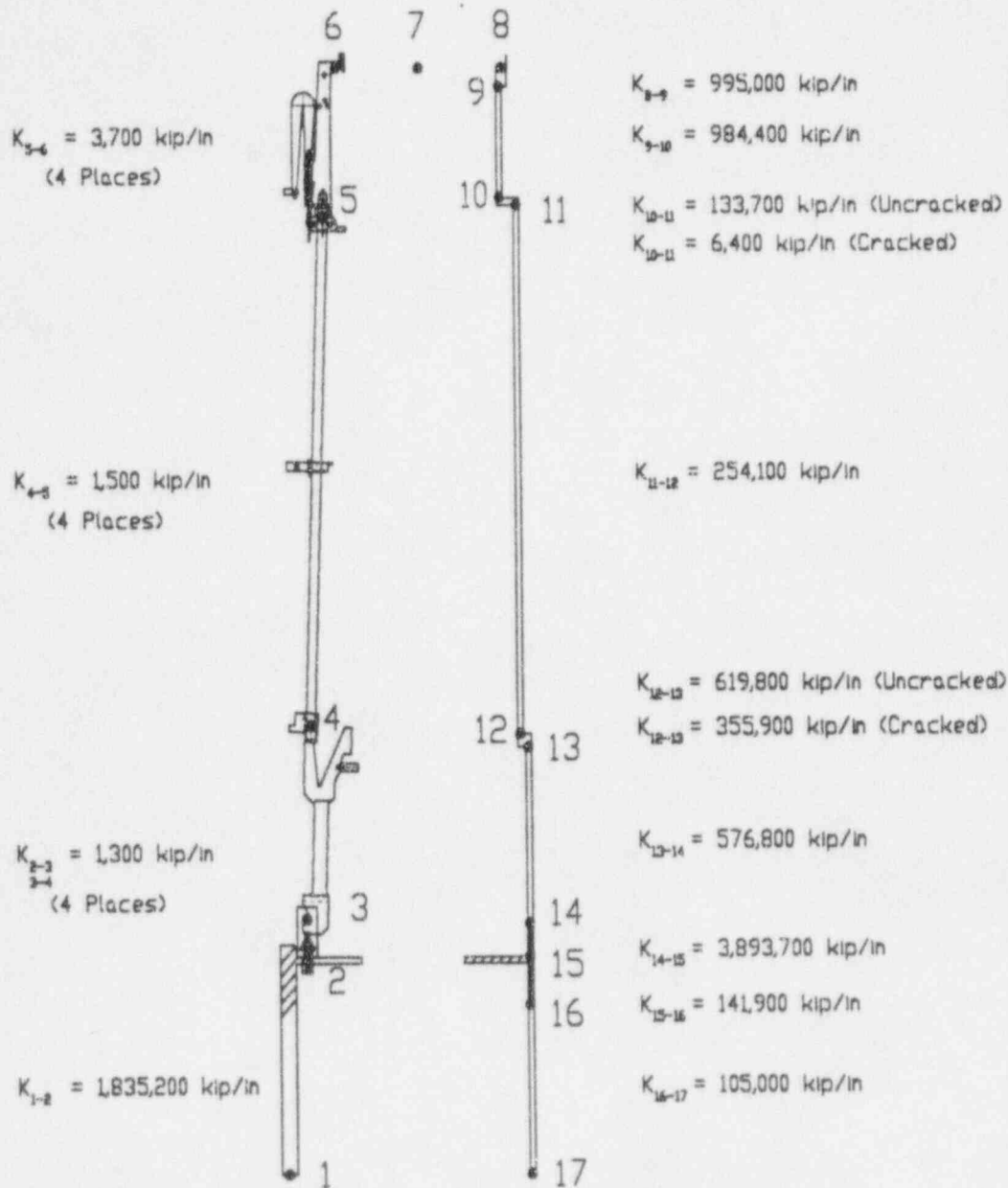


Figure 2. Peach Bottom Shroud / Stabilizer  
ASIST Model Axial Stiffness Values

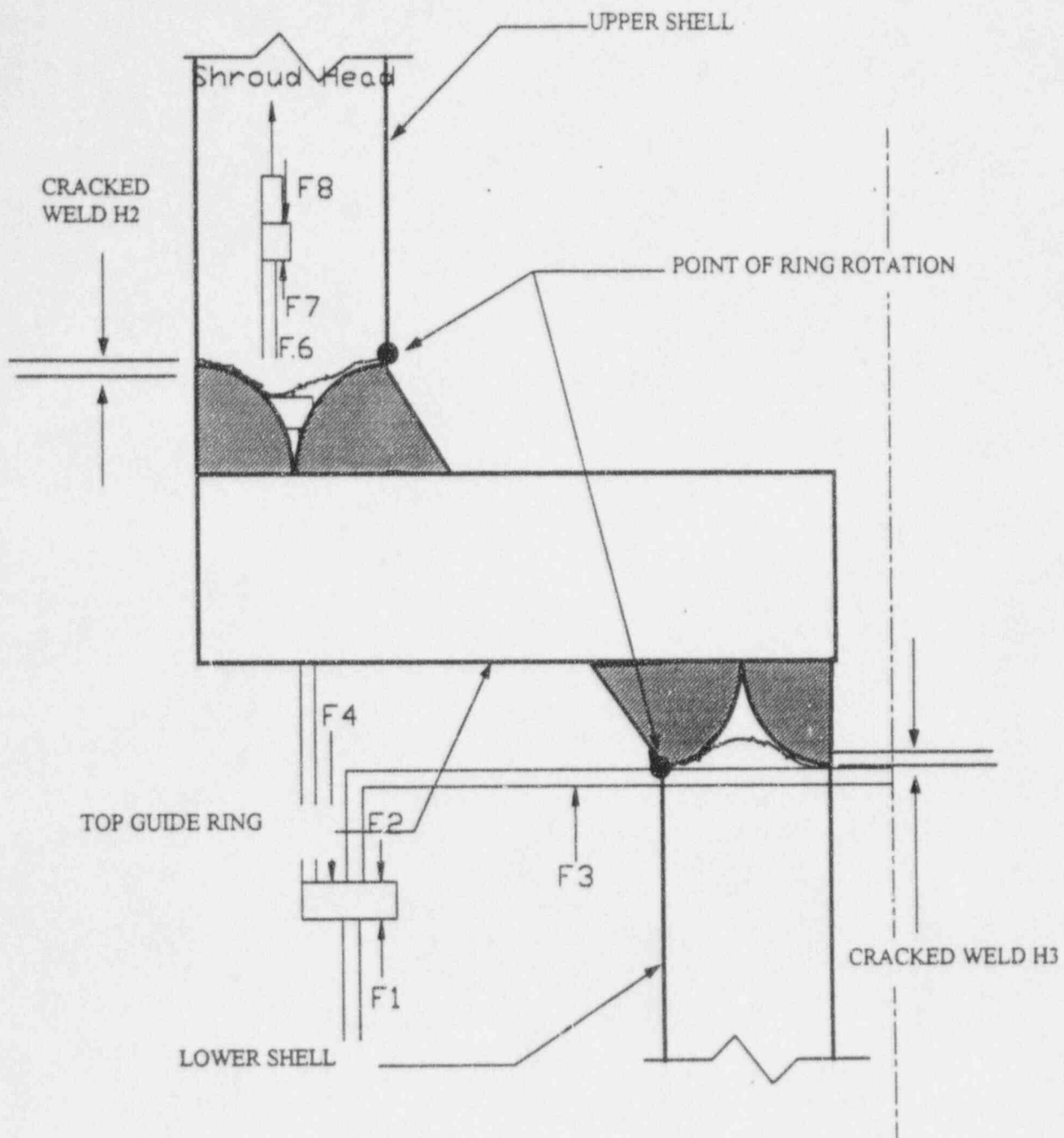


FIGURE 3  
RING ROTATION ABOUT TOP OF FILLET  
(NOT TO SCALE)

## Seismic Analysis

### Introduction

The information provided below are a selection of Seismic related questions asked by the NRC about the shroud repair installation. These seismic questions with their appropriate responses to the NRC were selected from the NRC questions and GE prepared responses for Nine Mile Pt. 1, Quad Cities, Hatch 1, and Pilgrim shroud repair projects.

### Seismic Analysis/Methods, Input, & Results

The seismic analysis with shroud repair hardware installed, and with numerous combinations of cracks at welds H1 through H8, was performed by time-history method. The peak responses from these seismic analysis were used to obtain loads and deflections in the shroud, the shroud repair hardware and the RPV & RPV internals for use in subsequent stress analysis. The NRC questions address the subjects which are listed below:

1. Seismic analysis methodology including request for copies of Criteria & computer program User's Manual.
2. Seismic Model details.
3. Seismic Input details.
4. Maximum gaps calculations at cracks with seismic loads included.
5. Seismic analysis results details / explanations.

*Following is the grouping of questions into the above FTVE topics.*

### Topic # 1

Seismic analysis methodology including request for copies of Criteria & computer program User's Manual.

### Question # 1

*Provide Reference 2 of GENE-771-60-0994 (GE document NEDO-10909, Rev. 7, December 1979, SAP4G07 Users Manual) which discusses the "standard, strain-energy weighted modal damping ratios."*

### Response # 1

The reference document is a Users Manual for computer program used by GE in performing the seismic analysis. This document is available in NRC offices because it was provided as part of ComED's March 3, 1995 submittal. Therefore, it is not submitted as part of Peach Bottom submittal. See page VIII.L-4 of the manual for the related details applicable to this question.

### Question # 2

*It is stated that the component stress evaluations are determined from the dynamic analysis of the horizontal seismic loads in combination with the vertical seismic loads. How were the horizontal and vertical loads combined (i.e., by absolute summation or by another method), and how were they combined according to the original plant design basis? Similarly, how were the SSE and LOCA dynamic loads combined for the two faulted service conditions, and how were they combined in the original design of the core shroud?*

### Response # 2

There are three possible collinear contributions for each seismic load. One for each of the two horizontal components of seismic excitation and one for the vertical. For the Peach Bottom shroud repair hardware design, the maximum contribution from either of the two horizontal seismic analyses was combined absolute sum with the corresponding peak vertical contribution for each seismic load "See GENE-771-60-0994". This method for combining peak collinear contributions due the three orthogonal spatial components of excitation is identical to the original (and existing) licensing design basis for Peach Bottom.

Also, commensurate with the primary structure being vertically rigid with respect to the vertical seismic free-field input motion, the Peach Bottom seismic licensing design basis necessitates only horizontal dynamic analyses. Consequently, in conjunction with existing geometric symmetry in the primary structure, the peak horizontal components were obtained from separate N/S and E/W horizontal analyses and the peak vertical contributions were from static dead weight analyses.

The peak collinear contributions due to the SSE and LOCA dynamic loads were combined by absolute sum for the Peach Bottom shroud repair hardware design. It is not clear how they were combined in the original design of the core shroud. However, the absolute sum methodology presently used is the most conservative method employed for nuclear application.

### Topic # 2

Provide seismic model details such as core data, rotational spring constants, including their derivations, how a hinge or roller condition at cracks is determined as well as modeled.

### Question # 1

*Provide the differences between the original core configuration and the Cycles 11 (Unit 2) & 10 (Unit 3) core configuration*

**Response # 1**

Both the original and Cycles 10 & 11 core configurations contain 764 fuel bundles in each unit. The differences between the two core configurations are summarized below.

	<u>Original Core</u>	<u>Cycle 11 Core</u>	<u>Cycle 10 Core</u>
		Unit 2	Unit 3
Young's Modulus (ksf)	1.67E6	1.59E6	1.59 E6
Poisson's Ratio	0.30	0.41	0.41
Total Shear Area (ft <sup>2</sup> )	4.48	3.99	4.30
Total Moment of Inertia (ft <sup>4</sup> )	0.285	0.268	0.286
Total Fuel + Water Mass (k- sec <sup>2</sup> /ft)	16.4	15.22	15.58

Both the stiffness and mass of the Cycles 10 and 11 cores are smaller than those of the original core. The revised Cycles 10 and 11 core properties were included in the seismic analyses used for the design of the shroud repair hardware

Future core configurations are not expected to be significantly different from the Cycles 10 & 11 core configurations and, hence the seismic loads in the restraint hardware and the RPV/internals are not expected to be sensitive to future changes in the core configurations.

**Question # 2**

*Provide Reference 1 (GE Document 383HA691, Rev. 0, Peach Bottom Units 2 & 3 - RPV and Internals Seismic Analysis, April 6, 1972).*

**Response # 2**

The reference is provided as Attachment A.

**Question # 3**

*Provide the detailed calculation of the rotary spring constant K4 for both an uncracked and cracked weld H8, and indicate how it is introduced in the analysis.*

**Response # 3**

The Peach Bottom Core shroud is physically supported by a shroud support plate and six vertical shroud support legs. The shroud support plate is an annular plate with its outer edge welded to the vessel wall and its inner edge welded to the shroud support ring. The plate also serves as a support for the jet pumps. The shroud support legs are steel bars of rectangular cross-section.

The vertical legs are connected in uniform circumferential spacing between the bottom of the shroud support ring and the vessel bottom head.

Considering the moment resistance characteristics of the design configuration and the fact that the primary structure seismic model is a mathematical beam element model, the shroud support hardware is modeled as a rotational spring (K4). Both the shroud support plate and the support legs contribute to the total stiffness of the K4 spring. The rotational stiffness of the two parts are computed separately, and the total K4 stiffness is the summation of the two.

For the shroud support plate, the rotational stiffness is derived using the appropriate moment-rotation resistance equation representing a fixed-support annular ring by applying a moment to a central rigid circular block. The reduction in plate area due to the jet pump holes are also taken into consideration in computing the equivalent plate stiffness. For the shroud support legs, the axial stiffness of the individual legs is computed first. The rotational stiffness is derived by a moment-rotation relationship considering stiffness contributions from support legs placed at proper geometrical locations around the bottom of the shroud support ring. For a total rotational stiffness K4 of Peach Bottom, the rotational stiffness contributions from the support plate and support legs are, respectively, about one-tenth ( 10 % ) and nine-tenth ( 90 % ) of the total stiffness value.

The H8 weld is the weld that connects the shroud support plate to the shroud support ring. When H8 has a full 360 degree through-wall crack, the worst case will result in no rotational coupling between the support plate and the shroud. However, since the support plate only contributes about 10 % of the total rotational stiffness for K4 spring, there is still at least 90 % of the rotational stiffness remaining to resist the seismic responses. As compared to the other crack cases, which assume full 360 degree through-wall cracks in the shroud wall, the H8 crack is not a controlling case in the shroud safety evaluation nor in the shroud repair hardware design. The reduction in the stiffness of the shroud support by approximately 3 % is a much less severe case than either the hinge or roller cases assumed in the design of the shroud repair hardware and thus is adequately enveloped by the various parametric analysis performed.

#### **Question # 4**

*Clarify the basis and conditions under which the assumption of hinges or rollers is chosen to model the shroud. Provide detailed diagrams of the hinge and roller models of the shroud structure, showing the attachments to the RPV. For each loading combination and crack configuration state the model which was used in the analysis.*

#### Response # 4

A hinge was chosen to model a 360 degree through wall circumferential crack in the shroud when contact is maintained under a compressive load, based on mechanical interference at the crack resisting lateral motion. A roller was chosen to model a crack when sufficient pressure and seismic loads exist to overcome the mechanical and thermal preloads and dead weight such that the full crack surface may open up, losing mechanical interference. This only occurs for the main steam line LOCA in combination with a MCE. Note that the results of the parametric study were used to determine the location of the crack that produced the largest response for the shroud and the shroud stabilizer hardware.

