CALCULATION NO.: M-DSC-354 REVISION 1

TITLE: PRESSURIZER BOTTOM HEAD INSTRUMENTATION LEVEL NOZZLE EVALUATION

FROM: J. RAINSBERRY

ORGANIZATION: SOUTHERN CALIFORNIA EDISON

DATE: JULY 11, 2006

PLANT NAME: SAN ONOFRE NUCLEAR GENERATING STATION, UNITS 2 AND 3

DOCKET NOS.: 50-361 AND 50-362

"N. Kaly Kalyanam"
<NXK@nrc.gov>
07/11/2006 11:35 AM

To <rainsbjl@songs.sce.com>
cc
bcc
Subject Calculation M-DSC-354 Rev. 1

History: This message has been replied to and forwarded.

Jack,

Can you please send me a copy (Electonic or hard copy - electronic is preferred, but either one is fine,) of the calculation referenced below, done for Relief Request ISI-3-17?

M-DSC-354 Rev. 1: PRESSURIZER BOTTOM HEAD INSTRUMENTATION LEVEL NOZZLE EVALUATION

This might have been sent once. However, I am unable to locate it.

Thanks

Kaly

Kaly
Copy attached
Jack

CALCULATION TITLE PAGE

ICCN NO./ PRELIM. CCN NO.	PAGE ____ OF ____
	CCN CONVERSION: CCN NO. CCN-

Calc. No. M-DSC-354 ECP No. & Rev. N/A

Subject PRESSURIZER BOTTOM HEAD INSTRUMENTATION LEVEL NOZZLE EVALUATION – SONGS UNITS 2 AND 3 Sheet 1 of 97

System Number/Primary Station System Designator 1201 /BBB SONGS Unit 2 AND 3 Q-Class I

Tech. Spec./LCS Affecting? ☒ NO ☐ YES, Section No. ____ Equipment Tag No. S2(3)1201ME087

Site Programs/Procedure Impact? ☒ NO ☐ YES, AR No. ____

10CFR50.59/72.48 REVIEW	CONTROLLED COMPUTER PROGRAM / DATABASE		
IS THIS CALCULATION REVISION BEING ISSUED SOLELY TO INCORPORATE CCNs? ☒ NO ☐ YES AR No. 030900690-2	☒ PROGRAM ☐ DATABASE ACCORDING TO SO123-XXIV-5.1	PROGRAM / DATABASE NAME(S) - ☐ ALSO, LISTED BELOW COSMOS *	VERSION / RELEASE NO.(S) 1.71 / 1.75

RECORDS OF ISSUES				
REV. / DISC.	DESCRIPTION	TOTAL SHTS. / LAST SHT.	PREPARED BY: (Print name/sign/date) Initial PQS Block - Requires PQS T3EN64	APPROVED BY: (Signature/date) Initial PQS Block - Requires PQS T3EN64
1	SEE BELOW **	97	ORIG. Nabil M-El-Akily [signature] 12/16/05 PQS VER. BY: NME	FLS [signature] 12/23/05 PQS VER. BY: [initials]
N-M / DEO		C-6	IRE JVP GAOR J-Gaor 12/16/05 PQS VER. BY: J-G.	Other PQS VER. BY: ____
			ORIG. PQS VER. BY: ____	FLS PQS VER. BY: ____
			IRE PQS VER. BY: ____	Other PQS VER. BY: ____
			ORIG. PQS VER. BY: ____	FLS PQS VER. BY: ____
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			ORIG. PQS VER. BY: ____	FLS PQS VER. BY: ____
			IRE PQS VER. BY: ____	Other PQS VER. BY: ____

Space for RPE Stamp, identify use of an alternate calc., and notes as applicable.

* THE FINITE ELEMENT PROGRAM COSMOS WAS USED BY APTECH ENGINEERING TO GENERATE THE FINITE ELEMENT MODELS USED IN THE EVALUATION.

** REVISION 1 IS ISSUED TO PROVIDE TECHNICAL JUSTIFICATION FOR NONCIRCULAR WELD PAD SHAPES.

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This calc. was prepared for the identified ISCO ECP. ECP completion and turnover acceptance to be verified by receipt of a memorandum directing ECN Conversion. Upon receipt, this calc. represents the as-built condition. Memo date ____ by ____.

SCE 26-121-1 REV. 8 4/05 [REFERENCE: SO123-XXIV-7.15]

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I-DSC-354

M-DSC-354

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Calc. rev. number and responsible FLS initials and date	INPUTS These interfacing calculations and/or documents provide input to the subject calculation, and if revised may require revision of the subject calculation.		OUTPUTS Results and conclusion of the subject calculation are used in these interfacing calculations and/or documents.		Does the output interface calc/document require Change?	Identify output interface calc/document CCN, ECP, TCN/Rev., or tracking number.
	Calc/Document No.	Rev. No.	Calc/Document No.	Rev. No.	YES / NO	
RU 12/23/05	SPECIFICATION NO. SO23-919-3, PROJECT SPECIFICATION FOR PRESSURIZER ASSEMBLY	8				
	DRAWING NO. SO23-919-79, PRESSURIZER GENERAL ARRANGEMENT	0				
	DRAWING NO. SO23-919-2, PRESSURIZER OUTLINE FOR SAN ONOFRE II	9				
	DRAWING NO. SO23-919-57, PRESSURIZER OUTLINE FOR SAN ONOFRE III	0				
	DRAWING NO. SO23-919-13, BOTTOM HEAD WELDING AND MACHINING	2				

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	Calc/Document No.	Rev. No.	Calc/Document No.	Rev. No.	YES / NO	
[signature] 5/2/06	Drawing 41011, Sheet 6, Pressurizer Nozzle detail Drawing 41116, Sheet 2, Primary System Instrument Nozzle details	0 3				
	Drawing 41116, Sheet 6, Primary System Instrument Nozzle details	0				

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Calc. rev. number and responsible FLS initials and date	INPUTS These interfacing calculations and/or documents provide input to the subject calculation, and if revised may require revision of the subject calculation.		OUTPUTS Results and conclusion of the subject calculation are used in these interfacing calculations and/or documents.		Does the output interface calc/document require Change?	Identify output interface calc/document CCN, ECP, TCN/Rev., or tracking number.
	Calc/Document No.	Rev. No.	Calc/Document No.	Rev. No.	YES / NO	
RM 4/25/06	ECP 031100614-5 41011 Sht. 7 41011 Sht. 8	– 0 0	41011 Sht. 7 41011 Sht. 8	0 0	No No	New drawing New drawing

CALCULATION COVER SHEET

SCE No. M-DSC-354, Rev. ____ SHEET 3 OF ____

Calculation No.: AES-C-3213-1

Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3

Client: Southern California Edison Company

Project No.: AES 97103213-1Q

APTECH Office: Sunnyvale

Sheet No. 1 of 66

☐ Uncontrolled ■ Controlled

Document Control No.: I-2

Purpose: The purpose of this calculation is to evaluate the replacement design for the instrumentation nozzle penetration in the pressurizer bottom head. This calculation addresses the allowable stress limits and fatigue evaluation requirements of NB-3200 of the American Society of Mechanical Engineers (ASME) Code, Section III. The original design loadings for a 40 year design basis are considered in the calculation. Appendix C has been added to original calculation which provides technical justification for noncircular weld pad shapes.

Assumptions: The analysis assumptions are described in Section 3.

Prelim CCN No. N-1
CCN CONVERSION:
CCN No. CCN-1
Page 3 of

Results: The results of this calculation are summarized in Section 2. The stress allowables of ASME Section III are satisfied for all design requirements, including normal, upset, faulted, and test conditions. The nozzle is exempt from fatigue evaluation per NB-3222.4(d), as shown in Section 8. Reconciliation assessments for other pad shapes (Appendix C) and modified nozzle sleeve geometry (Appendix D) also meet ASME Section III requirements.

Revision No.	Prepared By / Date	Checked By / Date	Verified By / Date	Approved By / Date	Revision Description
1	RCC 3/30/98	CQL 3/30/98	MTC 3/30/98	RCC 3/30/98	Modification to stress summary tables in Section 8 (Original signatures on file)
2	RCC 12/8/05	MTC 12/8/05	MTC 12/8/05	RCC 12/8/05	Addition of reconciliation to cover noncircular pad shape - Appendix C. (Original signatures on file)
3	[signature] 3/8/06	MTC 8 March 06	MTC 8 March 06	[signature] 3/8/06	Addition of reconciliation for modified nozzle sleeve (Appendix D).

APTECH ENGINEERING SERVICES, INC.

QAN45
REV. 8/96

Calculation No.: AES-C-3213-1	Made by: RC	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: MTC	Date: 8 May 06	Project No.: AES 97103213-1Q
	Revision No.: 3	Document Control No.: I-2	Sheet No.: 2 of 66

STRESS REPORT CERTIFICATION STATEMENT

The undersigned, a Registered Professional Engineer competent in the field of vessel/piping design and stress analysis, certifies that the stress report complies with the requirements of the Design Specification and Section III of ASME Boiler and Pressure Vessel Code 1971 Edition through Summer 1971 addenda, is correct and complete with respect to the design calculations set forth in this report.

Russell C. Cipolla — Registered Professional Engineer

3/8/06 — Date

State of California

Certificate Number 17973

REGISTERED PROFESSIONAL ENGINEER
RUSSELL C. CIPOLLA
No. 17973
8/30/07
MECHANICAL
STATE OF CALIFORNIA

Calculation No.: AES-C-3213-1	Made by: RK	Date: 12/08/05	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: MTC	Date: 8 Dec 2005	Project No.: AES 97103213-1Q
	Revision No.: 2	Document Control No.: I-2	Sheet No.: 3 of 66

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Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: MTC	Date: 8 Mar 06	Project No.: AES 97103213-1Q
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1.0 INTRODUCTION

The pressurizers at San Onofre Nuclear Generating Station, Units 2 and 3 (SONGS 2 and 3) are provided with several small instrumentation nozzles. There are two 3/4-inch instrumentation level nozzles per pressurizer that penetrate the bottom head. The design conditions for the pressurizer are given in the design specifications (Refs. 1 and 2). A replacement nozzle design made of Inconel 690 has been developed by Southern California Edison Company (SCE). The replacement nozzle is of similar configuration to the original design except that the attachment weld is located on the outside diameter (OD) side of the primary head rather than on the inside diameter (ID) side.

This nozzle design will replace the existing Inconel 600 level nozzles in the event that repairs to the original nozzles become necessary. The original nozzle configuration is shown in Figure 1-1 (Ref. 3). The original nozzle is attached to the head by a J-groove weld at the ID surface of the head. The original design analysis for this nozzle is documented in Ref. 4. The replacement design is shown in Figure 1-2 (Ref. 5). The new design is installed by cutting and removing an outer segment of the existing nozzle, laying down a base pad on the OD by welding, and installing a new nozzle by a J-groove attachment weld with a reinforcing fillet to the base pad.

The purpose of this calculation is to demonstrate that the replacement design meets the stress allowable limits and fatigue requirements of the American Society of Mechanical Engineers (ASME) Code, Section III, 1971 Edition through Summer 1971 Addenda (Ref. 6). The design analysis for this replacement nozzle is based on a 40 year design condition consistent with the original design specification.

The original calculation (Rev. 1) covers a circular weld pad geometry as modeled in the finite element stress analysis (i.e., axisymmetric model). The circular weld pad ligament length is 1.375 inches and the thickness is 7/16 inch. Revision 2 provides the technical basis and engineering reconciliation to cover a noncircular pad shape (i.e., six-sided nonsymmetric polygon) of similar ligament length and thickness. There is no impact to the results or conclusion of the original analysis. The details of this reconciliation are given in Appendix C.

In addition, a modified nozzle sleeve repair was used in the repair of 2LT-0110-2 instrumentation level nozzle in the Unit 2 pressurizer. The modified geometry was reconciled to the original calculation as described in Appendix D.

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Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: CQL	Date: 1/14/98	Project No.: AES 97103213-1Q
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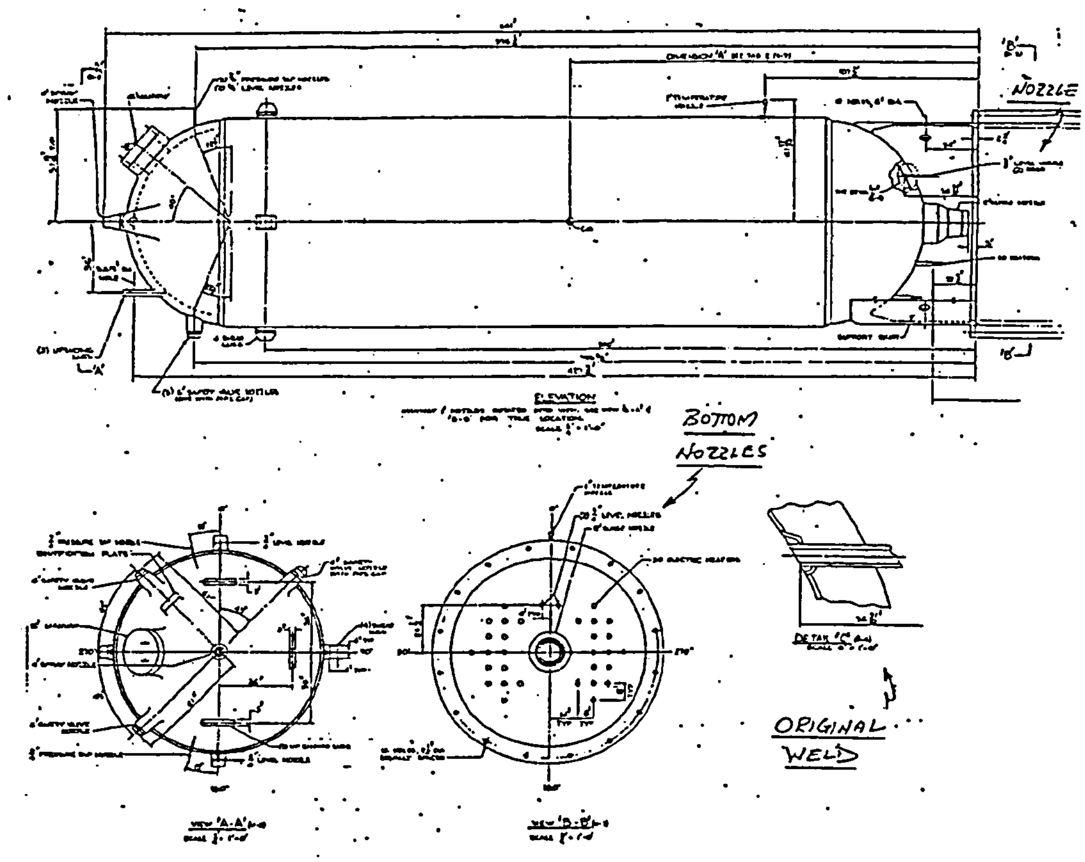

Figure 1-1 — Original Nozzle Configuration.