The detailed seismic model is shown in Figure 1 of the GE Document GENE 771-60-0994, Revision 2, "Peach Bottom Units 2 & 3 Seismic Analysis. Two coincident nodes are modeled at each shroud circumferential weld location; one attached to the upper beam element, and one attached to the lower beam element. If there is no crack, the nodes are coupled in both translation and rotation. If there is a crack which is modeled as a hinge, the nodes are coupled in translation only, with no moments transmitted through the nodes. If there is a crack which is modeled as a roller, the nodes are uncoupled, with no shear or moment transmitted through the nodes.

For the design basis load combinations of DBE plus normal condition, and the MCE plus normal condition, assumed weld cracks are always modeled as hinges, since for the normal operating conditions a preload is always maintained. For the beyond design basis load combination of MCE plus recirculation line LOCA condition, the assumed weld cracks are always modeled as hinges, since for this condition a preload is always maintained. For the beyond design basis load combination of MCE plus main steam line LOCA condition, with a single crack (critical bounding location assumed), the crack is modeled as a roller, since the uplift forces overcome the preload. For the MCE plus main steam line LOCA condition, with multiple assumed cracks, all cracks are modeled as hinges except for the topmost crack which is modeled as a roller. In this case, the uplift forces overcome the preload for the topmost crack, while the deadweight of the lower portion of the shroud is sufficient to keep the remaining cracks closed (i.e. pinned condition).

#### Topic # 3

Seismic model input details

#### Question # 1

*Describe how uncertainties were accounted for in the structural model and the time-history input.*

**Response # 1**

The purpose in addressing the effects of parameter variations is to account for uncertainties in the calculated natural frequencies due to uncertainties in such parameters as material and soil properties, structural damping and soil damping, soil-structure interaction techniques, geometrical dimensions and approximations inherent to dynamic modeling and analysis. The concern is the effect the parameter variations will have on response of the RPV and internals.

The current NRC acceptance criteria for the consideration of the effects of parameter variations are provided in Subsections II.9 and II.5 of Standard Review Plan (SRP), Section 3.7.2, "Seismic System Analysis", Rev. 2 - August 1989. Per the SRP, one acceptable approach is to smooth the computed floor response spectra obtained from the primary structure time history analyses and broaden the spectral peaks that are coincident with the structural natural frequencies for subsequent use in decoupled secondary system analyses. Also, from Subsection II.5 of SRP 3.7.2, it is acceptable to use a "single" artificial input time history (without expanding or contracting the time history time step) in the primary structure seismic analysis. However, since the original design basis seismic analysis in UFSAR did not require applying these criteria, the current analysis does not specifically document compliance with these criteria even though, the intent of Subsection II.5 of SRP 3.7.2 is met.

For the Peach Bottom shroud repair, a coupled model time history analysis was performed in which the reactor and internals are modeled in detail in the primary structure model. Key input parameters such as the rotational stiffness of the tie rod assemblies along with the various crack locations and joint restraint configurations were parametrically evaluated by performing analysis of bounding conditions. Conservative peak dynamic loads were then calculated in the primary structure analysis; without the need for a separate secondary system analysis procedure.

Two separate time histories ( DBE and MCE ) were used in the primary structure time history analyses for the seismic design adequacy evaluation of the shroud repair hardware. Time history analyses were performed using both of these synthetic time histories. Synthetic acceleration time-histories were constructed for both DBE and MCE in accordance with the guidelines in the USNRC Standard Review Plan ( NUREG-0800 ), such that the response spectra corresponding to the synthetic time-history envelopes the spectra of Figures C.3.1 & C.3.2 of Peach Bottom UFSAR. The UFSAR spectra ( Target spectra ) and the spectra corresponding to the synthetic time-history used in the current analysis are shown in Figure 2 of the seismic report GENE-771-60-0994, Rev. 2.

Finally, it is noted that only the peak bounding dynamic loads from the Peach Bottom time history analyses were applied to perform the static stress analyses

of the shroud and shroud repair hardware, and thus no secondary subsystem analysis was required.

#### Topic # 4

Provide Maximum gaps calculations at cracks with seismic loads included.

#### Question # 1

*Provide the magnitude of the maximum separation of each cracked weld during a MSLB plus vertical seismic loading.*

#### Response # 1

The magnitude of the maximum separation at a cracked weld during a MSLB plus the Maximum Credible Earthquake considering vertical seismic excitation will be 0.30 inches.

#### Topic # 5

Provide seismic analysis results details such as a few mode shapes & modal dampings for uncracked, the hinged and the roller models; RPV loads etc.

#### Question # 1

*Provide a detailed discussion of the difference between the seismic axial and bending loads in the original skirt stress analysis report and the present analysis.*

#### Response # 1

The bending moments in the original analysis and present analysis are of the same nature, but have different numerical values as noted in Section 4.9 of the present stress report. The original bending moments were calculated based on the seismic horizontal design acceleration coefficient of 0.6 g ( in DBE ) and 0.12 g ( in MCE ) and taking the summation of the moments of the horizontal seismic loads located at the center of gravity (C.G.'s) of each load causing overturning moments. This was given in GE Drawing 886D499, sheet 7, Revision 8, table 10 for the original analysis. This drawing is being provided as Attachment B.

In the present analysis the bending moments are taken directly from the dynamic analysis of the seismic model, the details are available in GENE-771-60-0994, Revision 2, which is included in this submittal. This analysis was performed using time-history methodology.

The original seismic axial load was based on a vertical acceleration coefficient ( $=0.08g$  DBE &  $0.16g$  MCE ) multiplied by the total downward load. This axial load has not been changed in the present analysis.

**Question # 2**

*Provide the detailed calculation showing that the shroud legs have been checked for buckling with H8 cracked under preload and vertical and horizontal seismic loading.*

**Response # 2**

The original compressive stress in the shroud support legs using conservative design ( DBE ) loads is 12.1 ksi, which is below the allowable of 14 ksi ( $= 0.4 S_y$ ) thus meeting the buckling stress limits. The new compressive stress in the shroud support legs for MCE is 22.9 ksi, which is below the allowable of 28 ksi ( $= 0.8 S_y$ ). Since the revised seismic moments from the seismic time history analyses on the shroud support legs are lower than those used in the original analysis, the existing buckling stability evaluation documented in the original stress report is still valid. The new loads are from the case of H8 uncracked but are the same for the H8 cracked case.

**Question # 3**

*Provide the number of modes, the first five modal shapes and the corresponding modal damping values, for the uncracked, the hinged and the roller models.*

**Response # 3**

The seismic analysis included all modes with modal frequencies less than 33. Hertz. Shown in the following tables are the number of modes, the first five modal frequencies and composite modal damping ratios along with the identification of the location of the predominate mass by mode. Provided in Figures 1, 2, and 3 below are the first five mode shapes for the uncracked model, a representative hinged model (weld H7 cracked as a hinge), and a representative roller model (weld H7 cracked as a roller). Because of similarity in modal properties between the East-West and North-South direction, it is sufficient to show only the modal properties in the North-South direction. Note that for most of the internal components the N-S model produces the bounding responses.

Uncracked (22 modes)			H3 Hinge (22 modes)			H3 Roller (23 modes)		
Freq. Damping			Freq. Damping			Freq. Damping		
(Hz) (% crit.)			(Hz) (% crit.)			(Hz) (% crit.)		
3.64	2.00	(2)	1.66	1.12	(1)	1.08	2.04	(1)
4.34	6.07	(4)	3.64	2.00	(1)	3.02	2.18	(1)
5.25	3.48	(3)	4.87	6.65	(4)	3.64	5.02	(2)
5.89	2.06	(2)	5.25	3.49	(3)	5.24	3.50	(3)
7.17	1.74	(1)	5.89	2.02	(2)	5.54	6.63	(4)

Predominant Response Location Legend

- (1) Shroud, Fuel
- (2) Reactor Building Roof Structure
- (3) Control Rod Drives
- (4) Fuel

Figure 1  
Mode Shapes for Uncracked Case

Figure 2  
Mode Shapes for H3 Hinge Crack Case

Figure 3  
Mode Shapes for H3 Roller Crack Case

*ATTACHMENT A*

GE Document 383HA691, Rev. 0, Peach Bottom Units 2 & 3 - RPV and Internals  
Seismic Analysis, April 6, 1972.

*ATTACHMENT B*

GE Drawing 886D499, Sheet 7 of 8, Revision 8

**GENERAL ELECTRIC INSPECTION RECOMMENDATIONS**  
**FOLLOWING THE INSTALLATION OF THE SHROUD STABILIZERS**  
**AT PEACH BOTTOM 2, 3**

GE Nuclear Energy recommends that the following in vessel inspections be performed after the installation of the shroud stabilizer assemblies at Peach Bottom Unit 2 or Unit 3. The complete inspection recommendations are not yet finalized, and will depend in part on the criteria established by the BWRVIP.

Perform a VT-3 visual inspection of each shroud stabilizer assembly and interfacing areas on the shroud and vessel after one operating cycle, and once per interval thereafter. This inspection should include verification that the crimp nuts on the toggle bolts, and other locking devices are in place. The inspection should include the interface locations between the stabilizers and the shroud and reactor pressure vessel. The anchor points at the shroud support plate, lower spring and clevis pin should be included to verify structural rigidity. It is not considered necessary to mechanically check the tie rod nut torque.

Perform an enhanced VT-1 visual inspection or UT inspection of each of the four vertical shroud welds at the intersection with the H4 weld once every two fuel cycles or after every three years, whichever is longer. A minimum length of eight inches should be inspected for each weld. It is not considered necessary to inspect the remaining vertical welds which do not intersect the H4 weld.

Follow the BWRVIP plan for the inspection of the H9 weld between the shroud support plate and the vessel, and any recommendations for inspection of the shroud support plate segment welds. An analysis for maximum allowable flaws in the H9 weld would help determine inspection criteria.

There is no inspection required for the top guide support ring (between the H2 and H3 welds), and the core plate support ring (between the H5 and H6 welds) as these are one piece rings without any welded ring segments.

There is no recommended inspection for the H8 weld between the shroud support plate and the shroud support cylinder as it has been shown by analysis that the structural integrity of the H8 weld is not required by the shroud stabilizers.

## Materials

### Introduction

The information provided below are a selection of material related questions asked by the NRC about the shroud repair installation. These material questions with their appropriate responses to the NRC were selected from the NRC questions and GE prepared responses for Nine Mile Pt.1, Quad Cities and Peachbottom shroud repair projects.

### Shroud Repair Materials

The shroud is fabricated from 304 series stainless steel. The shroud repair hardware is fabricated from three (3) types of materials which are listed in the Peachbottom fabrication specification 25A5601 Rev 1. These repair hardware materials are;

1. The X-750 is a nickel-chrome-iron (Ni-Cr-Fe) alloy shall be in accordance with ASTM B-637, UNS N07750, Type 3 with additional requirements as defined in paragraph 3.2.1 of the fabrication specification.
2. The austenitic 300 stainless steel shall be in accordance with ASTM A-479, A-182 or A-240 type 304, 304L, 316 or 316L with a maximum carbon content of 0.020 percent with additional requirements as defined in paragraph 3.2.2 of the fabrication specification..
3. The XM-19 stainless steel shall be in accordance with ASTM A-479, A-182 or A-240 with a maximum carbon content of 0.040 percent with additional requirements as defined in paragraph 3.2.3 of the fabrication specification.

### Subjects Addressed By NRC Material Questions

The NRC questions address the follow subjects and are listed below.

- \* Details of heat treatment
- \* Sensitization testing
- \* Cold work during fabrication
- \* Lubricant used during installation
- \* Use of XM-19 material for tie rods
- \* Certified Material Test Reports (CMTR)

## Selected NRC Questions

Listed below are a selection of material questions asked by the NRC during the review of the documentation submitted for Nine Mile Pt.1, Quad Cities and Peachbottom shroud repair projects for additional information. GE reviewed each NRC question and submitted the appropriate response for each material question.

### Question 1

*Please provide the heat treatment details such as time, temperature and cooling rate that are specified for the alloy X-750 components.*

### Response 1

Heat treatment for the X-750 consists of  $1975^{\circ} \pm 25^{\circ}$  for 60 to 70 minutes, followed by forced-air cooling. Age hardening is done at  $1300 \pm 15^{\circ}$  F for 20 to 21 hours, followed by air cooling.

### Question 2

*Is solution annealed condition specified as the final material condition for all components made of XM-19 and 316 or 316L austenitic stainless steel materials?*

### Response 2

Solution heat treatment is required for all 300-series and for XM-19 parts. This is done before machining and trimming. Threads on the XM-19 tierods are not annealed after machining.

### Question 3

*What is the material condition of XM-19 that were previously used in the BWR environment?*

### Response 3

This material was selected for the shroud-reinforcement-assembly tie rods because of its strength, corrosion resistance in BWR environments, and other engineering properties.

As purchased, this material is delivered in the solution heat treated condition. This involves heating the item into the temperature range, approximately  $2000^{\circ}$  F for UNS S20910, where the  $Cr_{23}C_6$  carbides break down and the component atoms disperse into the matrix. This heating is followed by cooling at a rate rapid enough to maintain the dispersion in the matrix.

For some materials, and for small parts, the rapid cooling is most conveniently achieved by quenching in a water bath. But for the stock for shroud-restraint tie rods, which are approximately 3-1/2 inches in diameter by 14 feet long, attempts at water quenching will introduce severe local distortions because the

entire length of such an object rarely, if ever, reaches the same temperatures at the same times. Therefore, air cooling was selected to reduce the likelihood of problems due to nonuniform temperature distribution.

For this specific alloy, air cooling is sufficiently rapid to avoid reprecipitation of carbides, as has been verified by a number of laboratory tests and experiments. For example, data published by EPRI's M. J. Povich and D. E. Broeker in the October 1979 issue of *Materials Performance* (National Association of Corrosion Engineers; "The Stress Corrosion Cracking of Austenitic Stainless Steel Alloys in High Temperature Air Saturated Water") show that UNS S20910 is as resistant to corrosive attack in the cold-worked and/or furnace-sensitized condition as in the fully solution-heat-treated condition. Therefore, for parts of the size, shape, and basic material of the tie rods, more is to be lost than gained from water cooling after solution heat treatment. Air cooling is sufficiently rapid to preserve the corrosion-resistant properties of the material without the risk of unacceptable loss of straightness.

This, and other similar data in the literature, also supports the decision to place the completed tie rods into service in the as-machined condition, without incurring the schedule delays and added expenses that would have resulted from an unnecessary post-machining heat treatment cycle.

#### Question 4

*In the fabrication specification, GE stated that the successful completion of the sensitization testing shall be accepted as evidence of the correct solution heat treatment if time and temperature charts are not available. The staff considers that in a good quality assurance program, accurate records of item, temperature and cooling rate are necessary to be maintained as evidences that proper heat treatment has been performed. Therefore, the use of sensitization test results as a substitute for the proper heat treatment documentation is not acceptable.*

#### Response 4

The purpose of the requirements on heat treatment of stainless steel core shroud repair materials is to provide material that is not sensitized. Accordingly, sensitization testing of the material after heat treatment is an accurate indicator that the heat treatment was effective. The attributes of the final material condition is considered as evidence that the engineering requirements of material performance have been met. Therefore, sensitization testing is considered an adequate alternative to detailed heat treatment records in assuring that proper heat treatment has been performed. Also, complete reliance on heat treatment records can be misleading. GE has indicated that isolated cases have occurred in which heat treatment details were recorded, even to the extent of using embedded thermocouples, but that the subject material failed to pass a sensitization test.

ASME NCA-3800 was followed to procure the core shroud repair material. With respect to material test reports, NCA-3860 does not require that detailed time/temperature records for heat treatment be recorded but that specific time and/or temperature parameters be recorded if such values are specified in the underlying Section II material specification. For the austenitic stainless steels used for the shroud restraints, the only stated requirement is a minimum temperature of 1900 degrees F (followed by rapid cooling).

The fabrication specification adds additional requirements for heat treating stainless steel that is over and above the ASME code. When material is ordered in heat lots from a primary melter, it is possible to get such detailed records of heat treatment. However, in the current environment of performing internals repairs, materials are procured in small quantities, often from a third party supplier out of a warehouse inventory. In these cases, detailed records showing complete conformance to the additional requirements are not always retrievable. It is in these cases where, as an alternative to detailed heat treatment records, the attributes of the final material condition is considered as evidence that the engineering requirements for materials performance have been met.

In summary, the material ordering requirements are appropriate for the intended use and are in conformance with applicable codes.

**Question 5.**

*General Electric stated that a minimum of 0.030 inches of austenitic 300 series stainless steel materials will be removed after high temperature annealing as a control of intergranular attack (IGA). Will this process or any other process be applied to machined threads made of XM-19 and Alloy X-750 after high temperature annealing to ensure there is no IGA.*

*Please provide test data to support that the removal of 0.030 inches surface material would effectively eliminate the IGA effect resulting from the high temperature annealing.*

**Response 5.**

Material removal processes are not used on the XM-19 tie rod threads after the final machining. The minimum of 0.030-inches to be removed after annealing or high temperature heat treatment of 300 series stainless steel, XM-19 and Alloy X-750 is intended to address parts which may be in an air atmosphere furnace for several hours. At temperatures of 1800-2000 degrees F, in air for several hours a thick surface oxide layer and grain boundary oxidation (IGA) may occur.

The local solution annealing of the threads is a very short cycle with very short heat up and cool down times. Considering the outstanding corrosion and oxidation resistance of XM-19, it is expected that the oxidation of the surface

will not be of a significant depth, and IGA is not expected during this very short process. Therefore, no material removal processes are used on the XM-19 tie rod threads after the local induction annealing.

Re-resolution anneal or additional material removal processes are not performed on X-750 parts after machining. Typical UNS N07750 (X-750) samples were selected at random from their actual production runs, cross-sectioned, and the microhardness measured as a function of depth into the metal from the polished surface. The sequence of manufacture was:

<u>Sample "A"</u>	<u>Sample "B"</u>
Machined	Age Hardened
Polished	Machined
Age Hardened	Polished
Penetrant Examined	Penetrant Examined
Dimensions Checked	Dimensions Checked

In both specimens, the hardness at and near the polished surfaces was identical to that of the unaffected interior: Rc 36 for "A" and Rc 35 for "B". All readings remained within a plus or minus 3-point tolerance band, which is uniform and consistent for 100-gram Knoop readings. The surface showed no evidence of work hardening or cold work. Additionally, samples representing turning and milling operations on X-750 after age hardening showed no significant increase of surface hardness compared to internal bulk hardness (38Rc max surface versus 34Rc interior). Therefore, no re-resolution anneal is required for X-750 parts after machining.

Over the past 25 to 30 years GE has implemented a metallographic receipt inspection requirement for heats of stainless steel. The receipt inspection requirements consist of a destructive metallographic examination of the cross section from each heat to determine the depth of IGA that may have occurred due to high temperature annealing atmosphere or due to an overaggressive acid pickling process. The acid pickling process is the primary cause of IGA. The results of the numerous tests performed have shown that less than one sample per year have shown IGA deeper than 0.001 inch and in those cases the depth of the IGA was less than 0.003 inches.

The criteria for removal of 0.030 inches of material was originally established many years ago to be a conservative bounding limit to ensure that any IGA induced by any process, especially due to overaggressive pickling, would be removed. This criteria was established based on engineering judgment prior to the results of the material receipt inspection testing as described above. The requirement for removal of 0.030 inches from the affected surfaces has been

implemented for this project to provide an order of magnitude of the margin over the maximum depth of IGA that has been observed.

#### Question 6

*Provide details of your controls in the practices of machining, grinding and threading to minimize the effect of cold work, such as amount of material to be removed in each pass, application of coolant and sharpness of the tool.*

#### Response 6

The amount of material removed in a single pass depends on the part and the particular machine doing the work. Parts are generally rough machined to within 0.10" of final size and skim passes are used to achieve the final dimensions. Tests show that Inconel X-750 surfaces are unaffected by machining and do not require heat treatment. The application of coolant and sharpness of the tool is considered adequate provided a surface finish of 125 root mean square or better is obtained.

#### Question 7

*Please provide details of your controls in the practices of machining, grinding and threading to minimize the effect of cold work, such as amount of materials to be removed in each pass, application of coolant and sharpness of the tool.*

#### Response 7

Each item that is manufactured has its own specific requirements when it comes to "how much" material is removed per pass and which machine is doing the work. Generally speaking, parts are "rough machined" down to within .100" of final dimensions. Then the final clean up (about .010") pass skims off the required amount of material to achieve the required size and surface finish. If a tool is dull, then the 125 rms surface finish would not be produced as required on all drawings. A dull tool produces a smeared or torn surface appearance which is the primary method of monitoring the adequacy of the tooling and the process in general.

The judgment and experience of the machinist is relied upon to determine how much material can be safely removed per cut or per pass. Written documents could not possibly address all possible eventualities of workpiece size, shape, and material or machine type and capacity or dimensions, tolerances, and surface finish necessary. Vendor in process control sheets or travelers are used to control the flow of material in the shop. While in process, machining is seldom, if ever, controlled by fixed documents. The end results are carefully specified on the drawings.

In addition, the fabrication specification states "Machined components that are not solution annealed after machining shall have metallographic and microhardness evaluation on test samples. Samples shall be provided from the same material, same fabrication shop and using the same process variables."

The purpose of these evaluations is to verify the materials' surface conditions have very shallow cold work depth. Control of the cold work depth will minimize the materials susceptibility to IGSCC.

The coolant used during the machining process is Trim-Sol. A stream of Trim-Sol is applied directly to the cutting tool where it makes contact with the part. Afterward, the component is washed with acetone and followed by a demineralized water wash prior to any other operation.

#### Question 8

*In your fabrication specification it is stated that ,if grinding is not followed by solution heat treatment or machining, the grind surface shall be polished to an RMS 32 finish or better using successively finer grit abrasive. Please provide test data to support the above stated polishing to be effective in eliminating the unacceptable surface cold work resulting from grinding*

#### Response 8

The fabrication specification was based upon several evolutions of shroud-reinforcement documents and has retained several contingency options that at earlier times were thought to be prudent to have available "just in case". Shaping metal by heavy grinding was one of these options. Experience now shows that such a technique is not necessary and, in fact, has not been used.

While experiments have been conducted to verify the metallurgical acceptability of the manufacturing operations that we do use or intend to use, no specific tests were made of 'heavy grinding with and without subsequent polishing'. Thus there are no test data available to be provided on this specific phenomenon

#### Question 9

*In the fabrication specification it is stated that electropolishing can be specified to remove any cold-worked surface by using mixed phosphoric/sulfuric acid. Please describe the details of the electropolishing process and its controlling parameters, as well as how this process was qualified. Is there any test requirement after electropolishing to ensure that there is not pitting or IGA on the electropolished surface?*

#### Response 9

Electropolishing to remove surface material for elimination of mechanical-working effects, refinement of surface texture, fine adjustments to dimensional attributes, or similar reasons; is permitted under the following mandatory requirements:

- a) All work shall be performed in accordance with written and approved procedures. Such documents shall control, as a minimum: basic electrolyte composition with limits, maximum permissible bath

contaminants by type and level, immersion temperatures with limits, current polarity and maximum amperes/cm<sup>2</sup> density, precleaning and postcleaning requirements, and limitations to preclude insufficient or excessive material removal.

b) The electrolyte shall be based upon the mixed phosphoric/sulfuric acid system, with appropriate buffers and/or intensifiers permitted.

c) Demonstration samples shall be prepared and submitted for information in conjunction with the written procedure (subparagraph (a) above). These shall clearly show the alteration in surface texture and appearance after electropolishing and compared with before electropolishing, and shall include polished and etched metallographic cross sections of before and after specimens to illustrate typical internal structures.

#### Question 10

*Please discuss the mitigation methods that you plan to apply to the machined threads such as re-solution annealing to minimize the cold work effect. Please also describe how the methods were qualified and the details of controls for application.*

#### Response 10

The XM-19 material used for the tierods is procured in the solution annealed condition. The machined threads on the tierods are not solution annealed after the machining of the threads.

General Electric has been specifying and using XM-19 components in commercial power reactors since the mid-1970s, especially for parts which must be stainless steel and also must be nitrided. The nitriding process involves holding the parts in a chlorine-rich nitrogen environment at 1060° to 1100°F for 16 to 24 hours. Only XM-19 is able to withstand this treatment without becoming sensitized to Intergranular Stress Corrosion Cracking (IGSCC). Types 304, 304L, 316, and 316L quickly fail after exposure to such thermal conditions, but not XM-19. Therefore it is not necessary to remove or anneal any "IGSCC-prone" surface layers after machining, because the material is inherently resistant to IGSCC, even in the as-machined condition.

GE has access to test results which show that XM-19, in BWR environments, is more corrosion and crack resistant in tight crevice situations than 316L or other 300-series stainless. To cite an example; a set of tensile specimens, each bearing a sleeve to create a crevice at the specimen surface, was loaded to 120% of yield in 1981 and that load maintained for the duration of the test. Today, 14 years later, none of the XM-19 specimens has failed or even cracked. Thus, concerns about the durability of XM-19 in threaded joints because of "crevices" are not valid.

All in all, XM-19 is an excellent material for use in BWR applications. It may safely be used in the as-machined condition; it may safely be used in threaded and other highly-creviced geometries, and is superior to 316, 316L, and other alloys for the intended application. Its only drawback is cost and availability - it is not as commonly found in supplier's inventories as the more traditional materials.

### **Question 11**

*Please provide details of your controls in the practices of machining, grinding and threading to minimize the effect of cold work, such as amount of materials to be removed in each pass, application of coolant and sharpness of the tool.*

### **Response 11**

Each manufactured piece has its own specific requirements when it comes to "how much" material is removed per pass and which machine is doing the work. Generally speaking, parts are "rough machined" down to within .100" of final dimensions. Then the final clean up (about .010") pass skims off this rough surface to achieve the required size and surface finish. If a tool is dull, then the 125 rms surface finish which is required on all drawings would not be produced. A dull tool produces a smeared or torn surface appearance which is the primary method of monitoring the adequacy of the tooling and the machining process in general. A number of tests on various parts in various heat treated conditions has demonstrated that the most severe operation in terms of surface cold work is generation of the stub Acme threads on the tie rods which serve as a "worst case" bounding condition.

The judgment and experience of the machinist is relied upon to determine how much material can be safely removed per cut or per pass. Written documents could not possibly address all possible eventualities of workpiece size, shape, and material or machine type and capacity or dimensions, tolerances, and surface finish necessary to produce. Vendor inprocess control sheets or travelers are used to control the flow of material in the shop. While in process, machining is seldom, if ever, controlled by fixed documents, the end results are carefully specified on the drawings.

### **Question 12**

*Identify the lubricants that would be used on the machined threads during installation. What are the controls of the content of chlorides, sulfides, halogens and other elements that are known to promote stress corrosion cracking in stainless steel and high nickel alloy?*

### **Response 12**

The lubricant used for machined threads during installation is thread lubricant D50YP5B. The lubricant is referenced on GE reactor modification drawing parts list.

GE Specification D50YP12 provides the controls of the content of halogens, nitrate, sulfur and other elements in lubricant D50YP5B. The specification defines the requirements for limiting impurities in lubricants that are in crevices exposed to BWR primary reactor coolant at temperatures above 165°F. Impurity limits are as follows:

1. The maximum allowable level of halogens, when both sulfur and nitrates are less than 1 ppm, is 450 ppm.
2. The maximum allowable level of sulfur, when both halogens and nitrates are less than 1 ppm, is 630 ppm.
3. The maximum allowable level of nitrate, when both total halogens and total sulfur are less than 1 ppm, is 820 ppm.
4. Allowable simultaneous levels of halogens, sulfur and nitrates in combination can be determined from the nomograph in Addendum A in the following manner when the values of any two of the impurities are known, or are assumed. Place a straightedge through the two known or assumed values on their scales and read the third value from its scale. The third value must not be exceeded.
5. Allowable combined levels of halogens, sulfur and nitrates can also be determined using the formula below:

$$\frac{\text{ppm Halogens}}{35.453} + \frac{\text{ppm Sulfur}}{48.096} + \frac{\text{ppm Nitrates}}{62.004} < 13.2$$

6. The maximum allowable level of any single low melting point metal is 200 ppm.
7. The maximum allowable level of all low melting point metals in combination is 500 ppm.

### Question 13

*The staff realizes that the repair assemblies may be inspected by a combination of visual and ultrasonic examinations. However, the staff has some concern regarding the reliability of such inspection to identify the potential degradation in the threaded joints and areas of crevices and stress concentrations, which have limited access for inspection. Please provide a discussion and/or propose an alternative inspection such as disassembling the threaded joints for inspection to ensure that the areas mentioned above in the repair assemblies will be adequately inspected for early detection of potential degradation.*

**Response 13**

The tendency toward stress corrosion cracking is promoted by material type, condition, local water chemistry, applied loads, residual stresses, etc. In the case of stainless steel threaded fasteners, crevices, surface condition (surface cold work) and sustained tensile stress are of specific concern. For the shroud restraint hardware several factors mitigate the concern for potential stress corrosion cracking.

**Material - XM-19**

In the middle 1970's in the interest of improving the margin of control rod drive (CRD) performance, GE implemented the use of XM-19 for piston and index tubes in place of Type 304 stainless steel. The logic was that as a low carbon, high chromium, mildly stabilized (Nb,V) austenitic alloy XM-19 would offer a higher margin of resistance to intergranular stress corrosion cracking (IGSCC) in the nitrided condition than Type 304. Nitriding involves heating the material to approximately 1100 degrees F for several hours and results in furnace sensitization of 300 series stainless steels, but has no detectable effect on XM-19. As a side benefit, XM-19 has a significantly higher strength than Type 304 so equivalent components are stressed to a lower fraction of yield stress in service. Since the late 1970's all control rod drives manufactured by GE have contained XM-19 piston and index tubes. This includes all BWR-6s (more than 1500 drives) plus several other BWR-4/5's under construction at the time; as well as, all replacement drives manufactured since. In total there are easily more than 2000 such control rod drives in service.

By the nature of the CRD design there are numerous crevices including threaded joints exposed to the reactor environment. On the average 10 to 20 per cent of the drives at a given plant are refurbished each outage. During this work the drives are disassembled giving ample opportunity for examination and detection of problems. To date no instances of intergranular attack or IGSCC of nitrided XM-19 have been reported.

XM-19 shroud repair hardware material is provided solution annealed at  $2000 \pm 50$  degrees F after completion of final reduction, sizing, and forming operations. All XM-19 material has had sensitization testing performed for each heat and each heat treat lot. The sensitization requirements exceed the requirements ASTM A-262.

**Material - X-750**

X-750 shroud repair hardware material is provided solution annealed at  $1975 \pm 25$  degrees F after completion of final reduction, sizing, and forming operations. In addition, this material is age hardened at  $1300 \pm 15$  degrees

F. All X-750 has Intergranular attack (IGA) testing performed after annealing for each heat and each heat treat lot.

It should be noted that there are no welds in the shroud restraint design, so there are no weld residual stresses. Also, there is no grinding in the shroud restraint design, so there are no grinding induced residual stresses or cold work. As a consequence, the threaded fasteners in the restraint design experience a relatively low level of sustained tensile stress compared to welded crevice joints.

Finally, machined components that are not solution annealed after machining shall have metallographic and microhardness evaluation on test samples. Samples shall be provided from the same material, same fabrication shop and using the same process variables as the components which are being fabricated for the repair. The purpose of these evaluations is to verify the material's surface condition have very shallow cold work depth. Control of the cold work depth will minimize the materials susceptibility to IGSCC initiation.