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Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: CGL	Date: 1/14/98	Project No.: AES 97103213-1Q
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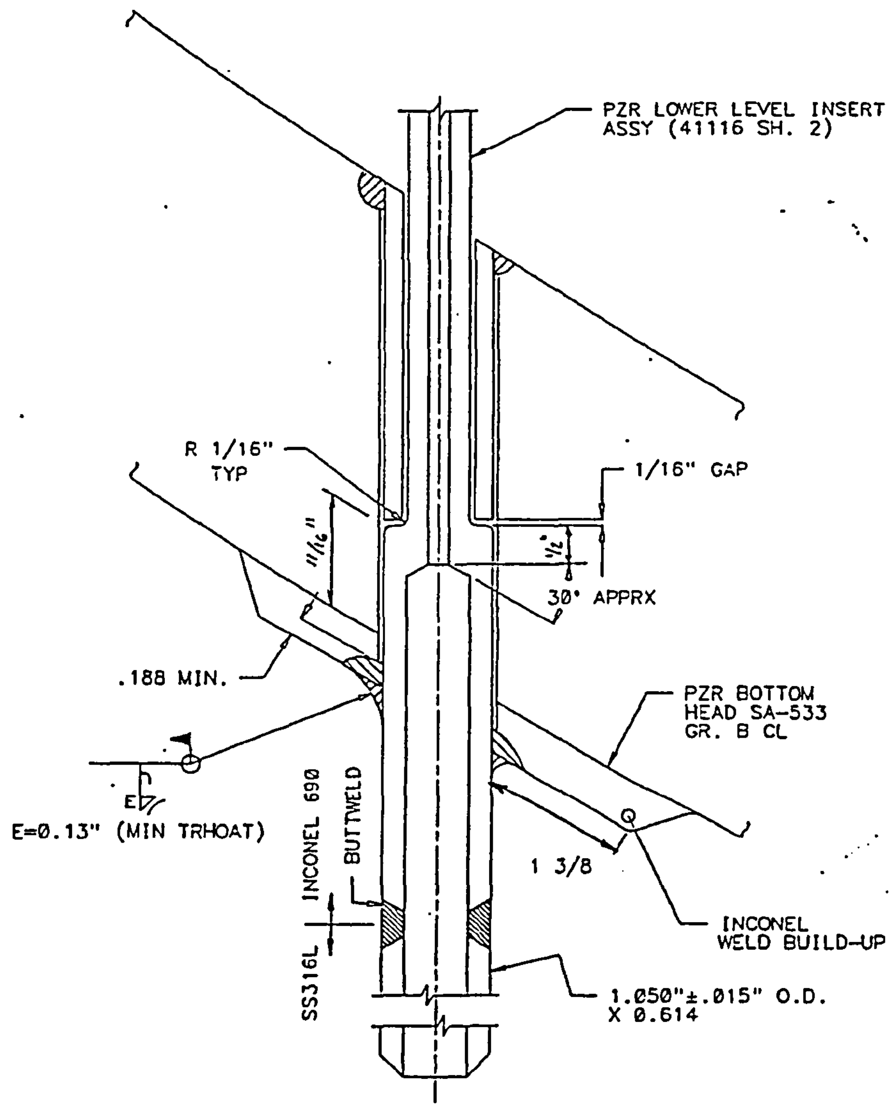

Figure 1-2 — Replacement Design Nozzle Configuration.

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2.0 SUMMARY OF RESULTS

2.1 Stress Allowable Limits

The code evaluation per NB-3200 of ASME Section III was performed at four critical locations in the nozzle-to-head penetration. The four critical sections and ID/OD nodal locations are illustrated in Figure 2-1. The four locations were selected on the basis of maximum computed peak and bending stresses for the individual load cases analyzed. All calculated stresses meet the ASME Code stress limits, as summarized below:

	Allowable Stress Ratio			
	Primary Stress		Primary + Secondary Stress	
	P_M	$P_L + P_b$	$P_L + P_b + Q$	Section
Design	0.62	0.70	---	3
Normal and Upset*	---	---	0.28	3
Faulted	0.26	0.29	---	3
Test	0.73	0.83	---	3

* Cooldown with thermal stratification

As shown above, all stress ratios are less than unity, indicating that the design loadings in this calculation do not exceed the ASME Code stress limits of NB-3200 (Ref. 6). The computed stress intensities and allowable stress limits are presented in Section 8.5. See Appendix D for the evaluation and Code acceptance of the modified nozzle sleeve.

2.2 Fatigue Analysis

The fatigue analysis is performed in Section 8.6 of this calculation. This evaluation demonstrates that the nozzle is exempt from detailed fatigue analysis requirements per the exemption rules of NB-3222.4(d). This result is consistent with the original design, which was also exempt from fatigue requirements (Ref. 4). Therefore, no further evaluation for fatigue design (i.e., transient analyses and cyclic evaluation) is required for the replacement nozzle design.

2.3 Weld Pad Geometry

The calculations cover a circular weld pad with a ligament length of 1.375" and thickness of 7/16". Appendix C provides the justification and design reconciliation that allows this calculation to cover a general polygon shaped pad provided that the ligament length and thickness are comparable.

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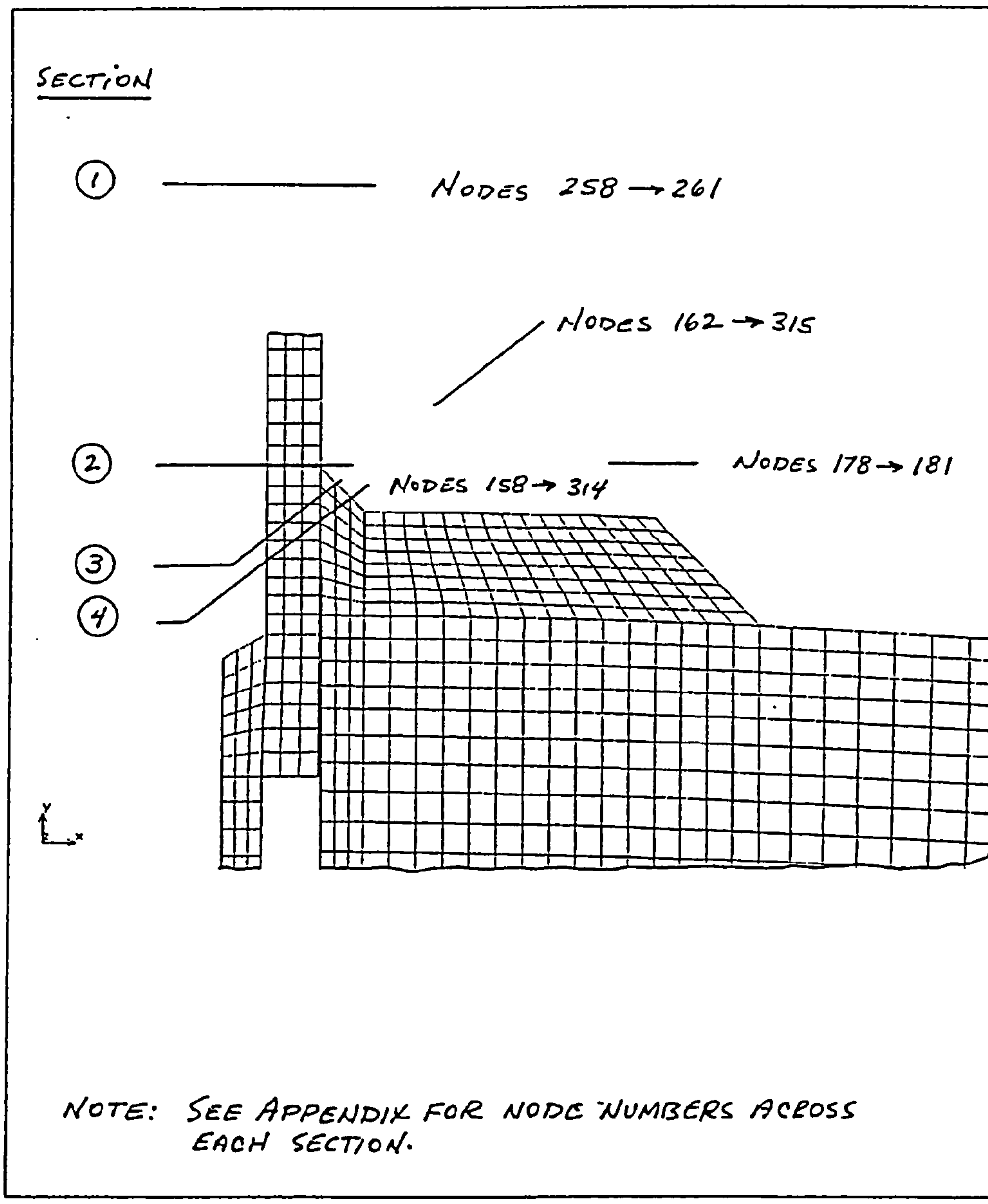

Figure 2-1 — Illustration Showing the Four Critical Sections and ID/OD Nodal Locations that were Evaluated.

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3.0 ANALYSIS ASSUMPTIONS

The following assumptions were made in performing the design analysis calculations:

1. The nozzle - head geometry is assumed to be axisymmetric and linear elastic. This assumption, which was made to simplify the finite element model, is consistent with the original design analysis (Ref. 4). The axisymmetric assumption has been evaluated to be reasonable since: (1) the additional metal reinforcement at the weld attachment caused by the nonradial penetration has been conservatively ignored and (2) thermal transient stresses are dominant loads and are not sensitive to three-dimensional geometry effects.

2. The discontinuity effects of the neighboring penetrations are assumed not to be significant since the level nozzle is remote from other penetrations.

3. The cladding on the ID of the head is ignored in the analysis. Since the nozzle attachment is at the OD, this assumption will have little effect on the stresses at the nozzle weld.

4. The mechanical and thermal properties are assumed constant with temperature. An average temperature of 350°F was assumed for defining material properties during transient conditions. This assumption is conservative for operating temperature conditions.

5. The external boundary of the nozzle and bottom head was assumed to be adiabatic in the thermal analysis. This assumption is reasonable since the pressurizer is insulated.

6. The stress results for the bottom head were not explicitly evaluated because the maximum stresses will be concentrated at the nozzle attachment weld. Since the head penetration size remains unchanged, the original design calculations are assumed to apply to the head.

7. The design basis earthquake (DBE) is equivalent to the seismic conditions of safe shutdown earthquake (SSE).

8. For the fatigue evaluation, one seismic event is assumed to cause 40 load cycles. This assumption is consistent with other nozzle calculations (Ref. 7)

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4.0 METHODOLOGY

The design analysis follows the rules of Subsection NB-3200 of the ASME Code, Section III (Ref. 6). The stress intensities due to design loads (i.e., internal pressure, applied pipe loads, and thermal transients) are calculated by the finite element method (FEM). The FEM was performed with the computer program COSMOS/M (Ref. 8). The COSMOS/M code has been independently verified. The geometry of the nozzle-to-head penetration is illustrated in Figure 4-1.

4.1 Finite Element Model

The nozzle geometry, including the primary head and weld attachment detail, was modeled by discrete finite elements. The FEM model is shown in Figure 4-2. The elements are 4-noded isoparametric linear elastic formulations and were designed to model the nozzle, base pad weld, and a 15° segment of the spherical head. A finer element mesh is used in the area of the nozzle-to-pad weld to provide greater accuracy where the maximum stress occurs. The larger section of the nozzle is modeled by a segment that extends 5.62 inches outward and 11/16-inch inward relative to the OD surface of the head. The nozzle is attached to the base pad by the attachment weld. This is the only connection between the nozzle and the head. Therefore, the elements of the nozzle and a 0.188 inch portion of the base pad are connected through coincident nodes. The nozzle elements within the head are separate and are not connected with the head. This is a reasonable assumption since a tolerance fit is used between the nozzle OD and the head penetration hole. Additional details of the FEM model are presented in Section 8.3.