Based on the material properties and fabrication processes described above, future disassembly of threaded fasteners, crevices, and stress concentrations areas for the express purpose of inspection is not intended. However, if these areas require disassembly in the future for other reasons, a visual inspection of the threaded, creviced, and stress concentration areas will be performed prior to reassembly. The detailed plans for future inservice inspection of the installed core shroud repair components have not yet been finalized. Quad Cities will submit these plans to the NRC staff at least ninety days prior to the first refueling outage following the outage in which the shroud repair components are installed."

#### Question 14

*Please discuss the reasons that GE selects XM-19 material for the tie rods instead of austenitic 304 or 316 stainless steel (low carbon content). The 304 or 316 stainless steel has extensive service experience in the BWR environment. It should be noted that the acceptable yield strength of XM-19 material is limited to 90 ksi. Since there is limited service experience of XM-19 material in the BWR environment, the staff recommends that an accelerated stress corrosion testing of a mock-up simulating the XM-19 tie rod thread joint in a BWR environment should be performed to ensure there is no development of unexpected degradation.*

#### Response 14

XM-19 has experienced no known failures or other problems in approximately twenty years of BWR service. This is considered to be adequate confirmation that the material is acceptable for use.

XM-19 was extensively studied and tested in the mid-1970s. Results of these tests were published in Document NEDE-21653, of which the NRC received copies in 1977. This document contains all of the applicable test information and will be provided in a separate submittal. XM-19 has experienced no known failures or other problems in approximately twenty years of BWR service. This is considered to be adequate confirmation that the material is acceptable for use.

#### Operating Experience With XM-19.

In the middle 1970's in the interest of improving the margin of control rod drive (CRD) performance, GE developed and implemented the use of XM-19 for piston and index tubes in place of Type 304 stainless steel. The logic was that as a low carbon, high chromium, mildly stabilized (Nb,V), austenitic alloy, XM-19 would offer a higher margin of resistance to intergranular stress corrosion cracking (IGSCC) in the nitrided condition than Type 304. Nitriding involves heating to ~1100 degrees F for several hours and results in furnace sensitization of 300 series stainless steels. As a side benefit, XM-19 has a significantly higher strength than Type 304 so equivalent components are stressed to a lower fraction of yield stress in service. Since the late 1970's all control rod drives manufactured by GE have contained XM-19 piston and index tubes. This includes all BWR-6s (more than 1500 drives) plus several other BWR-4/5s under construction at the time as well as all replacement drives manufactured since. In total there are easily more than 2000 such control rod drives in service.

By the nature of the CRD design there are numerous crevices including threaded joints exposed to the reactor environment. On the average 10 to 20 per cent of the drives at a given plant are refurbished each outage. During this work the drives are disassembled giving ample opportunity for examination and detection of problems. To date no instances of intergranular attack or IGSCC of nitrided XM-19 have been reported.

#### Question 15

*Please identify the ASME Code Material Specification Nos. that are specified for the procurement of the XM-19, 316 or 316L austenitic stainless steel and alloy X-750.*

#### Response 15

All of the materials are purchased to American Society for Testing Materials (ASTM) specifications: XM-19 = A182, A240, A336, A412, or A479. 316 or 316L = A182, A240, A336, or A479. X-750 = B637. The materials are identified in the GE fabrication specification.

**Question 16**

*Are Certified Material Test Report (CMTR) and heat treatment records available for all procured materials?*

**Response 16**

All materials procured for these assemblies are purchased with CMTRs. For the most part, and in keeping with the ASTM specifications, heat treatment information on CMTRs is limited to a statement that the material is "in the solution annealed condition", and the holding temperature is given. For the most part the mills do not include furnace charts or other specific details of the process to the suppliers from whom we buy the material. However, we require confirmatory testing, either to ASTM procedures or to GE equivalents of those procedures (such as E50YP20), which assures that the material was adequately and properly heat treated.

## CORE PLATE WEDGE ISSUE

### 1. Introduction

The purpose of this document is to describe the analysis performed to determine if core plate wedges were needed for the Peach Bottom shroud repair. The specific concern to be addressed was that of the horizontal motion of the core plate relative to the shroud during a seismic event. That motion when combined with the shroud horizontal seismic motion at the core plate elevation must meet the deformation limits specified in the design specification.

The method used to evaluate the horizontal motion of the core plate as a whole was to compare the friction force provided by the initial preload clamping force of the core plate studs to the horizontal seismic loads. Conservative localized deflections were assumed to occur between the studs and corresponding core plate holes and due to localized bending of the core plate studs. The total deflection of the core plate resulting from the shroud displacement plus the localized displacement of the core plate relative to the shroud was shown to be within the allowable displacements for all load combinations.

### 2. Analysis

The configuration with restraint hardware installed but no shroud cracking is non-limiting since the resulting shroud seismic loading is unchanged from the original design basis and the restraint hardware sees very low loads. Therefore, the case of seismic loading with stabilizers installed and a cracked shroud is evaluated.

#### 2.1 Gross Core Plate Deflection

The evaluation determined the net uplift force on the core plate due the combined effects of pressure differences, component weights and vertical seismic accelerations. The values are summarized in Table 1. The Peach Bottom core plate is installed with thirty-four 2½ inch diameter studs with each stud preloaded to approximately 43,500 pounds. Considering relaxation in the studs, the resulting clamping force on the core plate at operating conditions is approximately 1,257,000 pounds. Combining the stud preload with the operational and seismic uplift forces produces the net clamping forces reported in Table 1. Two values of coefficient of friction were considered in the analysis of the horizontal friction force maintained between the core plate and shroud to resist the horizontal seismic loading; 0.2 as specified by the VIP / BWROG and 0.5 which has been widely used in reactor internals design. The more conservative friction values for the 0.2 friction coefficient are given in Table 1. Also shown in Table 1 are the horizontal seismic loads on the core plate which result from the fuel and control rod guide tubes. A comparison of the horizontal seismic loads on the core plate to the friction force available to resist the seismic loading shows the

available friction force to be the significantly larger of the two. Therefore, no gross sliding or relative motion of the core plate relative to the shroud will occur due to the horizontal seismic shear loads.

## 2.2 Localized Core Plate Deflection

The seismic shear load that is transferred through the core plate into the shroud is not transferred uniformly around the circumference. For an uncracked shroud there is a tendency for more load transfer to occur at 90 degrees from the seismic line of action where the shroud is stiffer. For a cracked shroud with restraints installed, the lower spring provides a hard spot on the shroud at 45 degrees from the seismic line of action and a larger percentage of the seismic load would be transferred there. These non-uniform load paths may cause the friction between the core plate and the shroud to be overcome producing local sliding of the core plate relative to the shroud. The magnitude of the relative sliding will be limited to the sum of the gaps between the stud and the stud hole in the core plate plus the gap between the stud and its hole in the shroud. After these gaps are closed the stud acts as a shear pin with a horizontal stiffness of approximately 174 kip/inch. The total nominal radial gap is 5/16 inch. With stiffness of 174 kip/inch, the relative elastic deformation due to stud bending would be about 0.025 inch if only 17 of the 34 studs are conservatively assumed to resist the 74 kip seismic shear load for the Emergency case. The largest local horizontal motion of the core plate relative to the shroud could therefore be 0.34 inch. From the Peach Bottom seismic results for the shroud repair that appear in GENE-771-60-0994, the gross elastic horizontal seismic motions of the shroud at the core plate elevation are 0.32 inch, 0.67 inch and 0.88 inch for N+U, E and F load combinations respectively. Adding the 0.34 inch local deformation from above to these gross shroud motions results in values of 0.66, 1.01, and 1.22 inch for N+U, E and F load combinations which are less than the allowable elastic displacement values from the Design Specification of 0.75, 1.12, and 1.49 inch respectively.

## 3. Conclusions

3.1 No gross sliding of the core plate as a unit relative to the shroud will occur for any of the load combinations in the Peach Bottom Design Specification for the shroud repair project.

3.2 Local sliding of the core plate relative to the shroud may occur near one or more core plate studs. The magnitude of the local sliding is limited to the gap between the stud and the stud holes in the core plate and shroud plus the elastic deformation of the stud in shear and bending. This resultant local sliding, when added to the gross shroud seismic displacement, is less than the allowable elastic displacements for all load combinations.

3.3 Wedges between the core plate and shroud are not required.

Table 1

Load Condition	Uplift Force on Core Plate (kip)	Net Core Plate Clamping Force (kip)	Available Friction Load (kip)	Horizontal Seismic Load (kip)
Norm + Upset	258	999	200	42
Emergency	260	997	199	74
Faulted	341	916	183	69



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### REVISION STATUS SHEET

DOC TITLE REACTOR PRESSURE VESSEL.

LEGEND OR DESCRIPTION OF GROUPS

TYPE: STRESS REPORT

DENOTES CUMULATIVE  
CHANGES TO REVISION 2

FME: PEACH BOTTOM 2 AND 3

MPL NO: PRODUCT SUMMARY SEC. 7

THIS ITEM IS OR CONTAINS A SAFETY RELATED ITEM YES ☒ NO EQUIP CLASS P

REVISION				C
0	RM-01514 9/24/94			
1	J. L. TROVATO 11/8/94	RJA		
	CN01808 CHK BY: J. L. TROVATO			
2	J. L. TROVATO 11/18/94	RJA		
	CN 01861 CHK BY: J. L. TROVATO			
3	J. L. TROVATO 06/09/95	RJA		
	CN 02616 CHK BY: J. L. TROVATO			
4	J. L. TROVATO JUN 21 1995 RJA			
	CN 02806 CHK BY: J. L. TROVATO			
PRINTS TO				
MADE BY J.L.TROVATO 9/22/94		APPROVALS A.S. HERLEKAR 9/24/94	GENERAL ELECTRIC COMPANY 175 CURTNER AVENUE SAN JOSE CALIFORNIA 95125	
CHK BY J.L TROVATO 9/22/94		ISSUED BY R.J. AHMANN 9/24/94	CONT ON SHEET 2	

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**1. SCOPE**

1.1 This document is the ASME Code Section III Paragraph N-142 Stress Report for the Reactor Pressure Vessel. This analysis addresses the new loads applied to the vessel as a result of the installation of the shroud stabilizers, which function to replace horizontal welds H1 through H7 and cracking of weld H8 in the core shroud.

**2. APPLICABLE DOCUMENTS**

2.1 General Electric Documents. The following documents form a part of this stress report to the extent specified herein.

**2.1.1 Supporting Documents**

- |  |                |
|--|----------------|
| a. Code Design Specification                   | 25A5580 Rev. 4 |
| b. Shroud Repair Hardware Design Specification | 25A5579 Rev. 3 |

2.1.2 Supplemental Documents. Documents under the following identities are to be used with this stress report.

None

2.2 Codes and Standards. The following documents of the specified issue form a part of this specification to the extent specified herein.

**2.2.1 American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code**

- a. Section III, 1965 Edition and Addenda through Winter 1965

**2.2.2 Other Documents**

- a. General Electric Drawing 886D449 P2, Sht. 1 Rev. 11
- b. General Electric Drawing 886D449 P2, Sht. 7, Rev. 8, "Vessel Loadings"
- c. Babcock and Wilcox Report dated May 16, 1973, "Stress Report for Peach Bottom Unit 2 Reactor Vessel" (VPF #1896-146-1)
- (1) Report No. 20 "Shell Analysis", Rev. 0
- (2) Report No. 11 "Shroud Support System Analysis", Rev. 2
- (3) Report No. 10 "Brackets", Rev. 0.

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- (4) Report No. 8, "Support Skirt Analysis", Rev. 0
- d. Babcock and Wilcox Report dated September 5, 1973, "Stress Report for Peach Bottom Unit 3 Reactor Vessel" (#610-0146-51/52)
  - (1) Report No. 20 "Shell Analysis", Rev. 0
  - (2) Report No. 11 "Shroud Support System Analysis", Rev. 2
  - (3) Report No. 10 "Brackets", Rev. 0.
  - (4) Report No. 8, "Support Skirt Analysis", Rev. 0
- e. "Theory of Plates and Shells", by S. Timoshenko, 2nd Edition
- f. "Roark's Formulas for Stress and Strain", by W.C. Young, 6th Edition
- g. General Electric Drawing No. 112D6490, Rev. 0, "Detail Support, Lower."
- h. "Reactor Pressure Vessel Power Rerate Stress Report Reconciliation for Peach Bottom Nuclear Power Plant Units 2 and 3", G.E. Report No. NEDC-32166, Class II, dated January 1993
- i. "Fatigue Evaluation of the Peach Bottom II and III Reactor Vessels", G.E. Report No. GE-NE-523-61-0493, dated May 1993.
- j. General Electric Drawing No. 729E762, Rev. 0, "Reactor Thermal Cycles."
- k. General Electric Drawing No. VPF # 1896-64-7, "Shroud Support."

### 3. GENERAL DESCRIPTION

3.1 The purpose of the shroud stabilizers is to structurally replace all of the horizontal girth welds in the core shroud and shroud support. These welds were required to both horizontally and vertically support the core top guide, core support plate, and shroud head, and to prevent core bypass flow to the downcomer region. The core top guide and core support plate horizontally support the fuel assemblies and maintain the correct fuel channel spacing to permit control rod insertion.

3.2 The design requirements for the shroud stabilizers were separated into two documents. The first document addressed those requirements that were not under the jurisdiction of the ASME Code (Paragraph 2.1.1.b). The second document addressed those requirements that were under the jurisdiction of the ASME Code (Paragraph 2.1.1.a).

3.3 This Stress Report documents the acceptability of the structural integrity requirements of the Code Design Specification defined in Paragraph 2.1.1.a.


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#### 4. ANALYSIS

4.1 The Design Specification (2.1.1.a) defines three new design mechanical loads on the reactor pressure vessel. These loads and their point of application are shown in Figure 1 and Table 1. These loads are separated by a distance of greater than  $2.5 \sqrt{Rt} = 70"$  (2.2.1.a) and therefore, can be treated as separate forces. Each of F1, F2, and F3 are addressed below.

4.2 The force F1 (= 92,900 lbs) is applied to the reactor pressure vessel (RPV) shell 72 inches above the shroud support plate. It is a local force applied in the radial direction by the shroud repair during a maximum credible earthquake (MCE). At this elevation the RPV shell is 6.125 inches thick minimum (2.2.2.c(1)).

4.2.1 Compute stresses induced in RPV due to  $F_1 = 92.9$  kips applied at approximately 72 inches above the support plate during MCE:

Use theory of plate and shells by S. Timoshenko (2.2.2.e, pg. 471)

$$\begin{aligned} R &= 125.5" && \text{Inside R of RPV} \\ h &= 6.125" && \text{Thickness of RPV exclusive of cladding} \\ \alpha &= 125.5 + 6.125/2 = 128.563" && \text{mean radius} \end{aligned}$$

$$\beta = \left( \frac{3(1-\nu^2)}{\alpha^2 h^2} \right)^{1/4}$$

$$\nu = 0.29 \text{ Poisson's ratio (2.2.2.c(1))}$$

$$\beta = \left( \frac{3(1-0.29^2)}{128.563^2 \times 6.125^2} \right)^{1/4} = 0.046$$

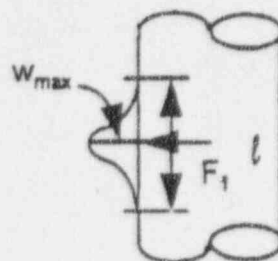
$$M_{Max} = P/4\beta \text{ and } P = F_1/2l$$

where  $l$  is contact width of lower contact plate, 5 in.

$$M_{MAX} = \frac{F_1}{(2)(5)(4\beta)} = 50.5 \text{ in-k/in}$$


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From paragraph 2.2.2.e page 474 deflection under load is

$$W_{MAX} = \frac{P_1 \alpha^2 \beta}{2Eh} = \frac{9.29 \times 128.563^2 \times 0.046}{2 \times 28.7 \times 10^3 \times 6.125} = 0.02"; \text{ since } E = 28.7 \times 10^3 \text{ ksi (2.2.2.c(1))}$$

$$\sigma_t = 6M_{MAX}/h^2 = 8.08 \text{ ksi}$$

$$\sigma_r = EW_{MAX}/\alpha + 6 \nu M_{MAX}/h^2 = 6.81 \text{ ksi}$$

$$\sigma_t = 8.08 \text{ ksi}$$

$$\sigma_r = 6.81 \text{ ksi}$$

4.2.2 The maximum value of  $P_t$  stress intensity due to this load is negligible and the maximum value of  $P_b$  stress intensity due to this load is 8.08 ksi. These stress intensities occur directly under the point of load application.

4.2.3 The existing primary membrane stress intensities in the shell per the original Stress Report (Paragraph 2.2.2.c(1), Page B-9-20) are 26.8 ksi ( $P_t$ ) and 28.2 ksi ( $P_t + P_b$ ).

4.2.4 The new value of  $P_t$  is same as original value of 26.8 ksi. The new value of  $P_t + P_b$  can be conservatively calculated as  $28.2 + 8.08 = 36.28$  ksi.

4.2.5 The allowable value of primary membrane  $P_m$  stress intensity is  $S_m$ , which equals 26.7 ksi and the allowable value of primary local ( $P_t$ ) plus primary bending ( $P_t + P_b$ ) stress intensity is  $3 S_m = 80.0$  ksi for faulted and  $2.25 S_m = 60$  ksi for emergency conditions. Therefore, both faulted and emergency conditions allowables are met.

4.2.6 Primary stress intensity ( $P_b$ ) for normal/upset condition  $F_1 = 33.4$  kips  $= 33.4/92.9 \times 8.08 = 2.91$  ksi, and primary local stress intensity ( $P_t$ ) is negligible.

4.2.6.1 The existing  $P_t = 26.8$  ksi, and ( $P_t + P_b$ ) = 28.2 ksi. The new  $P_t = 26.8$  ksi while new ( $P_t + P_b$ ) =  $28.2 + 2.91 = 31.11$  ksi < 40 ksi ( $1.5 S_m$ ). And since the increase in the stress intensity is very small ( 2.91 ksi compared to the allowable of  $3 S_m = 80$  ksi for primary plus


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secondary stress intensity), the power rerate analysis ( 2.2.2.h ) & fatigue evaluation for revised thermal cycles ( 2.2.2.i ) is unaffected.

4.3 The force  $F_1$  is applied to the reactor pressure vessel (RPV) shell 244 inches above the shroud support plate. It is a local force applied in the radial direction by the shroud repair during a MCE. At this elevation the RPV shell is 6.125 inches thick minimum (Paragraph 2.2.2.c(1)).

4.3.1 Stresses in RPV due to  $F_1 = 31.39$  kips applied at approximately 244 inches above the shroud support plate during MCE, can be obtained by scaling from values obtained for  $F_1 = 92.9$  kips with  $l = 4$  inches contact width.

$$\sigma_1 = 3.42 \text{ ksi}$$

$$\sigma_2 = 2.88 \text{ ksi}$$

4.3.2 The maximum value of  $P_1$  Stress intensity due to this load is negligible and the maximum value of  $P_b$  is 3.42 ksi. These stress intensities occur directly under the point of load application.

4.3.3 The existing primary membrane stress intensities in the shell per the original Stress Report (Page B-9-20 of 2.2.2.c(1)) is 26.8 ksi, ( $P_1$ ) and 28.2 ksi ( $P_1 + P_b$ ).

4.3.4 The new value of  $P_1$  is conservatively same as existing value of 26.8 ksi. The new value of  $P_1 + P_b$  can be conservatively calculated as  $3.42 + 28.2 = 31.64$  ksi.

4.3.5 The faulted allowable value of primary membrane stress intensity is  $S_m$ , which equals 26.7 ksi and the allowable value of primary local ( $P_1$ ) and the primary plus bending ( $P_1 + P_b$ ) stress intensity is  $3 S_m = 80.0$  ksi for faulted and  $2.25 S_m = 60$  ksi for emergency condition. Therefore, both faulted and emergency conditions allowables are met.

4.3.6 Since the faulted stress intensities ( $P_1$ ) and ( $P_1 + P_b$ ) are below upset condition allowable of 40 ksi., the primary stress intensity for normal/upset condition  $F_1 = 17,100$  lbs is satisfied by inspection as the  $F_1$  is lower than  $F_1$  of MCE condition. And since the increase in the stress intensity is very small [  $(17.1/31.39) 3.42 = 1.87$  ksi compared to the allowable of  $3 S_m = 80$  ksi for primary plus secondary stress intensity ], the power rerate analysis ( 2.2.2.h ) & fatigue evaluation for revised thermal cycles ( 2.2.2.i ) is unaffected.

4.4 The force  $F_2$  is applied to vertical plate at 4.25 (2.2.2.g) inches from the inside surface of the RPV shell (This results in moment arm of  $4.25 + 6.125/2 = 7.3$  at RPV shell center line). Since complete load & moment is transferred at shell center line, the analysis in 4.4.1 through 4.4.5 is valid for both weld H8 cracked & uncracked cases. The value of  $F_3$  is 372,650 pounds for maximum MCE, and 248,500 pounds for emergency and 172,910 pounds for DBE plus normal pressure & 249,500 pounds for Upset thermal condition. The effects of  $F_2$  on shell are


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addressed in 4.4.1 thru 4.4.5 and on baffle plate junction with shell in Section 4.4.6 (H8 uncracked) and Section 4.4.7 (H8 cracked).

4.4.1 Apply  $F_s$  in any condition as vertical load and it will transfer as axial load  $V = F_s$  lbs and moment of  $7.91 F_s$  k-in. This load  $V = F_s$  kips. and moment  $7.91 F_s$  k-in. will be assumed to be resisted by the width of RPV shell equal to the width ( $b = 13.5"$ ), of the horizontal plate of stabilizer lower support (paragraph 2.2.2.g).

4.4.2 Using analysis methods for edge loads for  $m_e$  (para. I-233 of 2.2.1.a) and direct membrane stress as  $P/t$ , the stresses in shell are as follows:

$$\sigma_t = 6 m_o / t^2 + P / t;$$

$$\sigma_t = \frac{EW_o}{R_m} + 6v \frac{m_o}{t^2}$$

where

- $m_e$  = End moment =  $7.91 F_s / 13.5$  k-in/in;
- $t$  = Thickness of shell =  $6.125"$ ;
- $P$  =  $F_s / 13.5$  kips/in;
- $E$  = Young's Modulus =  $28.7 \times 10^3$  ksi;
- $R_m$  = Vessel Mean Radius =  $128.5625$  in.;
- $v$  = Poisson's ratio =  $0.29$ ;
- $W_o$  = Deflection at edge (calculated below).

Using para. I-232(2) of 2.2.1.a, the limiting value of  $W_o = m_e / 2\beta^3 D$ , where  $D = Et^3 / 12 (1-v^2)$ ,  $\beta =$

$4 \sqrt{\frac{3(1-v^2)}{R_m^2 t^2}}$  and substituting values of  $D$ ,  $\beta$  in terms of  $E$ ,  $t$ ,  $R_m$ , the expression for  $\sigma_t$  can be

simplified as  $\sigma_t = \frac{6m_o}{t^2} \left( v + \sqrt{\frac{1-v^2}{3}} \right)$ . And with  $v = 0.29$   $\sigma_t = \frac{6m_o}{t^2} (0.84)$ .

Further, since  $t = 6.125"$ , the final  $\sigma_t = 0.094 F_s$  ksi,  $\sigma_r = 0.073 F_s$  ksi.


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These  $\sigma_1, \sigma_2$  stresses will be used to calculate the stress intensity by principle stress difference formulas. Since shear stress is zero, the principle stresses are  $\sigma_1 = \sigma_t$ ;  $\sigma_2 = \sigma_r$ . Primary stress intensity is maximum of  $\sigma_1, \sigma_2$  or  $\sigma_1 - \sigma_2$ .

4.4.3 Primary local membrane plus bending ( $P_t + P_b$ ) stress intensity for faulted conditions  $F_s = 372.65$  kips are as follows:

$$4.4.3.1 \quad \sigma_t = \sigma_1 = 0.094 \times 372.65 = 35.03 \text{ ksi}$$

$$\sigma_r = \sigma_2 = 0.073 \times 372.65 = 27.2 \text{ ksi}$$

Thus the maximum primary stress intensity ( $P_t + P_b$ ) = 35.03 ksi

4.4.3.2 From page B-9-20 of original stress report (2.2.2.c(1)) the existing maximum primary local membrane stress intensity is 26.8 ksi and ( $P_t + P_b$ ) is 28.2 ksi. And as the major stresses due to  $F_s$  are  $P_b$ , i.e.; while  $P_t = 0.007 F_s = 2.61$  ksi,  $P_b$  is  $0.087 F_s = 32.42$  ksi out of a total  $P_t + P_b$  of 35.03 ksi. And conservatively the new values will be

$$P_t = 26.8 + 2.61 = 29.41 \text{ ksi}$$

$$\text{and } P_t + P_b = 28.2 + 35.03 = 63.23 \text{ ksi}$$

However, the maximum  $P_t$ ,  $P_t + P_b$  values from page B-9-20 of the existing stress report at location of  $F_s$  (i.e. elem. #20 of Seal Shell model on page B-2-1 of 2.2.2.c(1)), are 17.86 ksi and 19.81 ksi. Thus these values could be used if required.

The allowable  $P_t$  and  $P_t + P_b$  stress intensity is  $1.5S_m = 40$  ksi in the original stress report. However, this is a faulted event and per 2.2.1.a the allowable for faulted conditions is  $3S_m = 80$  ksi.

4.4.4 Primary stress intensity ( $P_t + P_b$ ) and ( $P_t$ ) for emergency conditions  $F_s = 248,500$  lbs are as follows:

4.4.4.1 The primary stress intensity value from 4.4.3.2 for  $F_s = 372,650$  lbs can be used to get the  $\sigma_1$  as follows:

$$\begin{aligned} \sigma_1 &= \frac{248500}{372650} \times 35.03 \text{ and } \sigma_r = \frac{248500}{372650} \times 2.61 \\ &= 23.36 \text{ ksi } (P_t + P_b) \quad = 1.74 \text{ ksi } (P_t) \end{aligned}$$

4.4.4.2 Using same existing maximum primary stress intensity of 4.4.3.2 (for faulted condition) of  $P_t = 26.8$  ksi and  $P_t + P_b = 28.2$  ksi., the new values are:



$$P_t + P_s = 28.2 + 23.36 \quad \text{and} \quad P_t = 26.8 + 1.74$$

$$= 51.56 \text{ ksi} < 60 \text{ ksi (2.1.1.a)} \quad = 28.54 \text{ ksi} < 2.25 S_m = 60 \text{ ksi. (2.1.1.a)}$$

4.4.5 Normal/upset conditions evaluations required for primary, primary plus secondary, and peak stress intensities per 2.2.1.a are shown in this section.

4.4.5.1 Primary stress intensity evaluation is required for  $F_s = 172,910$  pounds which will give  $(P_t + P_s)$  value of  $\frac{172910}{372650} \times 35.03 = 16.25 \text{ ksi}$ . and  $P_t = \frac{172910}{372650} \times 2.61 = 1.21 \text{ ksi}$

4.4.5.2 The existing primary stress intensity at this location for operating condition is  $P_t = 17.86 \text{ ksi}$ . and  $P_t + P_s = 19.81 \text{ ksi}$ . (page B-9-1 of 2.2.2.c(1)). Thus the new value of  $P_t + P_s$  at this location is

$$P_t + P_s = 19.81 + 16.25 \quad \text{and} \quad P_t = 17.86 + 1.21$$

$$= 36.06 \text{ ksi} < 1.5 S_m = 40 \text{ ksi} \quad = 19.07 \text{ ksi} < 1.0 S_m = 26.7 \text{ ksi}$$

4.4.5.3 The primary plus secondary stress intensity for upset condition load  $F_s$  is required for two (2) sets of loading cycles as follows (at RPV shell):

$F_s = 172,910 \text{ lbs}$  for 482 cycles normal & excessive heat-up / cooldown transients  
and

$F_s = 249,985 \text{ lbs}$  for 30 cycles of loss of feedwater pump & HPCI/RCIC injection transients

4.4.5.4 Primary plus secondary stress range for 482 cycles is  $S_n = \frac{172,910}{372,650} \times 35.03 = 16.25 \text{ ksi}$ .  
The existing value of same primary plus secondary stress intensity range is  $35.0 \text{ ksi}$  (page C-9-21 of 2.2.2.c(1)). Thus the new value of  $S_n = 35.0 + 16.25 = 51.25 \text{ ksi} < 3 S_m = 80 \text{ ksi}$ .

4.4.5.5 Primary plus secondary stress intensity range for 30 cycles is  $S_n = \frac{249,985}{372,650} \times 35.03 = 23.5 \text{ ksi}$ . The existing value of the same primary plus secondary stress intensity range is  $35.0 \text{ ksi}$  (page C-9-21 of 2.2.2.c(1)). Thus the new value of  $S_n = 35.0 + 23.5 = 58.5 \text{ ksi} < 3 S_m = 80 \text{ ksi}$ .

4.4.5.6 Fatigue, i.e., peak stress intensity range, evaluation for all 512 ( $= 482 + 30$ ) cycles per 2.2.2.i is calculated using peak stress intensity range of 30 cycles  $F_s$  since it is highest, is as follows:

$$S_r = K_t \frac{S_n}{2} \text{ Since } S_n < 3 S_m, K_t = 1.0 \text{ for all 512 cycles.}$$



And there is no stress concentration factor per section C-8 of 2.2.2.c(1)

$$S_s = 27.0 \text{ (existing } S_s, \text{ page C-10-1 of 2.2.2.c (1))} + 23.5/2 = 38.75 \text{ ksi.}$$

$$N_{su} = 8400 \text{ (Figure N-415(A) of 2.2.1.a)}$$

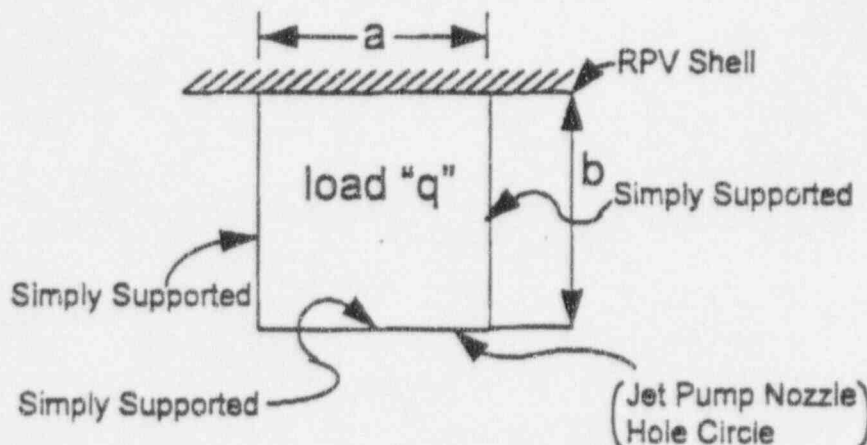
$$\text{Usage Factor} = UF = 512/8400 = 0.06 < 1.0.$$

Thus the power rerate analysis ( 2.2.2.h ) and fatigue evaluation for the revised thermal cycles ( 2.2.2.i ) is unaffected.