4.2 Mechanical Loads

The mechanical loads were applied to the model to determine the stresses in the nozzle due to internal pressure and applied pipe loads. Unit loading cases were used to establish the stress response for each individual loading condition. The total stress was computed by elastic superposition of individual unit cases. The unit loading boundary conditions were applied as follows:

1. Internal Pressure, P

   Internal pressure (P) is applied to the inside surface of the model, including the ID of the head, the ID of the nozzle, and the ID of the hole penetration. In addition, the

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annulus region between the nozzle stub and head is also pressurized. An end-cap load is applied on the outer end of the nozzle as a pressure, which is calculated from:

$$P_{Cap} = \pi r_i^2 P / \pi (r_o^2 - r_i^2), \text{psi} \quad (4\text{-}1)$$

2. Axial Force, F_A

A unit axial load (F_A) is applied to the outer end of the nozzle to represent axial force from the pipe. This load is uniformly distributed on the nozzle cross-section and applied in the global y - direction. Therefore,

$$F_A = \int_0^{2\pi} F_y \, d\theta$$

$$F_y = F_A / 2\pi, \text{lb/rad} \quad (4\text{-}2)$$

where F_y is the value of uniform axial force in the FEM model.

3. Lateral Force, F_L

A unit lateral load (F_L) is applied at the outer end of the nozzle in the horizontal and vertical directions. This load is assumed to vary sinusoidally along the circumference. Therefore,

$$F_L = \int_0^{2\pi} F_x \cos^2 \theta d\theta$$

$$F_x = F_L / \pi, \text{lbs} \quad (4\text{-}3)$$

where F_x is the magnitude of lateral force at $\theta = 0°$.

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4. Bending Moments, M_B

A unit bending moment (M_B) is applied to the outer end of the nozzle. The bending moment is represented by a loading function which is a single harmonic out-of-plane force acting in the axial direction. Therefore,

$$M_B = 2 \int_{-\pi/2}^{\pi/2} F_y r \cos^2 \theta \, d\theta$$

$$F_y = M_B / \pi r, \text{ lbs} \qquad (4\text{-}4)$$

where F_y is the magnitude of axial force at $\theta = 0°$ and r is the mean radius of the nozzle.

5. Torsional Moment, M_T

A unit torsional moment (M_T) is applied to the outer end of the nozzle. This torsional moment is applied as a uniform circumferential in-plane force acting on the cross-section, thus producing a twisting force. The in-plane force distribution is given by

$$M_T = \int_0^{2\pi} r F_z \, d\theta$$

$$F_z = M_T / 2\pi r, \text{ lb/rad} \qquad (4\text{-}5)$$

where F_z is the magnitude of uniform circumferential force and r is the mean radius of the nozzle.

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4.3 Thermal Transient Analysis

The heat transfer and thermal stress analyses were performed in a "unit load" format. Like the mechanical loads, unit thermal load cases can be scaled to calculate the thermal stresses associated with each design transient condition. Five thermal cases were developed which are bounding to all transient conditions:

1. Isothermal Steady State

   An isothermal steady state of 653°F is used to represent a uniform temperature case at operating conditions.

2. Unit Ramp

   A unit ramp loading at 200°F/hr is used to represent heatup/cooldown transients associated with plant startups and shutdowns.

3. Stratification Transient

   During plant cooldowns the pressurizer bottom head region may be subjected to thermal stratification, which causes a cooling rate greater than 200°F/hr. This transient is explicitly evaluated as a separate thermal case.

4. Step Change

   A unit step change of +20°F is used to represent thermal changes during plant load change conditions.

5. Loss of Flow Temperature Change

   The loss of flow transient causes a –40°F followed by a –20°F ramp change in reactor coolant system temperature, followed by a return to steady-state temperature. This transient is explicitly evaluated as a separate thermal case.

These thermal cases, with appropriate scaling factors will be bounding for the design transients. The design transient conditions are discussed later, in Section 5. In all thermal analyses, conservative film coefficients are used; specifically, a surface heat transfer of 500 BTU/HrFt^2°F on

the bottom head and on the inside surfaces of the nozzle and penetration. These assumptions are consistent with the original design (natural convection mode) and other evaluations (Refs. 4 and 7).

4.4 Fatigue Analysis

The rules and procedures of Subsection NB-3222.4 are applied to complete the fatigue analysis for cyclic operation. Specifically, the rules for fatigue analysis exemption are applied in the following areas, according to NB-3222.4(d):

1. Atmospheric to operating pressure cycle
2. Normal operating pressure fluctuations
3. Temperature difference for startup and shutdown
4. Temperature difference for normal service
5. Temperature difference for dissimilar materials
6. Mechanical loads cycling

Based on the above screening calculations, no fatigue evaluation is required. The details of the above screening calculations are given in Section 8.6.

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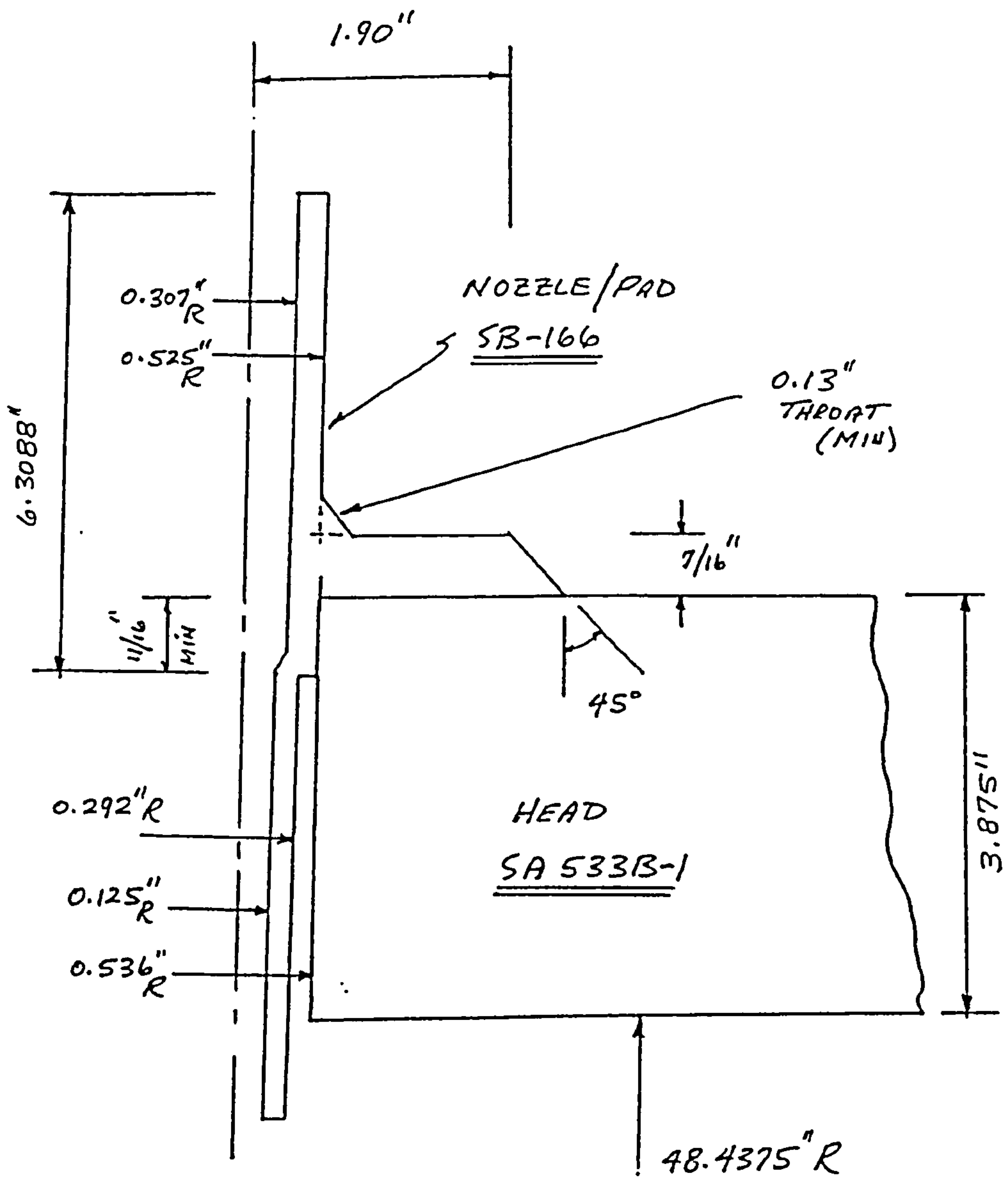

Figure 4-1 — Geometry of Nozzle-Head Detail.

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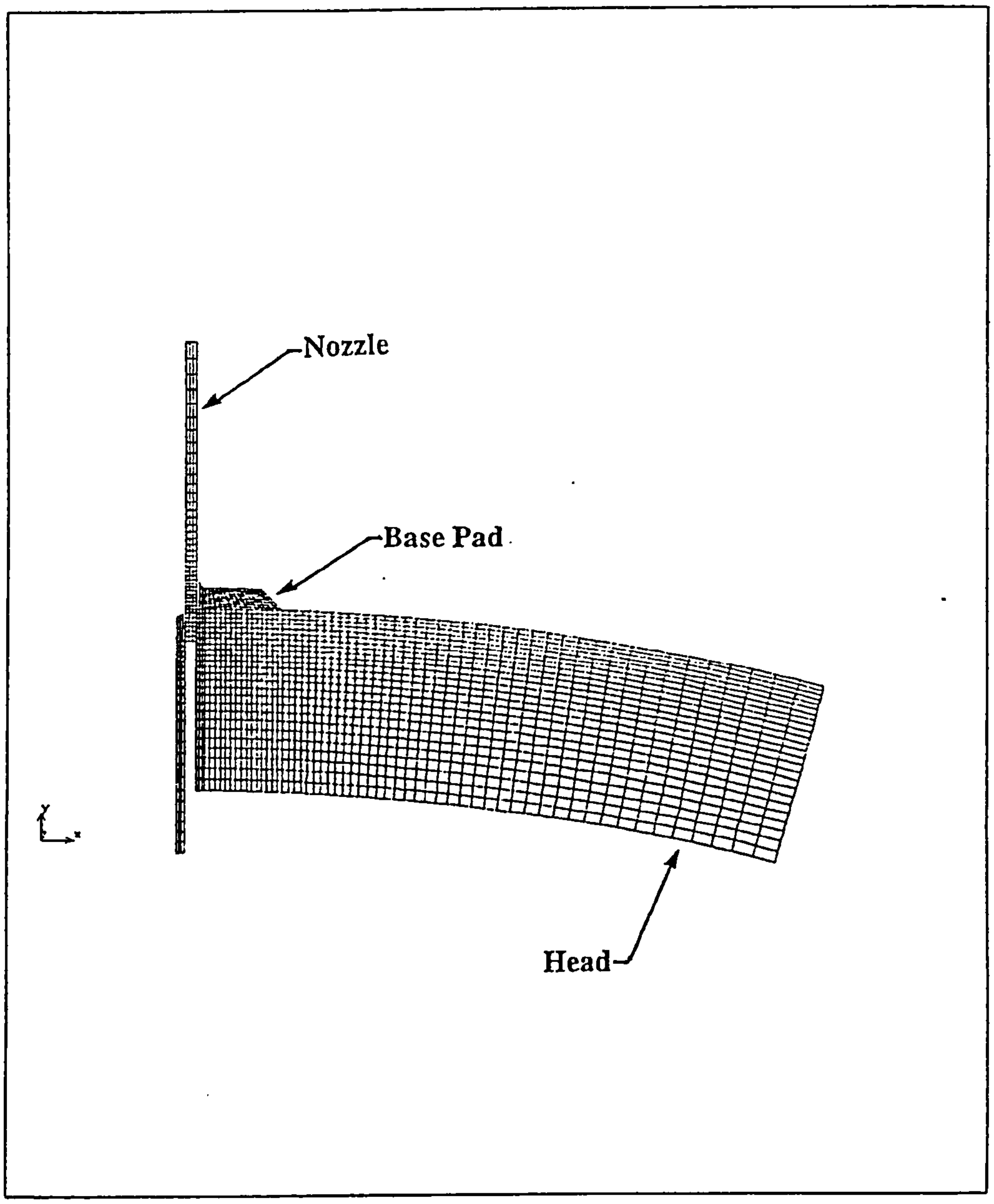

Figure 4-2 — Finite Element Model.

Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: CQL	Date: 1/14/98	Project No.: AES 97103213-1Q
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5.0 DESIGN INPUT

5.1 Component Geometry

The bottom head instrumentation nozzle is a 3/4-inch Schedule 160 pipe size. The penetration through the spherical head is vertical. A schematic illustration of the nozzle geometry is shown in Figure 5-1 (Refs. 5 and 9). The components of this penetration are described as follows from Refs. 5, and 9 through 11:

Nozzle:

- Outer radius: r_o = 0.525 inch
- Inner radius: r_i = 0.307 inch
- Wall thickness: t = 0.218 inch
- Inner step length: ℓ_s = 11/16 inch (min)
- Reduced outer radius: r_o = 0.292 inch
- Reduced inner radius: r_i = 0.125 inch

Bottom Head:

- Outer radius: R_o = 52.3125 inches
- Inner radius: R_i = 48.4375 inches (excluding clad)
- Wall thickness: t_h = 3.875 inches
- Clad thickness: t_c = 7/16 inch
- Hole diameter: d_h = 1.072 inches

Base Pad:

- Outer diameter: d_o = 3.80 inches
- Inner diameter: d_i = 1.072 inches
- Pad thickness: t_p = 0.4375 inch

5.2 Design and Operating Conditions

The design data for the pressurizer from Ref. 4 are as follows:

Design pressure	= 2500 psia
Design temperature	= 700°F
Operating pressure	= 2250 psia
Operating temperature	= 653°F
Hydrotest pressure	= 1.25 P_D = 3125 psia (3110 psig)

Thermal transients are given in Table 5-1. Five thermal cases are conservatively assumed that envelop the thermal transients. These are:

1. Isothermal steady-state load of 653°F
2. Heatup/cooldown at a rate of 200°F per hour
3. Cooldown with flow stratification
4. Temperature step change of ±20°F for plant load changes
5. Temperature change of –40°F and –20°F then +60°F for loss of flow conditions

The transient conditions for the above cases are illustrated in Figures 5-2 through 5-5 (Refs. 1 and 12). All normal/upset transients are less severe than loss of flow condition or cooldown transient with flow stratification.