#### 4.4.6 Evaluation of RPV Shell and Baffle Plate Junction( Weld H8 Uncracked )

##### 4.4.6.1 For Faulted Condition F,

Due to the support afforded by jet pump nozzles to the baffle plate, the load  $F$ , will be essentially distributed over a rectangular plate between RPV shell and jet pump nozzle hole circle with the width equal to the width of the lower support plate as shown below:



where

$$a = \text{Width of horizontal lower support plate (2.2.2.g)} = 13.5'';$$

$$b = \text{Distance (radial) between shell inside radius (=125.5'') and jet pump nozzle hole circle radius} = 226.5/2 = 113.25'' \text{ (per 2.2.2.k)} = 12.25'';$$

$$q = \text{Distributed load} = F3/(13.5 \times 12.5) = 372.65/(12.25 \times 13.5) = 2.253 \text{ ksi};$$

Using formulas for middle of fixed edge moments (for uniformly loaded plate with one edge fixed, other three edges simple supported) from Timoshenko (2.2.2.e, page 241), the moment


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$\bar{M}_y = d_y q l^2$  (symbols per 2.2.2.3). Further, since  $b/a = 0.907$   $d_y = 0.0914$  from Table 52 of 2.2.2.e. And since  $l = 12.25$ " (smaller of  $a = 13.5$ " or  $b = 12.25$ " ),

$$\begin{aligned}\bar{M}_y &= (0.0914) (2.253) (12.25)^2 \\ &= 30.9 \text{ in-kips/in.}\end{aligned}$$

Further the bending stress  $\sigma_b = 6 \bar{M}_y / t^3$  and with  $t = 2.0625$ " (thickness of baffle plate), the bending stress value is

$$\begin{aligned}\sigma_b &= 30.9 * 6 / (2.0625)^3 \\ &= 43.58 \text{ ksi}\end{aligned}$$

And shear stress  $\tau = F_s / \text{Area} = F_s / \text{Perimeter} * 't'$

$$\begin{aligned}\tau &= 372.65 / 2 (12.25 + 13.5) (2.0625) \\ &= 3.51 \text{ ksi}\end{aligned}$$

Principal stress  $\sigma_1 = 43.58/2 + [ (43.58/2)^2 + (3.51)^2 ]^{1/2} = 43.86 \text{ ksi}$

$$\sigma_2 = -0.28 \text{ ksi}$$

The maximum stress intensity  $= \sigma_1 - \sigma_2 = 43.86 - (-0.28) = 44.14 \text{ ksi}$

The maximum primary membrane plus bending stress intensity at this location from the existing stress analysis (paragraph 2.2.2.c(2), page B-16-6) is 16.7 ksi. Therefore, the new maximum primary membrane plus bending ( $P_1 + P_b$ ) stress intensity is  $= 16.7 + 44.14 = 61.84 \text{ ksi}$  which is less than faulted allowable of  $3 S_m = 80 \text{ ksi}$  (pages B-17-1, B-17-5 of 2.2.2.c(2)). However, since this junction is also of inconel material and therefore, the  $3 S_m$  of inconel material  $= 69.9 \text{ ksi}$ , being lower than  $3 S_m = 80 \text{ ksi}$  of carbon steel, the vessel material, will be used as allowable.

Since allowable for ( $P_1$ ) is same as for ( $P_1 + P_b$ ) and calculated value of  $P_1$  is always lower than the calculated value of ( $P_1 + P_b$ ) in all conditions,  $P_1$  evaluation is not documented separately for any cases.

4.4.6.2 Primary local membrane plus bending stress intensity ( $P_1 + P_b$ ) for the Emergency condition  $F_3 = 248.5 \text{ kips}$  is calculated by ratioing down the faulted condition value ( $P_1 + P_b$ ) for loading of 372.65 kips. Thus the new value is ( $P_1 + P_b$ )  $= 46.14 \text{ ksi}$  which is less than the allowable of  $2.25 S_m = 52 \text{ ksi}$  for this condition (paragraph 2.1.1.a).

4.4.6.3 Primary stress intensity evaluation for upset conditions is required for  $F_3 = 172,910$  pounds which will give ( $P_1 + P_b$ ) value of  $172,910 / 372,650 * 44.14 = 20.48 \text{ ksi}$ .



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The existing primary stress intensity for operating conditions is 11.5 ksi (page B-16-8 of 2.2.c(2)). Thus the new value of  $P_1 + P_b$  at this location is

$$P_1 + P_b = 11.5 + 20.48$$

$$= 31.98 \text{ ksi} < 1.5 S_m = 35 \text{ ksi}$$

4.4.6.4 The primary plus secondary stress intensity range for upset condition F3 is required for three (3) sets of loading cycles, (to account modified thermal cycles of 2.2.2.i) as follows (at junction of baffle plate and shell):

F3 = 172,910 lbs for 226 cycles of normal & excessive heatup / cooldown transients

and

F3 = 249,985 lbs for 30 cycles of loss of feedwater pump & HPCI/RCIC transients

and

F3 = 172,910 - 78,200 = 94,710 lbs for 256 cycles of cooldown transient without DBE

4.4.6.5 The primary plus secondary stress intensity range for 226 cycles is  $S_n = 172,910 / 372,650 \times 44.14 = 20.48$  ksi. The existing value of the same primary plus secondary stress intensity range is 31.6 ksi (page B-16-15 of 2.2.2.c(2) range of all cases except case VI See Table 2 for details). Thus the new value of  $S_n = 31.6 + 20.48 = 52.08$  ksi  $> 3 S_m = 70$  ksi. Thus simplified elastic-plastic analysis will be required.

4.4.6.6 The primary plus secondary stress intensity range for 30 cycles is  $S_n = (249,985 / 372,650) \times 44.14 = 29.61$  ksi. The existing value of the same primary plus secondary stress intensity range is 72.0 ksi (per B-7-1 of 2.2.2.c(2) only cases III and VI are part of this transient, Table 4 for details). Thus the new value of  $S_n = 72.0 + 29.61 = 101.61$  ksi, which is greater than  $3 S_m = 70$  ksi. Thus simplified elastic-plastic analysis will be required.

4.4.6.7 The primary plus secondary stress intensity range for 256 cycles is  $S_n = 94,710 / 372,650 \times 44.14 = 11.22$  ksi. The existing value of the same primary plus secondary stress intensity range is 31.3 ksi (page B-16-15 of 2.2.2.c(2) maximum of case IV either at bottom or at top). Thus the new value of  $S_n = 31.3 + 11.22 = 42.52$  ksi  $< 3 S_m = 70$  ksi. Thus no simplified elastic-plastic analysis will be required.

4.4.6.8 The peak stress intensity existing range, for 226 cycles is 66.3 ksi (Table 3 stress concentration factor, pg. B-17-2. for details). Thus the new  $S_p = 66.3 + (20.48)(1.64) = 99.89$  ksi where 1.64 is the bending stress concentration factor per page B-17-2 of 2.2.2.c(2).

The fatigue evaluation for 226 cycles F3 is as follows: ( Since  $S_n = 72.08$  ksi  $> 3 S_m = 70$  ksi and material parameters of  $m = 2$ ,  $n = 0.2$  (per pg. B-17-5 of 2.2.2.c(2)  $S_m < S_n < m S_m$ )



$$K_e = 1.0 + [(1-n)/(m-1)n] [S_n/3 S_m - 1] \text{ (per 2.2.1.a)}$$

$$= 1.0 + [0.8/(1 \times 0.2)] [(72.08/70) - 1] = 1.12$$

$$S_a = K_e \cdot S_p/2. \text{ Since } S_n < 3 S_m$$

$$S_a = (99.89) (1.12)/2 = 55.94 \text{ ksi}$$

$$N_{all} = 3,000 \text{ (Figure N-415(A) of 2.2.1.a)}$$

$$\text{Usage Factor} = UF1 = 226/3,000 = 0.075$$

4.4.6.9 The peak stress intensity evaluation for 30 cycles F3 is as follows: (Since  $S_n = 101.61 \text{ ksi} > 3 S_m = 70 \text{ ksi}$  and material parameters of  $m = 2$ ,  $n = 0.2$  (per pg. B-17-5 of 2.2.2.c(2)  $S_m < S_n < m S_m$ ). Thus

$$K_e = 1.0 + [(1-n)/(m-1)n] [S_n/3 S_m - 1] \text{ (per 2.2.1.a)}$$

$$= 1.0 + [0.8/(1 \times 0.2)] [(101.61/70) - 1] = 2.81$$

The fatigue evaluation for these 30 cycles is as follows: The existing peak stress intensity per page B-17-3 of 2.2.2.c(2) is 146.8 ksi (Table 5 for details).

The extra peak stress intensity for this F3 load is (29.61) (Bending stress concentration factor of 1.64 per page B-17-2 of 2.2.2.c(2)) = 48.56 ksi. The new (total) peak stress intensity  $S_p = 146.8 + 48.56 = 195.36 \text{ ksi}$ . And with  $K_e = 2.81$ , the alternating stress  $S_a = 2.81/2 \times 195.36 = 274.48 \text{ ksi}$ . The allowable cycles at this  $S_a$  level per Figure N-415(A) of 2.2.1.a are 45. Thus usage factor  $UF2 = 30/45 = 0.67$ .

4.4.6.10 The peak stress intensity evaluation for 256 cycles F3 is as follows: (Since  $S_n = 42.52 \text{ ksi} < 3 S_m = 70 \text{ ksi}$ ,  $K_e = 1.0$  per 2.2.1.a)

The fatigue evaluation for these 256 cycles is as follows: The existing peak stress intensity per page B-17-3 of 2.2.2.c(2), case IV, is 31.3 ksi.

The extra peak stress intensity for this F3 load is (11.22) (Bending stress concentration factor of 1.64 per page B-17-2 of 2.2.2.c(2)) = 18.4 ksi. The new (total) peak stress intensity  $S_p = 31.3 + 18.4 = 49.7 \text{ ksi}$ . And with  $K_e = 1.0$ , the alternating stress  $S_a = 49.7/2 = 24.85 \text{ ksi}$ . The allowable cycles at this  $S_a$  level per Figure N-415(A) of 2.2.1.a are 40,000. Thus usage factor  $UF3 = 256/40,000 = 0.006$ .

4.4.6.11 The cumulative usage factor (revised) is as follows:

$$UF = UF1 + UF2 + UF3$$

The cumulative  $UF = 0.075 + 0.67 + 0.006 = 0.751 < 1.0$  below limits of 2.2.1.a



Thus the power rerate analysis ( 2.2.2.h ) and fatigue evaluation for revised thermal cycles ( 2.2.2.i. ) is unaffected.

#### 4.4.7 Evaluation of RPV Shell and Baffle Plate Junction( Weld H8 Cracked )

##### 4.4.7.1 FEM for Weld H8 Cracked Condition

A one quarter finite element model of the baffle plate using computer program ANSYS was analyzed for this condition. The edge of plate at RPV junction was fixed while the junction at shroud was free representing severed H8 weld condition. At lines of symmetry i. e. , 0 degree and 90 degree, proper boundary conditions were used. First unit load case of 449.3 kips vertical load applied as pressure on very small areas ( representative case of tie rod load ) was analyzed. Second unit load case of uniform pressure of 1,000 psi was also analyzed representing  $\Delta P$  condition. The results of these unit loading cases are summarized below:

Unit  $\Delta P$  of 1,000 psi

$P_l = 0.5 \text{ ksi}$  ( 0.0005 ksi for  $\Delta P = 1 \text{ psi}$  ) and  $P_l + P_b = 442 \text{ ksi}$  ( 0.442 ksi for  $\Delta P = 1 \text{ psi}$  )

$P_l + P_b + Q = 442 \text{ ksi}$  ( = 0.442 ksi for  $\Delta P = 1 \text{ psi}$  )

Unit tie rod load of 449.3 kips

$P_l = 12.6 \text{ ksi}$  ( 0.028 ksi for 1 kip load ) and  $P_l + P_b = 47.5 \text{ ksi}$  ( 0.106 ksi for 1 kip load )

$P_l + P_b + Q = 106.8 \text{ ksi}$  ( 0.298 ksi for 1 kip load )

The  $\Delta P$  values for M. S. LOCA and Normal conditions are = 51 psi & 33.03 psi per 2.1.1.b while, the  $\Delta P$  value for Upset thermal condition is = 35.68 psi per 2.1.1.b.

##### 4.4.7.2 Evaluation for Faulted Condition

Primary local membrane (  $P_l$  ) stress intensity for faulted conditions  $F_3 = 372.65 \text{ kips}$  is =  $0.028 \times 372.65 + 0.0005 \times 51 = 10.46 \text{ ksi}$  which is less than faulted allowable of  $3S_m = 70 \text{ ksi}$ . for Inconel ( baffle plate material ) as well as  $3S_m = 80 \text{ ksi}$ . for carbon steel ( RPV shell material ). Since allowable for (  $P_l$  ) is same as for (  $P_l + P_b$  ) and calculated value of  $P_l$  is always lower than the calculated value of (  $P_l + P_b$  ) in all conditions,  $P_l$  evaluation is not documented for remaining cases.

Primary local membrane plus bending (  $P_l + P_b$  ) stress intensity for faulted conditions  $F_3 = 372.65 \text{ kips}$  is =  $0.106 \times 372.65 + 0.442 \times 51 = 62.04 \text{ ksi}$  which is less than faulted allowable of  $3S_m = 70 \text{ ksi}$ . for inconel ( baffle plate material ) as well as  $3S_m = 80 \text{ ksi}$ . for carbon steel ( RPV shell material ).

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#### 4.4.7.3 Evaluation for Emergency Condition

Primary local membrane plus bending stress intensity ( $P_I + P_b$ ) for the Emergency condition load of 248.5 kips is  $= 0.106 \times 248.5 + 0.442 \times 51 = 48.88$  ksi which is less than  $2.25S_m = 52.5$  ksi. for inconel ( baffle plate material ). as well as  $2.25S_m = 60$  ksi. for carbon steel ( RPV shell material ).

#### 4.4.7.4 Evaluation for Normal / Upset Conditions

##### 4.4.7.4.1 Evaluation for Primary Stress Intensity

Primary local membrane plus bending stress intensity ( $P_I + P_b$ ) for the Normal/Upset condition load of 172.91 kips is  $= 0.106 \times 172.91 + 0.442 \times 33.03 = 32.93$  ksi which is less than  $1.5S_m = 35$  ksi. for inconel ( baffle plate material ). as well as  $1.5S_m = 40$  ksi. for carbon steel (RPV shell material ).

##### 4.4.7.4.2 Evaluation for Primary plus Secondary Stress Intensity

The primary plus secondary stress intensity range  $S_n$  for upset condition loads of 172.91 kips , 94.71 kips and 249.985 kips is calculated for all loading cycles per 2.2.2.i at junction of baffle plate and RPV shell.

The highest primary plus secondary stress intensity range for 226 cycles of 172.91 kips is  $S_n = 0.238 \times 172.91 + 0.442 \times 33.03 = 55.75$  ksi, while  $S_n$  for 30 cycles of 249.985 kips is  $= 0.238 \times 249.985 + 0.442 \times 35.68 = 75.27$ ksi, and for remaining 256 cycles is  $= 0.238 \times 94.71 + 0.442 \times 33.03 = 37.14$  ksi. All of these  $S_n$  values are less than  $< 3S_m = 70$  ksi ( conservatively, for baffle plate material ), except for 30 cycles of 249.985 kips load. Thus a simplified elastic-plastic analysis will be required for the 30 cycle loading case.

##### 4.4.7.4.3 Evaluation for Fatigue

Since the  $S_n$  values in the H8 cracked case are lower than the  $S_n$  values for the corresponding cases of 226 cycles, 30 cycles , & 256 cycles under H8 uncracked case, the fatigue, and peak stress intensity range, for all cycles for H8 cracked is enveloped by the similar calculations for H8 uncracked case. Thus the maximum cumulative fatigue usage factor for H8 cracked condition, is conservatively, also equal to  $0.751 < 1.0$ .