Mechanical loads from attached piping are summarized in Table 5-2 for dead weight (DW) and seismic (OBE and DBE) conditions. Forces (F_a, F_b, F_c) and moments (M_a, M_b, M_c) are from the piping model and at a node located at the head OD (Ref. 13).

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5.3 Material Properties

The materials that comprise the bottom head and replacement instrument nozzle (Refs. 1, 4, and 5) are as follows:

Bottom head:	SA 533, Grade B, Class 1
Head cladding:	Stainless steel
Instrumentation nozzle:	Inconel 690
Pad:	Inconel weld

In the analysis, the cladding is conservatively ignored. The mechanical strength properties at design temperature are summarized below (Refs. 6 and 14):

Mechanical Strength at 700°F		
	Inconel 690	SA-533B-1
S_m (ksi)	23.3	26.7
S_y (ksi)	27.6	40.6
S_u (ksi)	85.0*	80.0

* Value at room temperature

Also, S_y for Inconel 690 at 100°F is 35 ksi.

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The physical properties of the above materials for an average temperature of 350°F are summarized below (Refs. 6 and 15):

	Inconel 690	SA-533B-1
Modulus of Elasticity, E (x 10^6 psi)	30.25	27.2
Thermal Expansion, α (x 10^{-6} in/in/°F)	7.63	6.71
Poisson's Ratio, υ	0.30	0.30
Thermal Conductivity, K (BTU/HrFt°F)	9.75	32.3
Thermal Diffusivity, d (Ft^3/lb)	0.1521	0.5387
Density, ρ (lb/ft^3)	522	488
Specific Heat, C (BTU/lb°F)	0.123	0.123

Note that material properties at 350°F represent the approximate physical properties during transient conditions. Thermal expansion properties are mean coefficients.

For evaluation of fatigue, the mechanical properties at operating temperature are used. For a temperature of 653°F:

	Inconel 690	SA-533B-1
Modulus of Elasticity, E (x 10^6 psi)	28.88	25.22
Thermal Expansion, α_i (x 10^{-6} in/in/°F)	8.54	8.55

The coefficient of thermal expansion, α_i, is the instantaneous value.

Table 5-1

THERMAL TRANSIENT CONDITIONS (Refs. 1 and 12)

Symbol	Transient Condition		Occurrence
A1	Normal heatup	200°F/hr	500
B1	Normal cooldown	-200°F/hr	500
B2	Cooldown with stratification	Figure 5-3	500
B3	End of cooldown		500
C1	Plant loading, 5% per min. Plant unloading, 5% per min. 10% step load increase 10% step load decrease Normal plant variation	+20°F	10^6
C2	Plant loading, 5% per min. Plant unloading, 5% per min. 10% step load increase 10% step load decrease Normal plant variation	-20°F	10^6
D1	Reactor trip Loss of reactor coolant flow Loss of flow/load	-40°F (50s) -20°F (550s)	480
D2	Reactor trip Loss of reactor coolant flow Loss of flow/load	+60°F (1400s)	480
E1	Plant leak test, heat up		200
F1	Plant leak test, cool down		200
F2	End of plant leak test, cool down		200
G1	Hydrostatic test		10
G2	End of hydrostatic test		10

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Table 5-2

NOZZLE EXTERNAL LOADS FROM PIPING (Ref. 13)

Loading	F_a (lb)	F_b (lb)	F_c (lb)	M_a (in-lbs)	M_b (in-lbs)	M_c (in-lbs)
Dead weight (DW)	−25	0	0	0	0	−60
Seismic (OBE)	±10	±30	±35	±120	±420	±360
Seismic (DBE)	±20	±60	±70	±240	±840	±720

Notes:

F_a = Axial to the nozzle, same as F_y in piping model (upward positive)
F_b = Lateral to nozzle, same as F_z in piping model
F_c = Lateral to the nozzle, same as F_x in piping model
M_a, M_b, M_c = Moments associated with a, b, c axes

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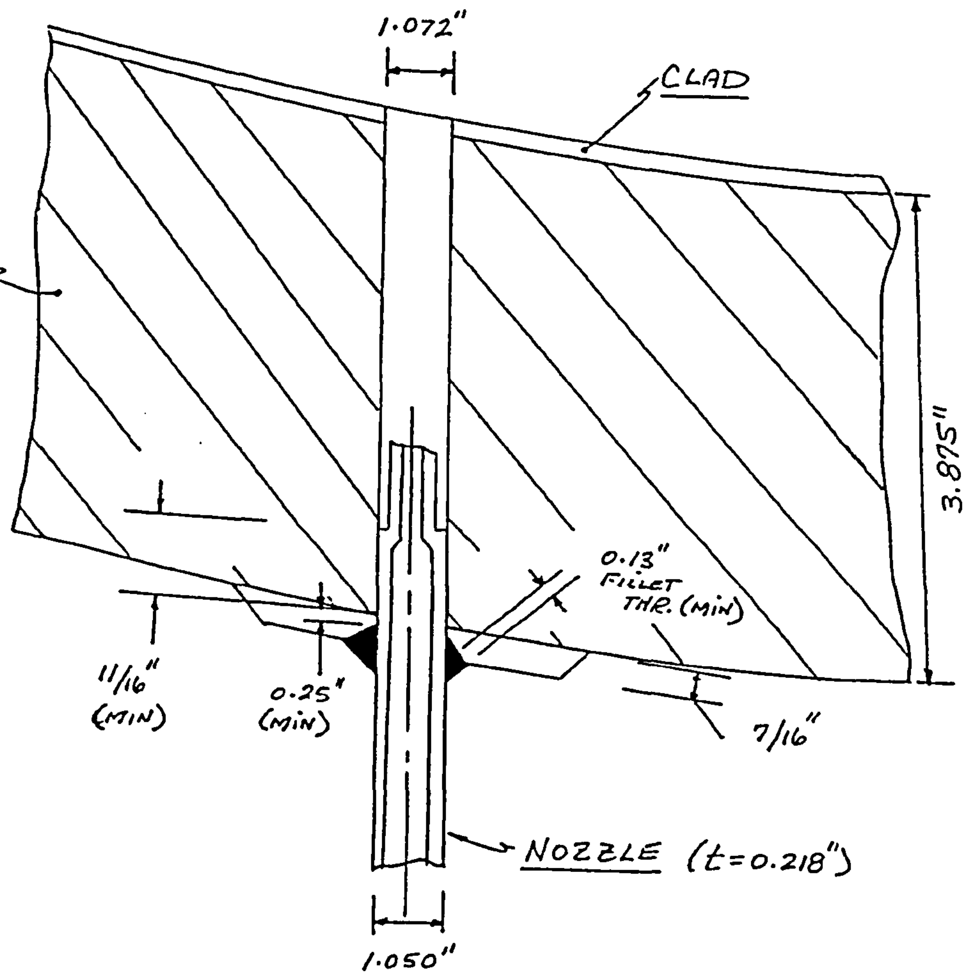

Figure 5-1 — Illustration of Nozzle and Head Geometry.

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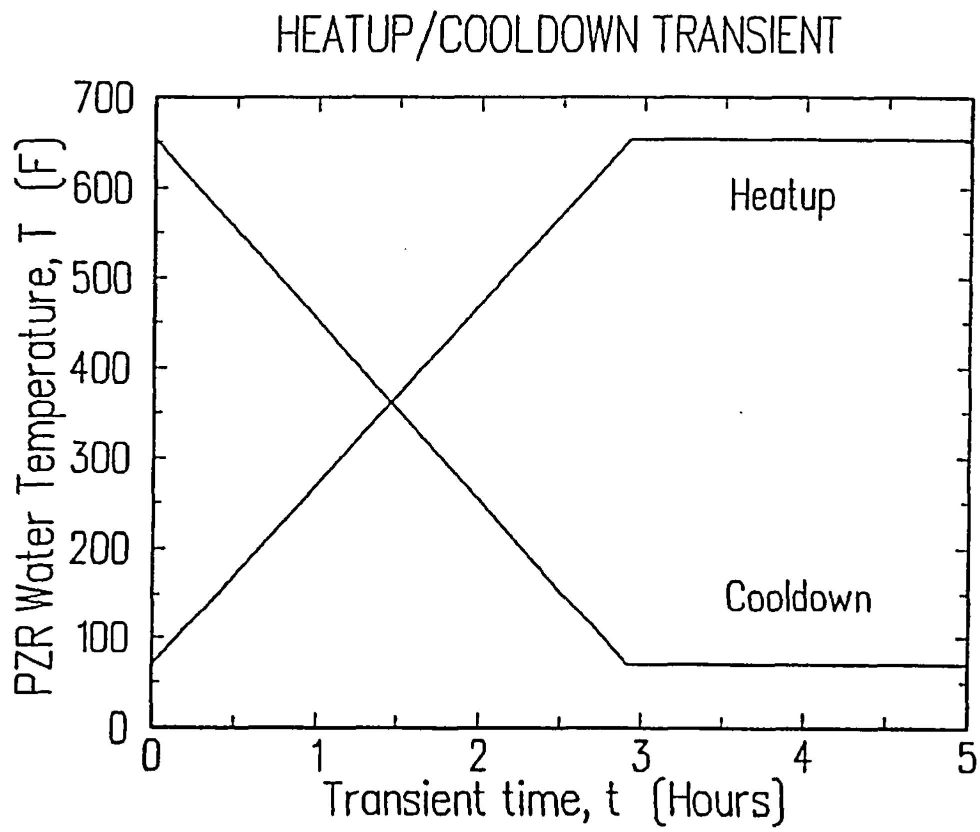

Figure 5-2 — Design Transient Condition — Heatup/Cooldown at a Rate of 200°F per Hour (Figure 2 of Ref. 1).

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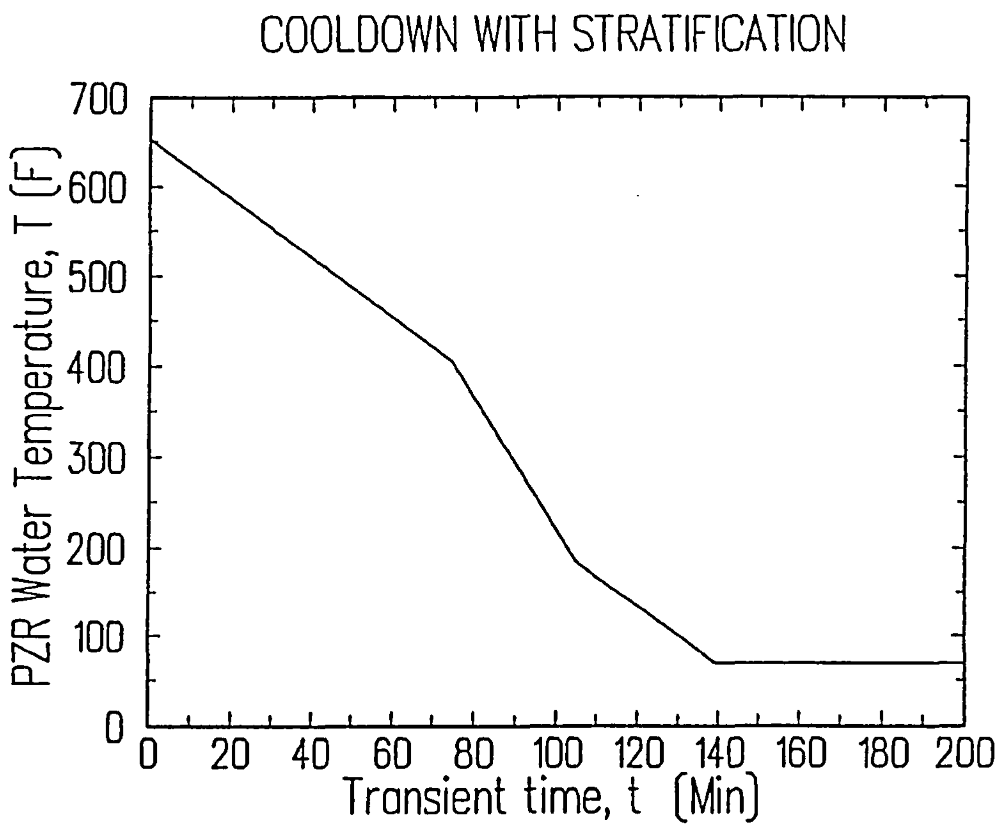

Figure 5-3 — Transient Condition — Cooldown Stratification Transient (Figure 13 in Ref. 12).

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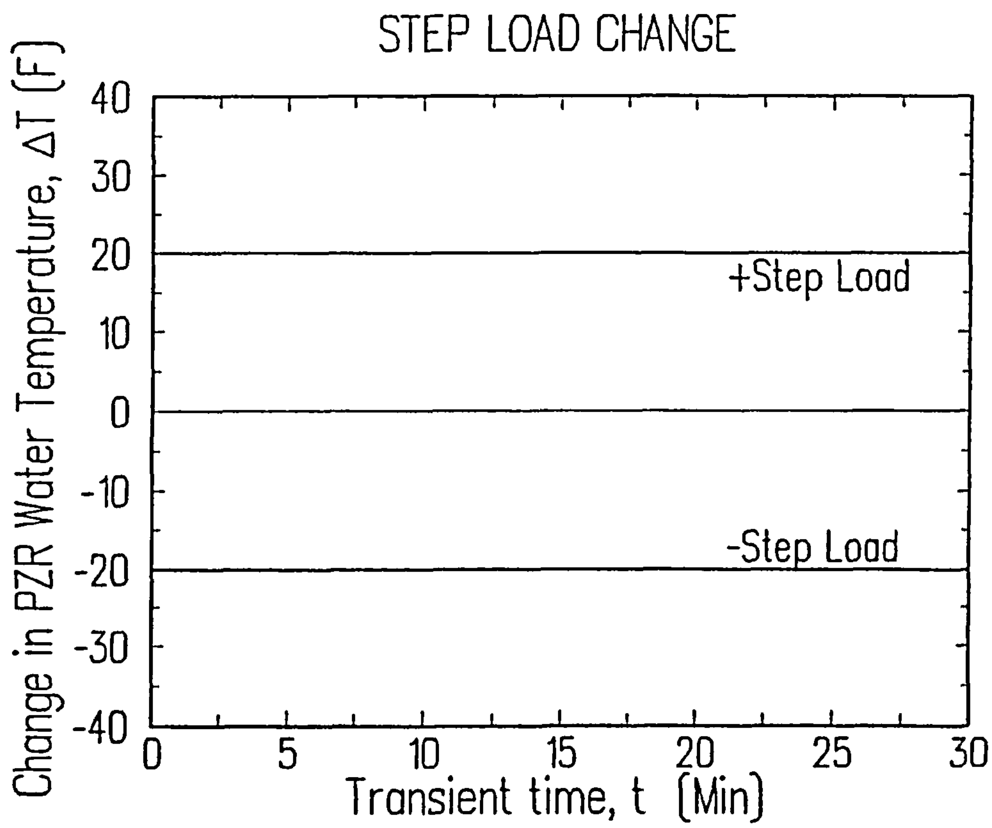

Figure 5-4 — Design Transient Condition — Temperature Changes of ±20°F for Plant Loading and Unloading and ±10% Step Load Change.

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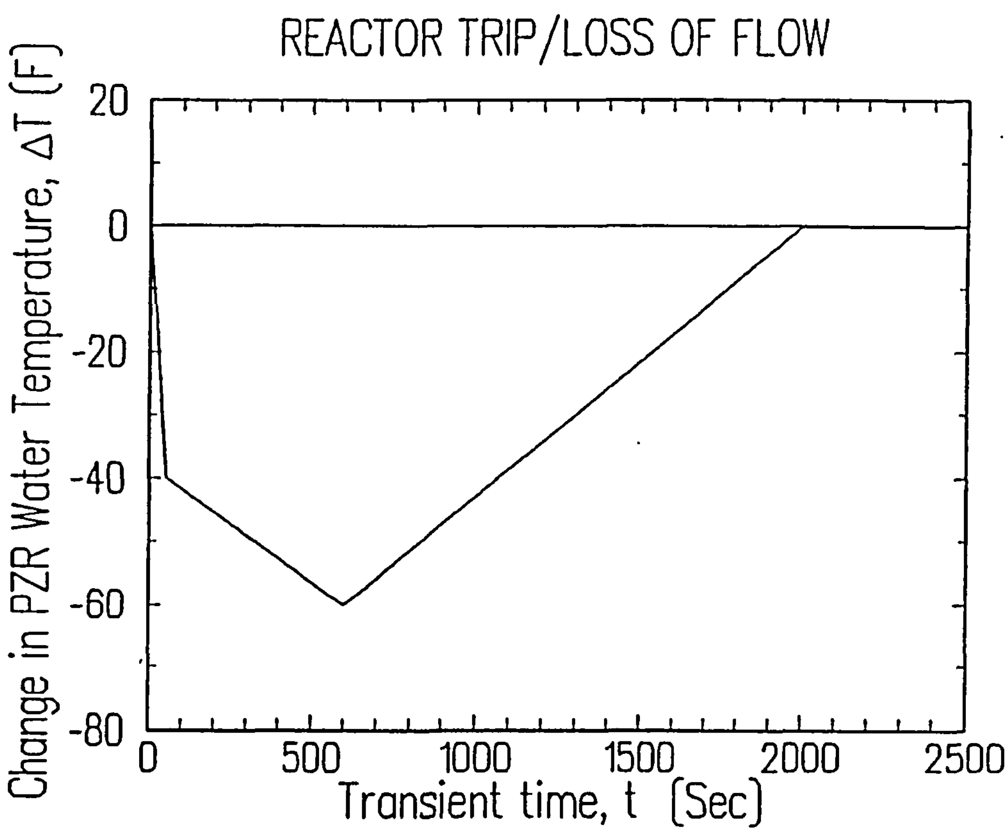

Figure 5-5 — Design Transient Condition — Temperature Change During Loss of Flow (Figure 3 of Ref. 1).

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6.0 REFERENCES

1. "General Specification for a Pressurizer Assembly," Specification No. 00000-PE-130, Revision 3, Combustion Engineering, (October 25, 1972) (ECD-2).

2. "Project Specification for a Pressurizer Assembly for San Onofre Unit No. 2 and 3," Specification No. 01370-PE-130, Revision 9, Combustion Engineering, (December 16, 1993) (ECD-3).

3. Drawing S023-919-2-~~0~~ Rev. 6, "Pressurizer Outline for San Onofre 2," (October 15, 1976) (ECD-8). nme 12/10/05

4. "Analytical Report for Southern California Edison, San Onofre, Unit 3, Pressurizer (CENC-1296)," (September 1977) (ECD-5).

5. "Pressurizer Primary Instrument Nozzle Geometry, 1/2 Nozzle Repair — Conceptual Design PZR Bottom Level Nozzle," (October 28, 1997) (ECD-6).

6. ASME *Boiler and Pressure Vessel Code*, Section III, "Rules for Construction of Nuclear Power Plant Components," (1971 Edition, 1971 Summer Addenda).

7. Calculation Number M-DSC-260, "Pressurizer Instrumentation Nozzle Evaluation — SONGS 2," Southern California Edison (March 29, 1992) (ECD-7, Project AES 97063098-1Q).

8. COSMOS/M, Version 1.71/1.75, "User's Manual," Structural Research and Analysis Corporation, (May 1994).

9. Drawing S023-919-79-~~0~~, Rev. 0 ~~Rev. 3~~, "Pressurizer General Arrangement for San Onofre 3," (October 20, 1976) (ECD-11). nme 12/10/05

10. Drawing S023-919-13-~~1~~, Rev. 2, "Bottom Head Welding & Machining for San Onofre 2," (November 7, 1974) (ECD-10). nme 12/10/05

11. Drawing S2-1201-ML-315, Rev. 0, "From Pressurizer E-087 to Valve R-039," (November 7, 1986) (ECD-13).

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12. "Pressurizer Stratification and Fatigue Evaluation," CEOG Task 788, CE NPSD-953, (December 1994) (ECD-4).

13. Pressurizer Bottom Head Instrument Nozzle — External Loads at the Outer Weld Location," (October 28, 1997) (ECD-7).

14. Code Case N-474-1, "Design Stress Intensities and Yield Strength Values for UNS N06690 With a Minimum Specified Yield Strength of 35 ksi," Class 1 Components; and Section II, Part B, "Nonferrous Material Specifications," ASME Section III, Div. 1, (1992 Edition).

15. *Nuclear Systems Materials Handbook*, Volume 1 — "Design Data," TID-26666, (Books 3 and 4), Oakridge National Laboratory (1986).

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7.0 NOMENCLATURE

α	=	Coefficient of thermal expansion, °F^{-1}
α_i	=	Coefficient of instantaneous thermal expansion, °F^{-1}
α_h	=	Coefficient of thermal expansion of the head, °F^{-1}
α_n	=	Coefficient of thermal expansion of the nozzle, °F^{-1}
C	=	Specific heat, BTU/lb °F
ρ	=	Density, lb/ft^3
d	=	Thermal diffusivity, Ft^3/lb
D_o	=	Outer diameter, inch
E	=	Modulus of elasticity, psi
E_H	=	Modulus of elasticity of the head, psi
E_N	=	Modulus of elasticity of the nozzle, psi
F	=	Force, lb
F_A	=	Axial force, lb
F_L	=	Lateral force, lb
F_a, F_b, F_c	=	Forces in the a, b, c directions acting at head surface, lb
F^*_a, F^*_b, F^*_c	=	Forces in the a, b, c directions acting at nozzle end, lb
F_x, F_y, F_z	=	Forces in the x, y, z directions, lb
K	=	Thermal conductivity, BTU/HrFt°F
M_B	=	Bending moment, in-lb
M_T	=	Torsion, in-lb
M_a, M_b, M_c	=	Moments in the a, b, c directions acting at head surface, in-lb
M^*_a, M^*_b, M^*_c	=	Moments in the a, b, c directions acting at nozzle end, in-lb
M_x, M_y, M_z	=	Moments in the x, y, z directions, in-lb

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n = Number of cycles

υ = Poisson's ratio

P = Pressure, psi

P_D = Design pressure, psi

ΔP = Pressure fluctuation, psi

ΔP_{SIG} = Significant pressure fluctuation, psi

r = Mean nozzle radius, inch

r_o = Outer radius of nozzle, inch

r_i = Inner radius of nozzle, inch

R_o = Outer radius of head, inch

R_i = Inner radius of head, inch

S_a = Stress value from design fatigue curve, psi

S_m = Allowable stress intensity, psi

S_u = Ultimate strength, psi

S_y = Yield strength, psi

t = Wall thickness, inch

T = Temperature, °F

ΔT = Temperature difference, °F

ΔT_{SIG} = Significant temperature difference fluctuation, °F

t_c = Clad thickness, inch

t_p = Pad thickness, inch

t_h = Head thickness, inch

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8.0 CALCULATIONS

8.1 Load Combinations

The design calculation of the pressurizer bottom head instrumentation nozzle defines the following loading conditions: pressure loads, applied piping loads, and thermal transient loads. In accordance with the design calculations, the above loads are combined to meet the requirements of ASME Section III, NB-3200 (Ref. 6). The following load combinations and service level definitions are used, as established from the appropriate design documents and references (Refs. 1, 4, 6, and 7):

Design Condition:	P_D + DW + OBE
Normal and Upset Conditions:	P + DW+OBE +THER
Faulted Conditions:	P_D + DW + DBE
Test Conditions:	P + DW

8.2 Applied Loading Conditions

The loading conditions include pressure, thermal transient loads, and mechanical piping loads as described below.

8.2.1 Pressure Loads

The design pressure of 2500 psia (2485 psig) is conservatively used to define internal pressure for all operating and faulted loading conditions. The design temperature of 700°F is used to define the material strength and stress allowables for all plant operating conditions.

8.2.2 Thermal Loads

The thermal transients are based on design conditions in Refs. 1 and 12, as discussed in Section 4. The thermal transients associated with plant conditions are given in Table 5-1. Five thermal cases are used in this evaluation. These thermal cases are described in Section 4.3.

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8.2.3 Mechanical Pipe Loads

The mechanical loads from attached piping used in this analysis are obtained from Ref. 13 and are summarized in Table 5-2. These loads act on the head surface and are adjusted by the following relations to allow for load application at the nozzle end in the FEM model:

$$F^*_a = F_a = F_A \qquad M^*_a = M_a = M_T$$
$$F^*_b = F_b \qquad M^*_b = M_b - F_c \ell$$
$$F^*_c = F_c \qquad M^*_c = M_c - F_b \ell$$

where ℓ is the length of the nozzle in the model ($\ell = 5.62$ inches). Also, the in-plane (horizontal and vertical) shear and bending moments are combined vectorily to give the absolute magnitude of lateral force (F_L) and bending moment (M_B):

$$F_L = [F_b^{*2} + F_c^{*2}]^{1/2}$$

$$M_B = [M_b^{*2} + M_c^{*2}]^{1/2}$$

Applying the above steps gives the following tabular summary for maximum absolute values of mechanical loads:

	F_A (lbs)	F_L (lbs)	M_T (in-lbs)	M_B (in-lbs)
DW	25	0	0	60
DW + OBE	35	46.1	120	336
DW + DBE	45	92.2	240	629

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8.3 Finite Element Analysis

8.3.1 Finite Element Model

The FEM model is an axisymmetric representation of the nozzle, base pad, and bottom head. The model was developed with COSMOS/M (Ref. 8). A plot of the FEM mesh and boundary conditions is shown in Figure 8-1. There are 1807 isoparametric elements (1965 nodes) designated as PLANE2D in COSMOS/M. The nozzle is attached to the welded portion of the pad by common nodes. The portion of the nozzle extending into the head is free. The annulus between the nozzle and head is open and provides a boundary to both the nozzle and head for pressure and thermal loads. The same model is used to perform the thermal analysis. Material properties taken at an average metal temperature of 350°F are assumed in the model (see Section 5.3). A heat transfer coefficient of 500 BTU/HrFt^2°F is conservatively assumed for the bottom head inside surface. The inner surfaces of the nozzle and head penetration also have a film coefficient of 500 BTU/HrFt^2°F.