4.5 Evaluation for Peach Bottom Unit 2 for  $F_1$ ,  $F_2$ ,  $F_3$  and their effects on all code requirements is satisfied as documented in sections 4.1 through 4.4. The original stress report for Peach Bottom Unit 3 (2.2.2.d) states that stress reports 20 (2.2.2.d(1)) and stress report 11 (2.2.2.d(2)) for Unit 3 are exact duplicates of same reports for Unit 2. Hence  $F_1$ ,  $F_2$ ,  $F_3$  assessments for Unit 3 is same as shown above for Unit 2 and thus meets all the code (2.2.1.a) requirements. It should be noted that seismic shears and overturning moments for shroud support used in the analysis (page B-11-A of 2.2.2.c(2)) are higher than those required by G.E. Drawing Design (2.2.2.b).


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4.6 In accordance with power rerate analysis/reconciliation documentation (2.2.2.h) and fatigue evaluation of Peach Bottom II and III Reactor Vessels for revised thermal cycles (2.2.2.i), there are no changes required to the original stress analysis (2.2.2.c and 2.2.2.d) in the regions affected by loads  $F_1$ ,  $F_2$ , and  $F_3$ . Thus power rerate analysis and fatigue evaluation for revised thermal cycles is still valid.

4.7 All of the stress intensities due to the new design mechanical loads  $F_1$ ,  $F_2$ , and  $F_3$  satisfy the allowable stress intensities of the original Code of Construction (Paragraph 2.2.1.a).

4.8 The new seismic loads on the stabilizer bracket location ( $F_4$ ) is 334,000 lbs for MCE. These when conservatively converted into individual bracket loads (i.e., taken two bracket only in any one directional earthquake) result in individual bracket loads of 167 kips (for MCE). This load is less than the stabilizer bracket seismic loadings of 300 kips (conservatively DBE only) per document 2.2.2.b, Table 9. Thus the effect of  $F_4$  (as a result of shroud stabilizer modification) on RPV is enveloped by the existing stress analysis including fatigue evaluation (2.2.2.c(3)) since page 12 of 2.2.2.c(3) states that it is using seismic loads from 2.2.2.b. Power rerate analysis (2.2.2.h) and fatigue evaluation for revised thermal cycles (2.2.2.i) are not affected since the existing analysis of stabilizer brackets is unchanged and these brackets were not critical components reevaluated in either document 2.2.2.h or 2.2.2.i.

4.9 The new seismic forces and moments on the base of RPV skirt are  $F_5$  and  $M_5$ . The max. of these values (MCE values) are  $F_5 = 284.2$  kips and  $M_5 = 6611$  kip-ft. These values are less than the seismic values of  $H_5 = 1083$  kips and  $M_5 = 40,138$  kip-ft (2.2.2.b) which are used in the original skirt stress analysis reports (page B-15-4 of 2.2.2.c(4) and 2.2.2.d(4)) for Peach Bottom Units 2 and 3 respectively. Thus original stress analysis of RPV skirt is still valid. These loads are only primary loads and do not affect fatigue evaluation. The power rerate analysis documentation (2.2.2.h) and fatigue evaluation documentation for revised thermal cycles (2.2.2.i) reevaluates support skirt but since seismic loading used in power rerate is the same as the original loading (2.2.2.b), the power rerate and fatigue evaluation for revised thermal cycles documentation is unaffected by these stabilizer modification forces and moments  $F_5$  and  $M_5$ .

4.10 The new seismic overturning moments and shears at the shroud support location are  $M_6$  = 129.6 k-ft,  $F_6$  = 143.1 kips in MCE. These loads are lower than the seismic moment and shear of 4885 k-ft and 238 kips (conservatively DBE only) per Table 10 of 2.2.2.b. Thus effects of  $M_6/V_6$  (new) on RPV is enveloped by the existing analysis since page B-11-A of 2.2.2.c(2) states that it is using seismic loads higher than those given in GE drawing (2.2.2.b). The shroud support leg buckling evaluation documented in the original stress report (pages B-18-2 through B-18-9 of 2.2.2.c(2)) is still valid because the seismic overturning moments from the revised analysis are lower than those used in the buckling evaluations. Power rerate analysis (2.2.2.h) and fatigue evaluation for revised thermal cycles (2.2.2.i) are not affected since the existing analysis of shroud support legs is unchanged and these legs were not critical components reevaluated in either document 2.2.2.h or 2.2.2.i.

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5.0 Based on the best of my knowledge and belief, it is hereby certified that the analysis documented in this Stress Report satisfies the requirements of ASME Boiler and Pressure Vessel Code Section III, 1965 Edition with Addenda through Winter 1965 and Design Specification listed in Paragraph 2.1.1.a. This certification is provided as required by Paragraph N-142 of said Section III.

Signature: *Ashokdewan*Date: *6/21/95*License Number: *C23562*State: *California**Expires on 12/31/1997*


**GE Nuclear Energy**

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**Table 1 - ADDITIONAL DESIGN MECHANICAL LOADS**

Force	(Normal/Uprct) DBE + Normal Pressure	Emergency	(Faulted) MCE + LOCA	Remarks
$F_1$	33,400 lbs	92,900 lbs	92,900 lbs	Primary Stress
$F_2$	17,110 lbs	51,990 lbs	51,990 lbs	Primary Stress
$F_3$	172,910 lbs	248,500 lbs	372,650 lbs	Primary Stress
	172,910 lbs(w/DBE)	-	-	Pri plus Sec. S.I Range (226 cycles) and fatigue
	94,710 lbs(w/o DBE)	-	-	Pri plus Sec. S.I Range (256 cycles) and fatigue
	249,985 lbs	-	-	Pri plus Sec. S.I Range (30 cycles) and fatigue
$F_4$	-	-	534,000 lbs	Seismic (Total) Tangential Load @ stabilizer Bracket
$F_5$	-	-	284,200 lbs	Seismic Shear Only @RPV skirt
$M_1$	-	-	6,611,000 ft-lbs	Seismic Moment @RPV skirt
$M_2$	-	-	129,600 ft-lbs	Seismic Moment @Shroud Support
$F_6$	-	-	143,100 lbs	Seismic Shear @ Shroud Support

**1) NOTES**

- $F_1$ ,  $F_2$ , and  $F_3$  are discrete loads applied over a small area. At any one point in time,  $F_1$ ,  $F_2$ ,  $F_3$  are each applied to one location. At any one point in time,  $F_4$  is applied to 4 locations 90° apart for the installation of four shroud stabilizer assemblies. DBE is a Design Basis Earthquake (OBE). MCE is a Maximum Credible Earthquake (SSE). The load  $F_4$  shown is the maximum and applies to one tie rod 180 degrees apart from  $F_1$  &  $F_2$ , while remaining tie rods have loads lower than  $F_4$  values shown above.
- The stress intensities shall meet the stress allowables of the ASME Code, Section III, for the load combinations defined by the Peach Bottom UFSAR. The original Code of Construction did not include Faulted load combinations. Faulted and Emergency load combinations shall meet the stress allowables as defined by the Peach Bottom UFSAR for the reactor pressure vessel.
- Loads  $F_1$ ,  $F_2$ ,  $F_3$  to be used in the evaluations are from document 2.1.1.a. Loads  $F_4$ ,  $F_5$ ,  $M_1$ ,  $M_2$  and  $F_6$  are those for cracked condition as documented in GENE-771-60-0994, Rev. 2.


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Table 2

Maximum primary plus secondary stress intensities ( $P + Q$ ), ksi, for 226 cycles case is range of all cases on page B-16-15 excluding case VI since it is L.O.F.W.P transition case.

Case	TOP			BOTTOM			2.2.2.c(2)
	H-L	L-R	R-H	H-L	L-R	R-H	Page #
Max. Primary	+6.6	+2.2	+2.4	+1.8	+9.3	+0.3	B-16-15 Case (1)
Min. Primary	-1.2	-8.8	-1.0	-6.0	-2.1	-3.3	B-16-15 Case (2)
Max./Min of cases	+21.0	+9.3	+9.4	+26.2	+0	+11.2	B-16-15
III,IV,V	-6.9	-31.3	-9.2	-8.3	-37.4	-6.3	B-16-15
Total +	+28.5	+11.5	+11.8	+28.0	+9.3	+11.4	Max.
Total -	-8.1	-40.1	-10.2	-14.3	-39.5	-9.9	Min.
Existing Range w/o Case VI	+36.6	+51.6	+22.0	+42.3	+48.8	+21.3	(Max-Min)
Absolute Max. Range	-	+51.6	-	-	-	-	Existing Revised
Contribution From $F_s$	-	+20.48	-	-	-	-	172.91/372.65* 44.14
Revised Value	-	72.08	-	-	-	-	Max= $S_e$



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## Table 3

Maximum primary plus secondary plus peak (P+Q+F) stress intensity in ksi for 226 cycles case is range of all cases on page B-17-3 except case VI since it is L.O.F.W.P. transient case

Case	TOP			BOTTOM	2.2.2.c(2)
	H-L	L-R	R-H		Page #
Case (1) Max. Primary	+11.6	+2.8	+4.1	Since "BOP" envelopes "BOTTOM" only "TOP" is evaluated for peak  stress intensities to be consistant with original stress report.	Max. (+), B-17-3
Case (2) Min. Primary	-1.4	-15.6	-1.5		Max (-), B-17-3
Max./min of cases III,IV,V	+21.9	+16.6	+9.4		Max (+), B-17-3
	-6.9	-31.3	-10.1		Min (-), B- 17-3
Max. (+)	+33.5	+19.4	+13.5		
Min. (-)	-8.3	-46.9	-11.6		
Range	+41.8	+66.3	+25.1		(Max-Min)
Absolute Max	-	+66.3	-		Existing for 120 cycles
Contribution of $F_s$	-	33.59	-		1.64*20.48
Sp Revised	-	99.89	-		Existing + Contri. of $F_s$



Table 4

Primary Plus Secondary Stress Intensity Range (P + Q)

Existing stress report page B-7-1 of 2.2.2.c(2) states that Case VI (which is L.O.F.W.P) is broken into two parts for down ramp i.e. VI iter 32 and VI iter 960 while up ramp is same as Case III. Thus maximum primary plus secondary stress intensities range (ksi) of original analysis for L.O.F.W.P. & HPCI/RCIC transients is as follows.

Case	TOP			BOTTOM			2.2.2.c(2)
	H-L	L-R	R-H	H-L	L-R	R-H	Page #
Case III (up)	-6.9	-2.1	9.0	-8.3	0	8.3	B-16-3
Case VI (max)	-	69.9	-	22.1	11.4	11.2	B-16-3
(min.)	-19.0	-	-50.9	-	-22.2	-33.5	B-16-3
Range (Case VI-Case III)	-12.1	72.0	-59.9	30.4	-22.2	-41.8	-
Absolute Max Range	-	+72.0	-	-	-	-	Existing Revised
Contribution of $F_s$	-	29.61	-	-	-	-	(249985/572 650) (44.14)
Revised Value	-	101.61	-	-	-	-	Max $S_s$


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Table 5
Peak Stress Intensity (P + Q + F)

This revised maximum primary plus secondary stress intensity for 30 cycles of this transient is 94.46 ksi which is greater than  $3S_m = 80$  ksi. Thus simplified elastic-plastic approach will be used for fatigue evaluation. Based on similar statement used for (P + Q) stress intensities, revised (P + Q + F) stress intensities (ksi) are as follows:

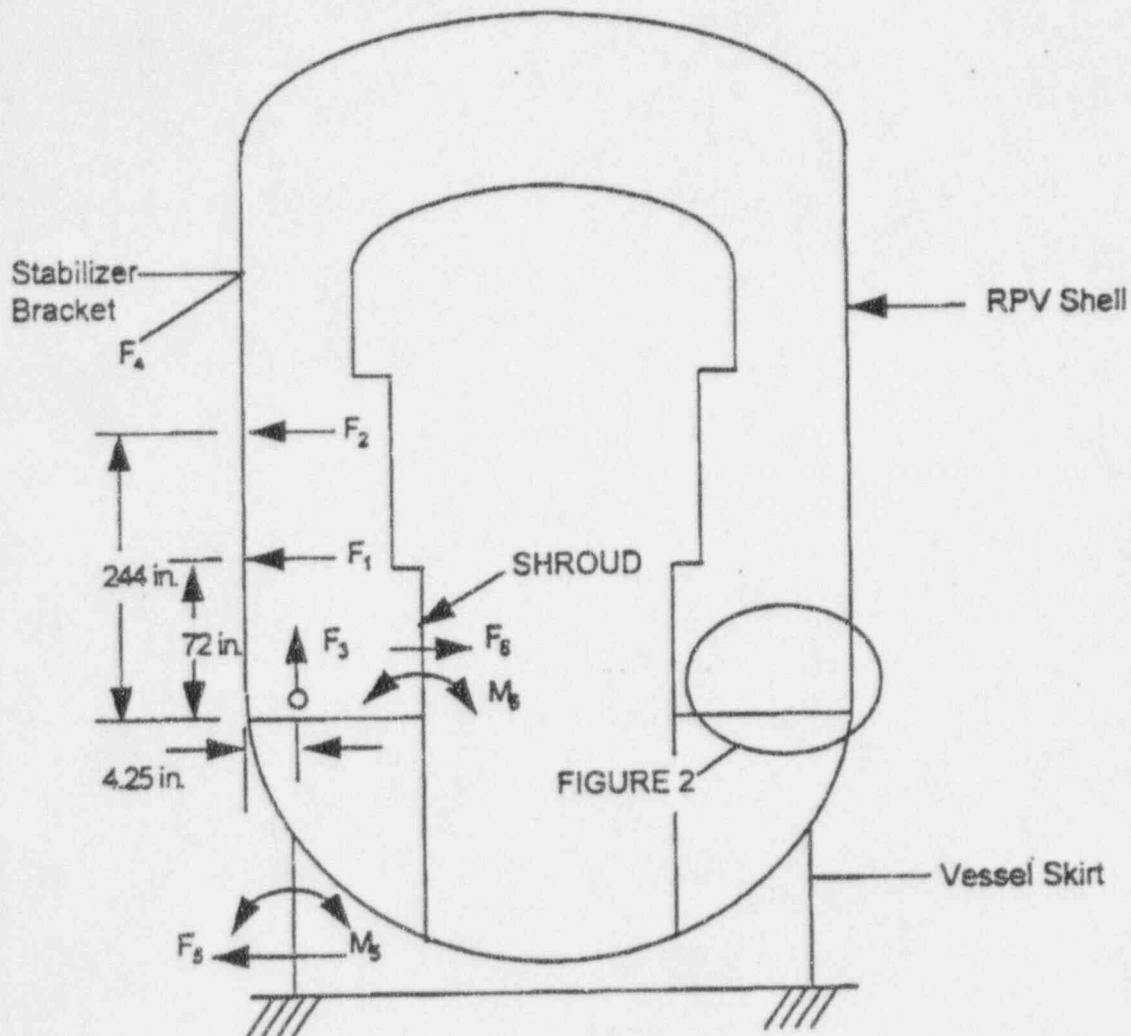
Case	TOP			Doc. 2.2.2.c(2)	Remark
	H-L	L-R	R-H	Page #	
Case III (up)	-6.9	-2.1	9.0	B-17-3	* Original Report evaluated only "TOP" since it enveloped "BOTTOM" as shown on P + Q evaluation. This is also true for new values as seen on previous page.
Case IV Max.	-	+144.7	+12.2	B-17-3	
Case IV Min.	-68.5	0	-76.2	B-17-3	
Range	-61.6	+146.8	-85.2	Existing Revised	
Absolute Max. Range	-	146.8	-	-	
Contribution of F3	-	48.56	-	(1.64) (29.61)	* Using stress concentration factor for bending = 1.64 page B-17-2 of 2.2.2.c(2)
Revised Sp	-	195.36	-		


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All other dimensions per 2.2.2.a