Symmetry boundary conditions are used at the end of the spherical head. Both axisymmetric and nonaxisymmetric loading conditions are used to represent the pressure and mechanical loads, as appropriate. Other details of the model and assumptions are provided in Sections 3 and 4.

8.3.2 Unit Load Conditions

There are ten unit load cases evaluated with the FEM model. These cases are later combined with appropriate scaling factors to produce the total stress state for each plant condition. The unit load cases are developed below following the method described in Section 4.

<u>Case 1 — Internal Pressure (p = 2500 psia)</u>

A design pressure of 2500 psia (2485 psig) is used to define the pressure load case. This pressure is applied to all interior surfaces of the head and nozzle. The end-cap loading on the end of the nozzle is applied as a pressure load. The end-cap pressure is computed below:

$$p_{cap} = \pi r_i^2 \, p / \pi (r_o^2 - r_i^2)$$

$$p_{cap} = \pi(0.307^2)(2485)/\pi(0.525^2 - 0.307^2) = 1291 \text{ psi}$$

This pressure is applied to the nozzle end elements.

<u>Case 2 — Axial Force (F_A)</u>

A unit load of 1000 lbs is applied to the nozzle end in the axial direction. This load is axisymmetric, and the FEM loading condition determined from Eq. 4-2 is given below:

$$F_y = F_A/2\pi = 1000/2\pi$$

$$F_y = 159.15 \text{ lbs/rad}$$

This load is divided among the four nodes on the nozzle end in proportion to the element areas as follows:

End nodes (Nodes 282 and 285): $F_y/6 = 26.53$ lbs/rad

Middle nodes (Nodes 283 and 284): $F_y/3 = 53.05$ lbs/rad

<u>Case 3 — Lateral Force (F_L)</u>

A unit load of 1000 lbs is applied to the nozzle end in the lateral direction. This load is asymmetric and of the form:

$$F_x = (F_L/\pi)\cos\theta$$

The magnitude of the loading function is:

$$F_L = 1000/\pi = 318.31 \text{ lbs}$$

This force distribution is divided among the four nodes on the nozzle end in proportion to the element areas, as follows:

End nodes (Nodes 282 and 285): $F_x/6 = 53.05$ lbs

Middle nodes (Nodes 283 and 284): $F_x/3 = 106.10$ lbs

The lateral force F_L is defined as the vector magnitude of the horizontal and vertical force components and is assumed to act in the direction that gives the worst combination of stress.

Case 4 — Bending Moment (M_B)

A unit bending moment of 1000 in-lbs is applied to the nozzle by a distribution of axial forces defined as:

$$F_y = (M_b/\pi r)\cos\theta$$

where r is the mean nozzle radius. This loading is asymmetric and the magnitude of the loading function is:

$$M_B/\pi r = 1000/\pi(0.416) = 765.17 \text{ lbs}$$

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This force distribution is divided among the four nodes on the nozzle end in proportion to the element areas, as follows:

End nodes (Nodes 282 and 285): $F_y/6 = 127.53$ lbs

Middle nodes (Nodes 283 and 284): $F_y/3 = 255.06$ lbs

The bending moment M_B is defined as the vector magnitude of horizontal and vertical moments and is assumed to act in a plane that gives the worst combination of stress.

<u>Case 5 — Torsion (M_T)</u>

A unit torsional moment of 1000 in-lbs is applied to the nozzle end by a uniform distribution of tangential forces from Eq. 4-5:

$$F_z = M_T/2\pi r = 1000/2\pi(0.416)$$

$$F_z = 382.58 \text{ lbs/rad}$$

This force is applied to the four end nodes in proportion to the element areas, as follows:

End nodes (Nodes 282 and 285): $F_z/6 = 63.76$ lbs/rad

Middle nodes (Nodes 283 and 284): $F_z/3 = 127.53$ lbs/rad

<u>Case 6 — Isothermal Condition (THER1)</u>

A uniform temperature of 653°F is applied to the model. This thermal stress analysis was performed to establish the stress developed due to dissimilar materials. A reference temperature of 70°F was assumed for the stress calculations.

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Case 7 — Thermal Ramp Loading (THER2)

A unit ramp loading of +200°F/Hr is applied to the fluid temperature in contact with the inside surfaces of the nozzle and head (see Figure 5-2). A heat transfer coefficient of 500 BTU/HrFt^2°F is assumed for the head surface and the nozzle/penetration inner surfaces. A fluid temperature ramp load from 453°F to 653°F was assumed for the transient. At the start of the transient, the model was assumed isothermal at 453°F. A reference temperature of 653°F was assumed for the stress calculations. The results scaled from this case will be combined with Case 6 to give total thermal stress, as appropriate.

Case 8 — Cooldown with Thermal Stratification (THER3)

The cooldown transient with thermal stratification effects is represented by a trilinear ramp loading. A ramp loading from 653°F to 405°F in 74.4 minutes, followed by a ramp loading to 185°F in 30 minutes, followed by a ramp loading to 70°F in 34.5 minutes is applied as the fluid temperature (see Figure 5-3). A 653°F isothermal condition was assumed at the beginning of the transient. A reference temperature of 70°F was assumed for the stress calculation.

Case 9 — Thermal Step Change (THER4)

A unit step change of +20°F is applied to the fluid temperature in contact with the inside surfaces. The same thermal convection boundary conditions were assumed here as with Case 7 (see Figure 5-4). A fluid temperature step change from 653°F to 673°F was assumed. A 653°F isothermal condition was assumed at the beginning of the transient. A reference temperature of 653°F was assumed for the stress calculations. The results scaled from this case will be combined with Case 6 to give total thermal stress, as appropriate.

Case 10 — Loss of Flow Transient (THER5)

The multi-ramp transient of –40°F followed by –20°F, followed again by +60°F change in reactor coolant system temperature is applied as the fluid temperature (see Figure 5-5). The same thermal convection boundary conditions were assumed here as with Case 7. A fluid temperature change from 653°F to 613°F in 50s, followed by linear temperature drop to 593°F in 550s, followed by a linear increase in temperature to 653°F in 1400s was

assumed. A 653°F isothermal condition was assumed at the beginning of the transient. A reference temperature of 70°F was assumed for the stress calculation.

8.4 Analysis Results

8.4.1 Unit Load Results

The time at which the maximum stress intensities occur in the thermal transient analyses was determined by first computing the ΔT across the nozzle/weld thickness as a function of time. These results are shown in Figures 8-2 through 8-5. The time where ΔT was a maximum was used to select the temperature solution for processing stress results. For ramp loading (Cases 7, 8 and 10), the maximum ΔT occurs at the end of the ramp. For the step change loading (Case 9), the maximum ΔT occurs early in the transient (within the first minute). The temperature distributions within these times were used to define the stress solution for the unit load cases.

The stress results for the unit load cases are summarized in Appendix A. For each case, the six component stresses at each of the four critical sections are provided. The membrane and bending stress components across each section are computed by COSMOS/M for all symmetric load cases. This computation is provided under the ASME Code Evaluation option in the COSMOS/M program. For the asymmetric loadings, the membrane and bending stress components are conservatively determined by simple linearization using ID and OD stress values.

A plot of the stress intensities for each unit case is given in Figures 8-6 through 8-15. The maximum stress intensities occur at one of the four locations depending on the loading condition. These results are used in the code evaluation described in Section 8.5.

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8.4.2 Load Combination Factors

The total stresses are computed from the unit load cases by multiplying the unit load nodal stress results by a factor equal to the ratio of actual load to unit load. These stresses are then summed together to establish the stresses for each load combination defined in Section 8.1. Tabulation of the load multiplying factors is provided below.

	P	F_A	F_L	M_B	M_T	THER1	THER2	THER3	THER4	THER5
Design P_D + DW+OBE	1.0	0.035	0.046	0.336	0.120	0.0	0.0	0.0	0.0	0.0
Normal P + DW + OBE + THER	1.0	0.035	0.046	0.336	0.120	1.0	±1.0	0.0	0.0	0.0
Normal P + DW + OBE + THER	1.0	0.035	0.046	0.336	0.120	0.0	0.0	1.0	0.0	0.0
Upset P + DW + OBE + THER	1.0	0.035	0.046	0.336	0.120	1.0	0.0	0.0	±1.0	0.0
Upset P + DW +OBE +THER	1.0	0.035	0.046	0.336	0.120	0.0	0.0	0.0	0.0	1.0
Faulted P_D + DW + DBE	1.0	0.045	0.092	0.629	0.240	0.0	0.0	0.0	0.0	0.0
Test P + DW	1.25	0.025	0.0	0.060	0.0	0.0	0.0	0.0	0.0	0.0

8.5 Code Evaluation

The design requirements of NB-3200 are used to assess the stress allowables and design acceptance for all load combinations considered in Section 4. The results from the stress analysis (Appendix A) are scaled according to Section 8.4.2 for each critical nozzle location and compared with the code allowable stress limits. The stress allowable limits are provided below from the original design code (Ref. 6):

	Primary Membrane		Membrane + Bending	Primary + Secondary
Plant Condition	P_M	P_L	$P_L + P_b$	$P_L + P_b + Q$
Design	$1.0S_m$	$1.5S_m$	$1.5S_m$	---
Normal and upset	---	---	---	$3.0\ S_m$
Faulted	$2.4S_m$	$3.6S_m$	$3.6S_m$	---
Test	$0.9S_y$	---	$1.35S_y$	---

where P_M is the general primary membrane stress intensity, P_L is the local primary membrane stress intensity (including discontinuities), P_b is the primary bending stress, and Q is secondary stress (thermal stresses). Peak stresses are excluded from static stress evaluations, but are considered in the fatigue evaluation.

From the standpoint of nozzle design (NB-3217 and NB-3227.5 of Ref. 6) the P_m stresses for the nozzle section within the limits of reinforcement (Sections 2, 3, 4) are determined from pressure plus mechanical loads (see Table NB-3217-1). This loading condition is conservatively used for regions outside these limits (Section 1). Also, the nozzle is conservatively evaluated under the primary bending stress requirements ($P_L + P_b$) per NB-3220. This conservatively treats the nozzle discontinuity stresses as P_b stresses and addresses any concern of gross over-stressing of the welded attachment.

A spreadsheet analysis is used to combine stresses with the appropriate scaling factors. These results are given in Appendix B. Superposition is used to combine individual component stresses and membrane and bending stresses. The comparisons of computed stress intensities with code allowable stress limits are summarized below.

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1. For the design loading combinations (from Appendix B, Page B-2):

Design Condition (P_D + DW + OBE)						
	Primary Stress Intensities (ksi)					
Nozzle Section	P_M	Allowable $1.0S_m$	Ratio	$P_L + P_b$	Allowable $1.5S_m$	Ratio
1	4.80	23.3	0.206	6.70	34.95	0.192
2	9.59	23.3	0.412	12.83	34.95	0.367
3	14.52	23.3	0.623	24.41	34.95	0.698
4	14.10	23.3	0.605	23.08	34.95	0.660

Note: Design condition stresses are higher than some normal/upset stresses because thermal stresses act to reduce pressure stresses in the nozzle attachment weld region.

2. For normal and upset loading combinations considering heatup/cooldown thermal conditions (maximum values from Pages B-3 and B-4):

Normal and Upset Condition (P + DW + OBE + THER)			
	Primary + Secondary Stress Intensities (ksi)		
Nozzle Section	$P_L + P_b + Q$	Allowable $3.0S_m$	Ratio
1	6.73	69.9	0.096
2	6.06	69.9	0.087
3	3.97	69.9	0.057
4	4.22	69.9	0.060

3. For normal and upset loading combinations considering cooldown with thermal stratification transient (from Page B-5):

Normal and Upset Condition (P + DW + OBE + THER)			
	Primary + Secondary Stress Intensities (ksi)		
Nozzle Section	$P_L + P_b + Q$	Allowable $3.0S_m$	Ratio
1	6.78	69.9	0.097
2	11.81	69.9	0.169
3	19.45	69.9	0.278
4	18.42	69.9	0.264

4. For normal and upset loading combinations considering plant load/unload and step change transients (maximum values from Pages B-6 and B-7):

Normal and Upset Condition (P + DW + OBE + THER)			
	Primary + Secondary Stress Intensities (ksi)		
Nozzle Section	$P_L + P_b + Q$	Allowable $3.0S_m$	Ratio
1	7.24	69.9	0.104
2	6.82	69.9	0.098
3	5.01	69.9	0.072
4	4.26	69.9	0.061

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5. For normal and upset loading combinations considering reactor trip for loss of flow transient (maximum values from Pages B-8 and B-9):

Normal and Upset Condition (P + DW + OBE + THER)			
	Primary + Secondary Stress Intensities (ksi)		
Nozzle Section	$P_L + P_b + Q$	Allowable $3.0S_m$	Ratio
1	7.20	69.9	0.103
2	7.44	69.9	0.106
3	6.08	69.9	0.087
4	4.92	69.9	0.070

6. For faulted load combination under design basis earthquake (from Page B-10):

Faulted Condition (P_D + DW + DBE)						
	Primary Stress Intensities (ksi)					
Nozzle Section	P_M	Allowable $2.4S_m$	Ratio	$P_L + P_b$	Allowable $3.6S_m$	Ratio
1	6.36	55.92	0.114	7.19	83.88	0.086
2	9.72	55.92	0.174	12.93	83.88	0.154
3	14.51	55.92	0.259	24.21	83.88	0.289
4	14.01	55.92	0.251	22.85	83.88	0.272

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7. For test load combinations under hydrotest conditions (from Page B-11):

Test Condition (P + DW)						
	Primary Stress Intensities (ksi)					
Nozzle Section	P_M	Allowable $0.9S_y$	Ratio	$P_L + P_b$	Allowable $1.35S_y$	Ratio
1	5.50	24.84	0.221	8.23	37.26	0.221
2	11.92	24.84	0.480	15.95	37.26	0.428
3	18.18	24.84	0.732	30.74	37.26	0.825
4	17.73	24.84	0.714	29.12	37.26	0.782

Note: For test conditions, S_y is conservatively assumed as 27.6 ksi.

8.6 Fatigue Evaluation

The requirements of NB-3222.4(d) pertaining to fatigue exemption rules are evaluated. The original nozzle design was exempt from fatigue. Following the same code analysis procedure, the analysis for cyclic operation for the replacement nozzle design is not required if the following six conditions are satisfied. In performing the calculations, the properties from Section 5.3 are used as follows:

	Nozzle	Head
E, (psi)	28.88×10^6	25.22×10^6
α_i, (in/in/°F)	8.54×10^{-6}	8.55×10^{-6}
S_m, (ksi)	23.3	26.7

where α_i is the instantaneous coefficient of thermal expansion.

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1. Atmospheric-To-Operating Pressure Cycle (NB-3222.4(d) 1)

Cycles from atmospheric-to-operating are 500 heatup/cooldown and 200 primary leak test:

$$n = 500 + 200 = 700 \text{ cycles}$$

Number of cycles corresponding to $3S_m$:

$$S_a = 3S_m = 69.9 \text{ ksi}$$

From Ref. 6, Figure I-9.2, the allowable cycles for $S_a = 69.9$ ksi is 5,000 cycles.

Therefore, the condition is satisfied since 700 cycles < allowable = 5,000 cycles.

2. Normal Operation Pressure Fluctuation (NB-3222.4(d) 2)

The significant pressure fluctuations are those greater than $P_D S_a / 3S_m$:

$$\Delta P_{SIG} = \frac{P_D S_a}{3S_m}$$

where S_a is equal to 26.0 ksi at 10^6 cycles from Figure I-9.2 of Ref. 6.

$$\Delta P_{SIG} = 2485\,(26.0)/3\,(23.3) = 924 \text{ psi}$$

The maximum pressure fluctuation occurs during the combined transients of reactor trip and loss of load/flow. From Figure 3 of Ref. 1, P_{MAX} = 2550 psia and P_{MIN} = 1700 psia.

$$\Delta P = P_{MAX} - P_{MIN} = (2550 - 1700) = 850\,\text{psi}$$

Since ΔP = 850 psi < ΔP_{SIG} = 924 psi, no significant pressure fluctuations occur and the condition is satisfied.

3. Temperature Difference — Startup and Shutdown (NB-3222.4(d) 3)

The allowable temperature difference between two adjacent points must be less than $S_a/2E\alpha_i$. The number of startup/shutdown cycles including primary leak tests is 700. For 700 cycles, S_a = 125,000 psi from Figure I-9.2 (Ref. 6) and

$$\Delta T = 125{,}000/2\,(28.88 \times 10^6)(8.54 \times 10^{-6}) = 253°\,F$$

The maximum temperature difference during startup/shutdown conditions never exceeds ΔT = 253°F in the nozzle assembly, as indicated by Figures 8-2 and 8-3. Therefore, the condition of no significant temperature difference is satisfied.

4. Temperature Difference — Normal Operation (NB-3222.4(d) 4)

Significant temperature difference fluctuations between any two adjacent points are those greater than $S_a/2E\alpha_i$, where S_a is the allowable alternating stress at 10^6 cycles, from Figure I-9.2 (Ref. 6).

$$S_a = 26.0 \text{ ksi at } 10^6 \text{ cycles}$$

$$\Delta T_{SIG} = 26{,}000/2\,(28.88 \times 10^6)(8.54 \times 10^{-6}) = 53°\,F$$

The maximum temperature differences during operation occur during reactor trips. From Figure 8-5, the maximum ΔT is 13°F. Since $\Delta T = 13°F < \Delta T_{SIG} = 53°F$, there are no significant temperature fluctuations and the condition is satisfied.

5. Temperature Difference — Dissimilar Materials (NB-3222.4(d) 5)

Significant temperature difference fluctuations experienced by the nozzle assembly during normal service are those greater than $S_a/2(E_N\alpha_N - E_H\alpha_H)$, where S_a is defined as the minimum allowable stress range at 10^6 cycles, in Figure I-9.1 of Ref. 6.

$$S_a = (E_H/E)S_a$$

$$S_a = 11{,}800(25.22 \times 10^6/30 \times 10^6) = 9{,}920 \text{ psi}$$

$$\Delta T_{SIG} = 9{,}920/2[(28.88)(8.54) - (25.22)(8.55)] = 160° F$$

Maximum ΔT for the design transients is −60°F for reactor trips (see Figure 5-5). Therefore, ΔT range is equal to $60°F < \Delta T_{SIG} = 160°F$. There are no significant temperature fluctuation differences.

6. Mechanical Loads (NB-3222.4(d) 6)

The significant mechanical load fluctuations are those loads acting on the nozzle excluding pressures that produce alternating stresses exceeding S_a, where S_a is the allowable stress amplitude at 10^6 cycles. The calculated range of mechanical loads must not result in stresses exceeding S_a from Figure I-9.2 (Ref. 6) for the total number of cycles of "significant" mechanical loads.

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For the nozzle, $S_a = 26.0$ ksi at 10^6 cycles from Figure I-9.2. The applied loads from piping reaction forces are given in Table 5-2. At the nozzle-fillet location, the axial surface stress range is conservatively given by:

$$\Delta\sigma = 2K_t M/Z$$

where K_t is the stress concentration factor for a fillet weld, M is the applied moment, and Z is the section modulus. The value of K_t is taken from piping design or peak stress (bending stress term in Eq. 11 under NB-3653.2 of Ref. 6) where:

$$K_t = C_2 K_2$$

$$= (1.5)(2.0) = 3.0$$

The OBE seismic loads are assumed.

$$M = [M_a^2 + M_b^2 + M_c^2]^{1/2}$$

$$= [120^2 + 420^2 + 360^2]^{1/2} = 566 \text{ in-lbs}$$

$$Z = \frac{\frac{\pi}{4}(r_o^4 - r_i^4)}{r_o} = \frac{(\pi/4)(0.525^4 - 0.307^4)}{0.525} = 0.1004 \text{ in}^3$$

Therefore,

$$\Delta\sigma = 2(3)(566)/0.1004 = 33{,}830 \text{ psi}$$

The calculated stress range exceeds 26,000 psi, which indicates that mechanical loads caused by OBE are considered "significant" mechanical load fluctuations.

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The number of cycles for OBE loading is 200 (Paragraph 4.6.8 in Ref. 1). For the assumed 40 cycles for each seismic event, the total number of cycles is:

$$N = (200)(40) = 8{,}000 \text{ Cycles}$$

At 8,000 cycles, S_a = 64,000 psi from Figure I-9.2.

The calculated stress range is 33,830 psi < S_a = 64,000 psi. Therefore, all significant mechanical load fluctuations satisfy the requirements of NB-3222.4(d)(6).

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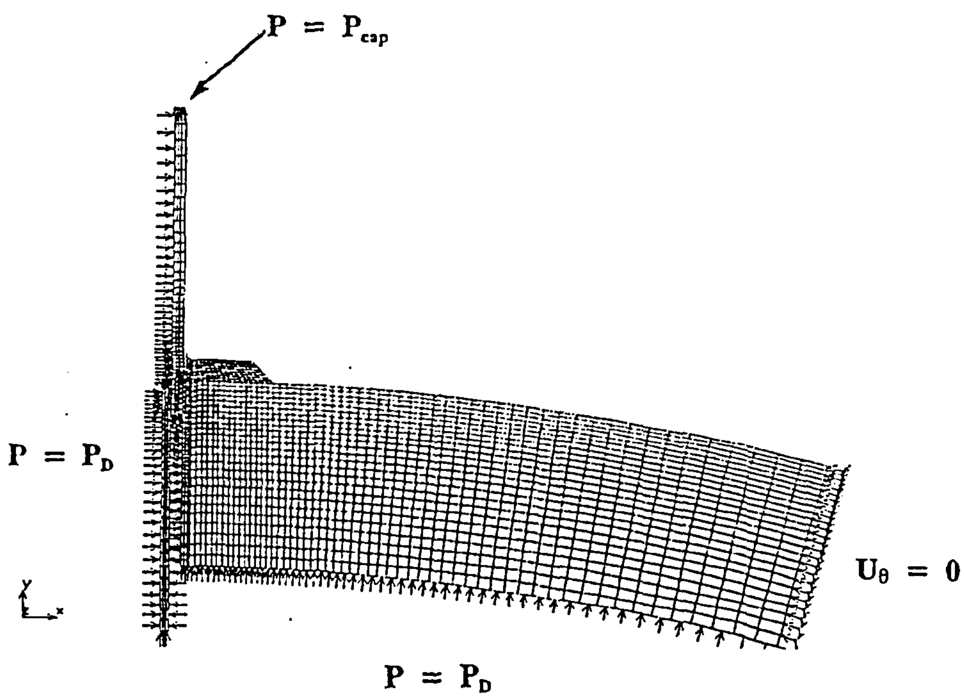

Figure 8-1 — Plot of the FEM Mesh and Boundary Conditions.

Calculation No.: AES-C-3213-1	Made by: REC	Date: 1/14/98	Client: SCE
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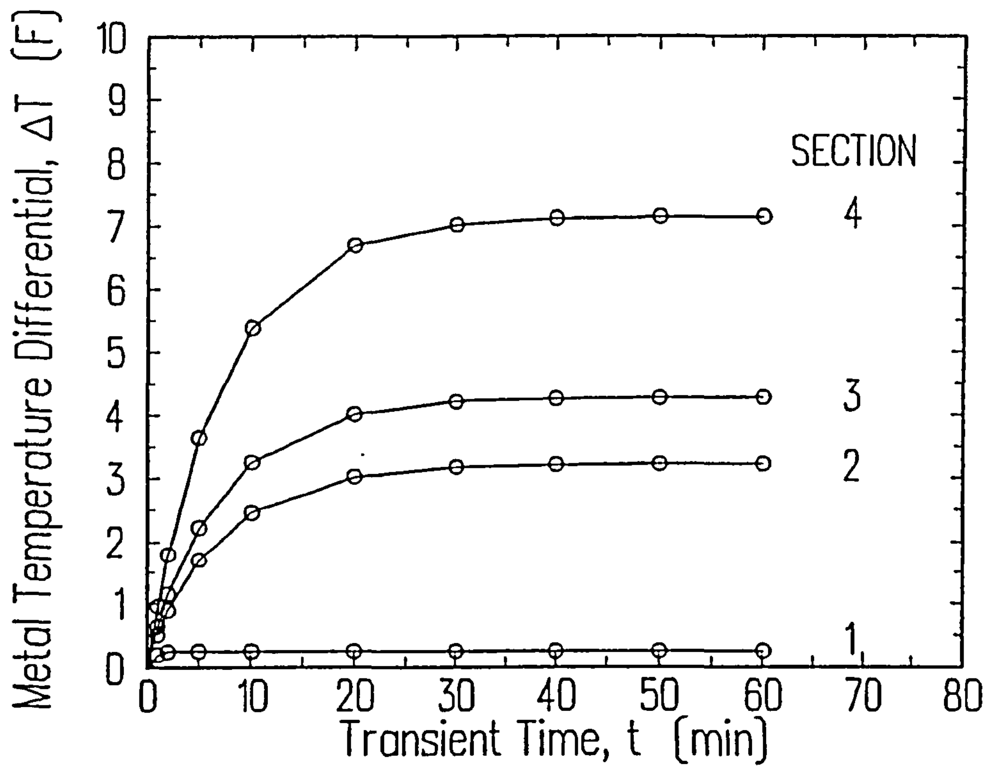

Figure 8-2 — Temperature Versus Time Results for Ramp Loading (Case 7).