FIGURE 1. APPLICATION OF DESIGN MECHANICAL LOADS

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FINAL

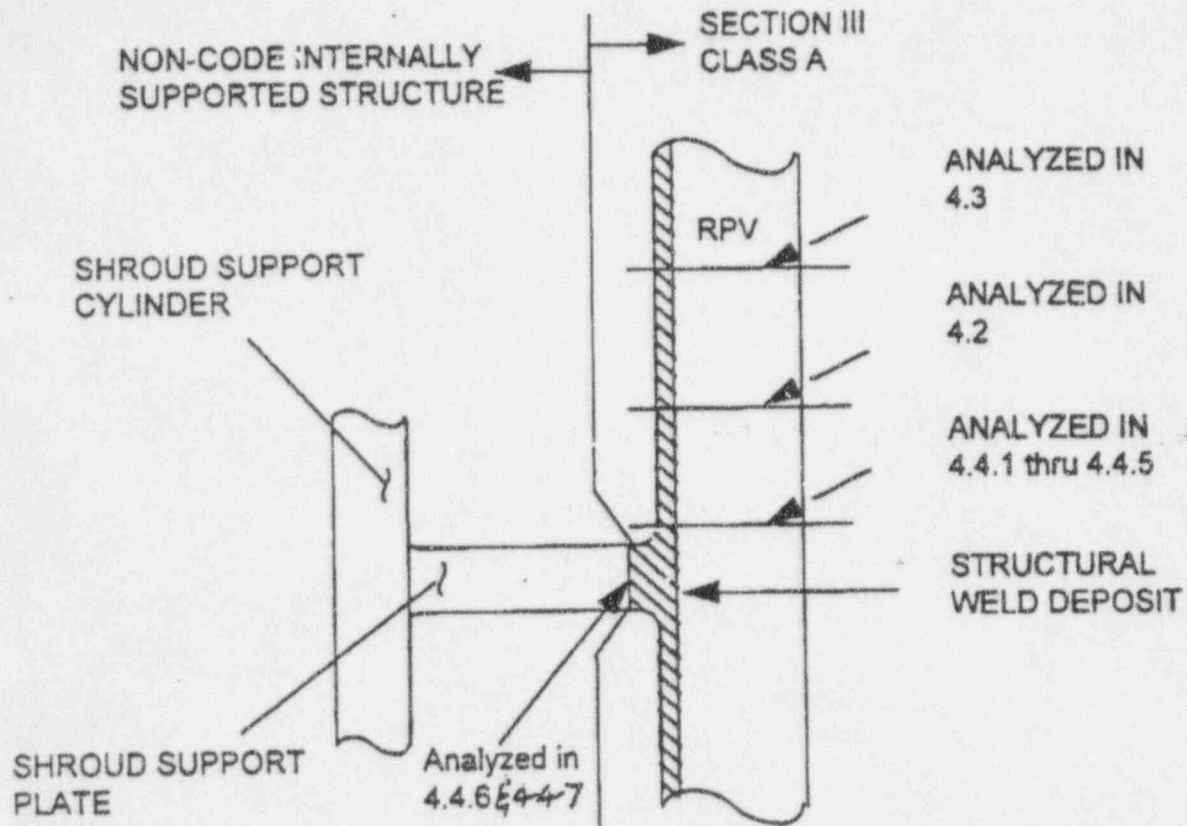


FIGURE 2. BOUNDARY OF ASME CODE JURISDICTION

**PECO ENERGY**

10 CFR 50.55a(a)(3)

PECO Energy Company  
Nuclear Group Headquarters  
965 Chesterbrook Boulevard  
Wayne, PA 19087-5691

August 17, 1995

Docket Nos. 50-277  
50-278

License Nos. DPR-44  
DPR-56

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

Subject: Peach Bottom Atomic Power Station, Units 2 and 3  
Response to Request for Additional Information Concerning  
the Proposed Alternative Repair Plan in Accordance  
with 10 CFR 50.55a(a)(3)

- References:
1. Letter from G. A. Hunger, Jr. (PECO Energy Company) to U. S. Nuclear Regulatory Commission (USNRC), dated September 16, 1994
  2. Letter from G. A. Hunger, Jr. (PECO Energy Company) to USNRC, dated September 26, 1994
  3. Letter from G. A. Hunger, Jr. (PECO Energy Company) to USNRC, dated February 14, 1995
  4. Letter from G. A. Hunger, Jr. (PECO Energy Company) to USNRC, dated June 22, 1995
  5. Letter from J. W. Shea (USNRC) to G. A. Hunger, Jr. (PECO Energy Company), dated July 27, 1995

Dear Sir:

In our Reference 1 letter, as supplemented by the Reference 2, 3, and 4 letters, PECO Energy Company requested approval of a proposed repair plan for the Peach Bottom Atomic Power Station (PBAPS), Units 2 and 3 core shroud, in accordance with 10 CFR 50.55a(a)(3), in the event that such a repair is determined to be necessary. In the Reference 5 letter, the staff requested additional information. Attachment 1 is our response to this request.

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9508290357 950817  
PDR ADOCK 05000277  
PDR

Enclosure 4

APC 11

August 17, 1995

Page 2

Also included in this package are eight revised or new detail PBAPS, Unit 2 and 3 drawings that reflect dimensional changes to the upper support assembly.

Attachment 1 contains information proprietary to General Electric. General Electric requests that the Attachment 1 information be withheld from public disclosure in accordance with 10 CFR 2.790(a)(4). In accordance with 2.790(b)(1), an affidavit supporting this request is provided in Attachment 1.

If you have any questions, please contact us.

Very truly yours,

*M. C. Kray for*

G. A. Hunger, Jr.,  
Director - Licensing

Attachment

cc: T. T. Martin, Administrator, Region I, USNRC  
W. L. Schmidt, USNRC Senior Resident Inspector, PBAPS

**ATTACHMENT 1**

# General Electric Company

## AFFIDAVIT

I, **George B. Stramback**, being duly sworn, depose and state as follows:

- (1) I am Project Manager, Licensing Services, General Electric Company ("GE") and 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 the GE proprietary report GENE-B13-01732-001, *GE Responses to NRC Questions for Peach Bottom Shroud Repair*, Revision 0, (GE Proprietary), August 1995, and those drawings listed in the Attachment which are individual parts of the overall reactor modification identified as "*Reactor Modification & Installation Drawing*" 105E1455. These documents, taken as a whole, constitutes a proprietary compilation of information, some of it also independently proprietary, prepared by the General Electric Company. The independently proprietary elements that are drawings are delineated by the GE drawings, being marked as proprietary information and the independently proprietary elements that are in reports are delineated by bars marked in the margin adjacent to the specific material.
- (3) In making this application for withholding of proprietary information of which it is the owner, GE 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), 2.790(a)(4), and 2.790(d)(1) for "trade secrets and commercial or financial information obtained from a person and privileged or confidential" (Exemption 4). The material for which exemption from disclosure is here sought is all "confidential commercial information", and some portions 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 which 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 General Electric's competitors

without license from General Electric 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 which reveals cost or price information, production capacities, budget levels, or commercial strategies of General Electric, its customers, or its suppliers;
- d. Information which reveals aspects of past, present, or future General Electric customer-funded development plans and programs, of potential commercial value to General Electric;
- e. Information which discloses patentable subject matter for which it may be desirable to obtain patent protection.

Both the compilation as a whole and the marked independently proprietary elements incorporated in that compilation are considered proprietary for the reason described in items (4)a., (4)b. and (4)e., above.

- (5) The information sought to be withheld is being submitted to NRC in confidence. That information (both the entire body of information in the form compiled in these drawings, and the marked individual proprietary elements) is of a sort customarily held in confidence by GE, and has, to the best of my knowledge, consistently been held in confidence by GE, has not been publicly disclosed, and 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. Access to such documents within GE 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, by the manager of the cognizant marketing function (or his delegate), and by the Legal Operation, for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside GE 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) and the Attachment, above, is classified as proprietary because it constitutes a confidential compilation of information, including reports and detailed design drawing results of a hardware design modification (stabilizers for the shroud horizontal welds) intended to be installed in a reactor to resolve the reactor pressure vessel core shroud weld cracking concern. The development and approval of this design modification utilized systems, components, and models and computer codes that were developed at a significant cost to GE, on the order of several hundred thousand dollars.

The detailed results of the analytical models, methods, and processes, including computer codes, and conclusions from these applications, represent, as a whole, an integrated process or approach which GE has developed, and applied to this design modification. The development of the supporting processes was at a significant additional cost to GE, in excess of a million dollars, over and above the large cost of developing the underlying individual proprietary reports and drawings information.

- (9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GE's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of GE's comprehensive BWR 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.

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

While some of the underlying analyses, and some of the gross structure of the process, may at various times have been publicly revealed, enough of both the analyses and the detailed structural framework of the process have been held in confidence that this information, in this compiled form, continues to have great competitive value to GE. This value would be lost if the information as a whole, in the context and level of detail provided in the subject GE drawings, were to be disclosed to the public. Making such information available to competitors without their having been required to undertake a similar expenditure would unfairly provide competitors with a windfall, and deprive GE of the opportunity to exercise its

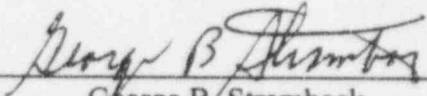
competitive advantage to seek an adequate return on its large investment in developing its analytical process.

STATE OF CALIFORNIA            )  
  )       ss:  
COUNTY OF SANTA CLARA       )

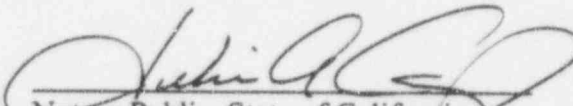
George B. Stramback, being duly sworn, deposes and says:

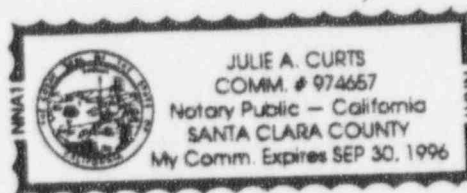
That he has read the foregoing affidavit and the matters stated therein are true and correct to the best of his knowledge, information, and belief.

Executed at San Jose, California, this 16<sup>th</sup> day of August 1995.

  
George B. Stramback  
General Electric Company

Subscribed and sworn before me this 16<sup>th</sup> day of August 1995.

  
Notary Public, State of California



## Attachment

### Drawing Number

B.	112D6348	Rev. 4	Stabilizer Support Assembly
I.	112D6353	Rev. 3	Support, Upper
K.	112D6354	Rev. 3	Support, Upper
H.	112D6498	Rev. 3	Bracket, Upper spring
EE.	112D6502	Rev. 3	Coupling, Top Support Bolting
AAA.	112D6752	Rev.1	Spacer, Upper Support
CCC.	112D6788	Rev. 0	Bolt, Top Support
DDD.	112D6789	Rev. 0	Retainer

DOCUMENT DESCRIPTION	DOCUMENT NUMBER	PREVIOUS SUBMITTAL REVISION	CURRENT SUBMITTAL REVISION	REASON FOR CHANGE (SEE NOTE)
REPAIR HARDWARE, DESIGN SPEC.	25A5579	3	3	1
STABILIZER CODE, DESIGN SPEC.	25A5580	4	4	1
FABRICATION SPEC	25A5601	1	1	1
CLEANING AND CLEANLINESS CONTROL	21A2040	1	1	1
INSTALLATION SPECIFICATION	25A5581	2	2	1
REACTOR VESSEL STRESS REPORT	25A5607	4	4	1
SHROUD & REPAIR HARDWARE STRESS ANALYSIS	771-58-0994	4	4	1
STABILIZER INSTALLATION, DESIGN REPORT	771-59-0994	4	4	1
SEISMIC ANALYSIS	771-60-0994	2	2	1
FIELD DISPOSITION INSTRUCTION	0257-71067	1	1	1
PARTS LIST	PL112D6347	1	1	1
PARTS LIST	PL112D6348	1	2	8
PARTS LIST	PL112D6349	0	0	1
PARTS LIST	PL112D6358	0	0	1
PARTS LIST	PL112D6359	0	C	1
PARTS LIST	PL112D6360	0	0	1
PARTS LIST	PL112D6495	0	0	1
PARTS LIST	PL105E1455	2	2	1
NUT, TIE ROD	112D6313	0	0	1
NUT, TOP SUPPORT	112D6321	3	3	1
BOLT, TOP SUPPORT	112D6322	0	0	1
NUT, TOP SUPPORT	112D6323	0	0	1
RETAINER	112D6324	1	1	1
SPRING, RETAINER	112D6325	1	1	1
SLEEVE, JACK	112D6327	0	0	1
WASHER, JACK	112D6328	0	0	1
RING, MID SUPPORT	112D6331	2	2	1
SCREW, MID SUPPORT	112D6332	0	0	1
LATCH	112D6338	0	0	1
UPPER STABILIZER	112D6347	2	2	1
STABILIZER SUPPORT ASSEMBLY	112D6348	3	4	8
TIE ROD ASSEMBLY	112D6349	1	1	1
ROD, TIE	112D6350	3	3	1
SPRING, LOWER	112D6351	1	1	1
SPRING, UPPER	112D6352	2	2	1
SUPPORT, UPPER	112D6353	2	3	8
SUPPORT	112D6354	2	3	8
CONTACT, LOWER	112D6355	1	1	1
SUPPORT, MID	112D6356	1	1	1
CONTACT, UPPER	112D6357	1	1	1
TIE ROD / SPRING ASSEMBLY	112D6358	1	1	1
MID SUPPORT	112D6359	1	1	1
LOWER STABILIZER	112D6360	1	1	1
BOLT, TOGGLE	112D6489	2	2	1
SUPPORT, LOWER	112D6490	2	2	1
TOGGLE	112D6491	2	2	1
PIN, TOGGLE BOLT	112D6492	1	1	1
WASHER, TOGGLE BOLT	112D6493	1	1	1
NUT, TOGGLE BOLT	112D6494	2	2	1
TOGGLE BOLT ASSEMBLY	112D6495	1	1	1
BOLT, JACK	112D6496	1	1	1
SPRING, RETAINER	112D6497	1	1	1
BRACKET, UPPER SPRING	112D6498	2	3	8
SCREW, TOP SUPPORT BOLTING	112D6501	1	1	1
COUPLING, TOP SUPPORT BOLTING	112D6502	2	3	8
EXTENSION, LOWER SPRING	112D6503	1	1	1
PIN	112D6504	1	1	1
PIN, CLEVIS	112D6505	1	1	1
ARM, TORSION	112D5242	1	1	1
BOLT, TORSION ARM	112D5243	1	1	1
NUT, LOCK	112D5244	0	0	1
MODIFICATION DRAWING	105E1455	2	2	1
SPACER, UPPER SUPPORT	112D6752	0	1	8
NUT, TIE ROD	112D6777	0	0	1
BOLT, TOP SUPPORT	112D6788	N/A	0	8
RETAINER	112D6789	N/A	0	8
GE RESPONSES TO NRC QUESTIONS (GENERIC)	DRF B13-01732	0	0	1
RESPONSES TO NRC QUESTIONS FOR PBAPS	GENE-B13-01732-001	N/A	0	N/A

NOTES:

1. NO CHANGE SINCE LAST SUBMITTAL.
2. DRAWING CORRECTIONS, NO CHANGE IN DESIGN.
3. INCORPORATED UNIT 3 SEISMIC ANALYSIS INFORMATION.
4. MINOR MODIFICATION TO IMPROVE LOAD CAPACITY, FABRICATION, OR ASSEMBLY.
5. DELETED HEAT TREATMENT REQUIREMENT FOR THREADS.
6. INCORPORATED ANALYSIS OF CORE SPRAY PIPING INSIDE THE VESSEL
7. SCOPE INCREASE TO ADD WELD H8 EVALUATION
8. INCORPORATE LESSONS LEARNED IMPROVEMENTS
9. INPROCESS REVISION DUE TO PECO/GE COMMENTS AND APPROVAL