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
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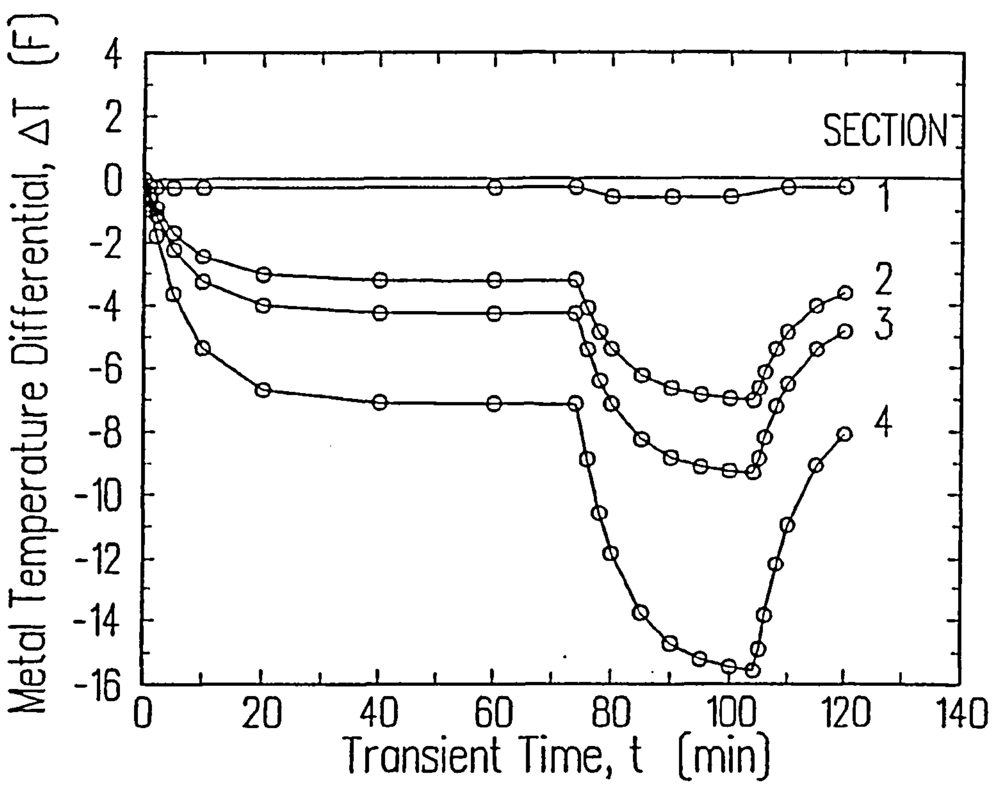

Figure 8-3 — Temperature vs. Time for Cooldown with Stratification Transient (Case 8).

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
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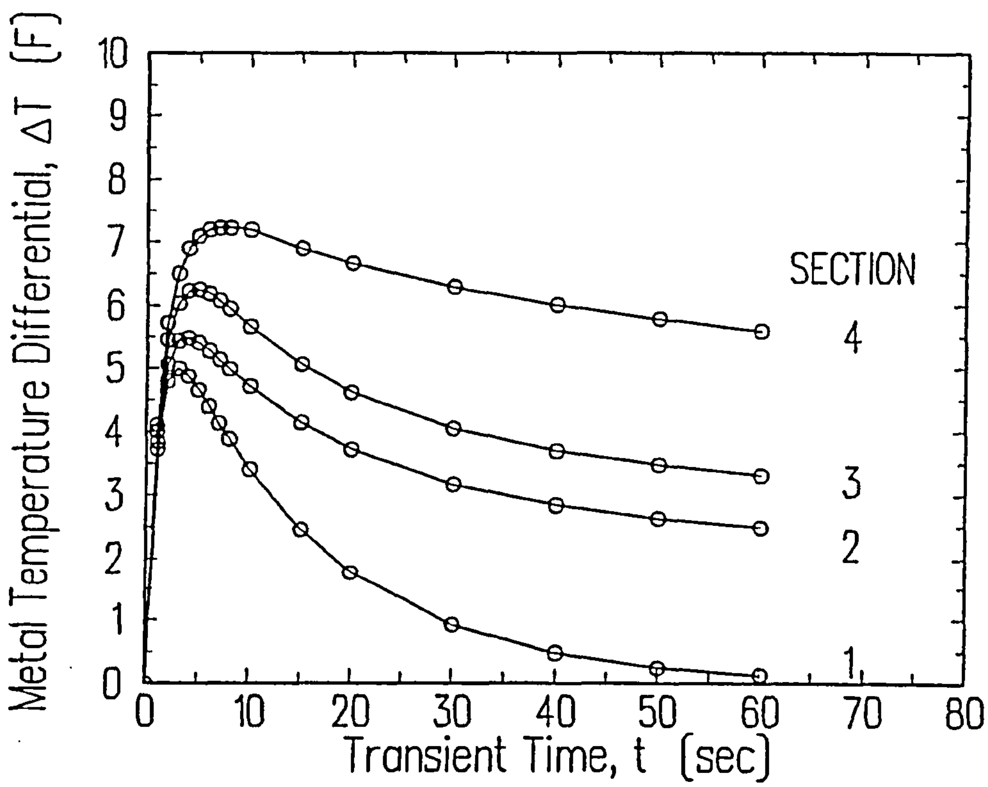

Figure 8-4 — Temperature Versus Time Results for Step Change Loading (Case 9).

Calculation No.: AES-C-3213-1	Made by:	Date: 1/14/98	Client: SCE
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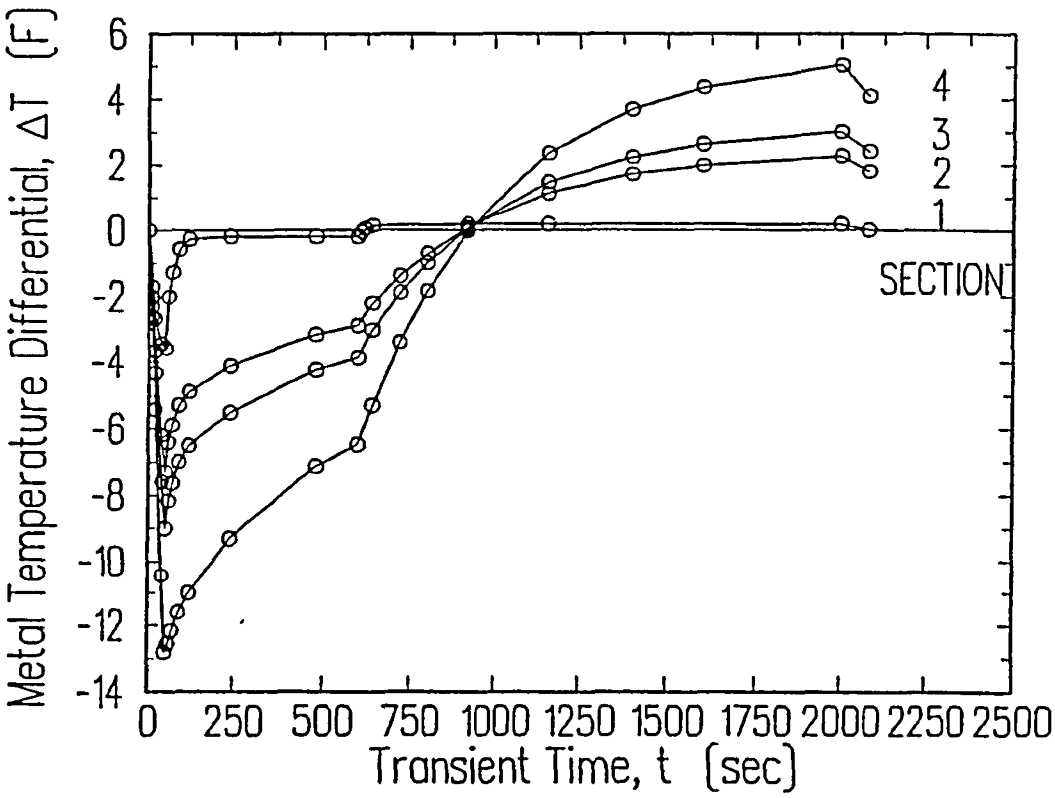

Figure 8-5 — Temperature Versus Time Results for Loss of Flow (Case 10).

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: PQL	Date: 1/14/98	Project No.: AES 97103213-1Q
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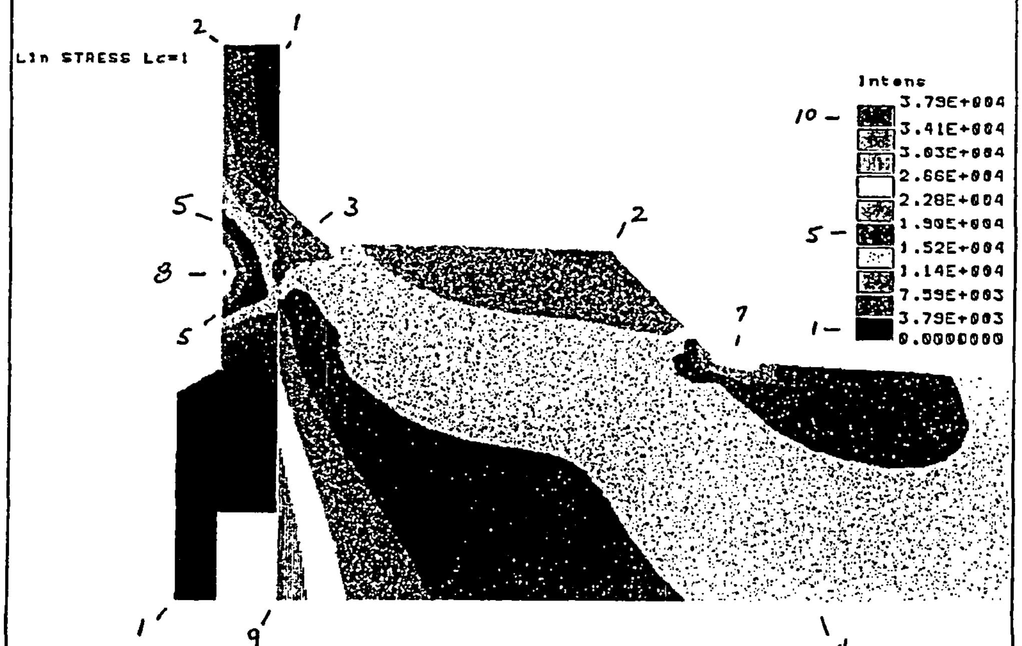

Figure 8-6 — Stress Intensities for Design Pressure (Case 1).

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
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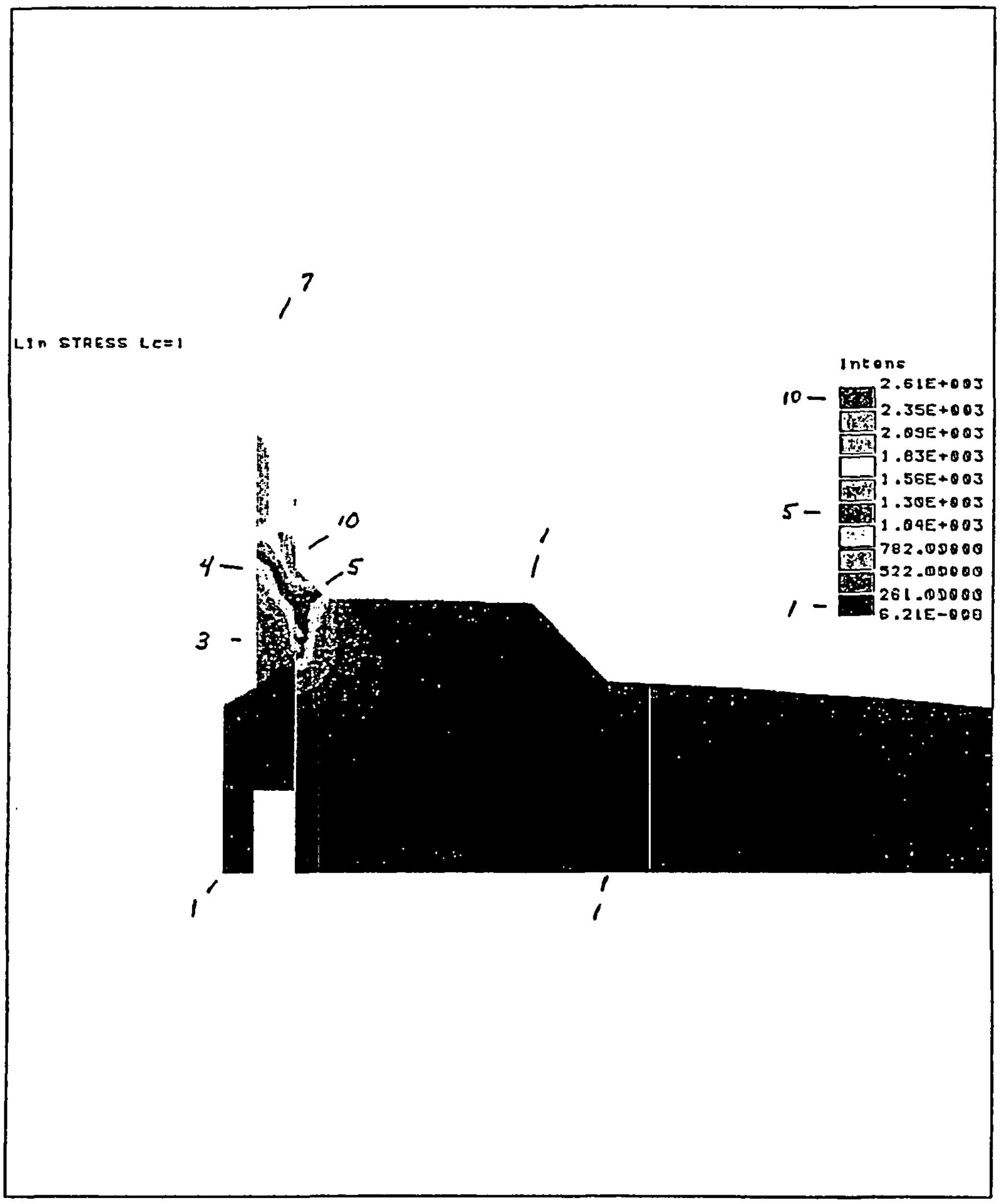

Figure 8-7 — Stress Intensities for Unit Axial Force (Case 2).

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: CQL	Date: 1/14/98	Project No.: AES 97103213-1Q
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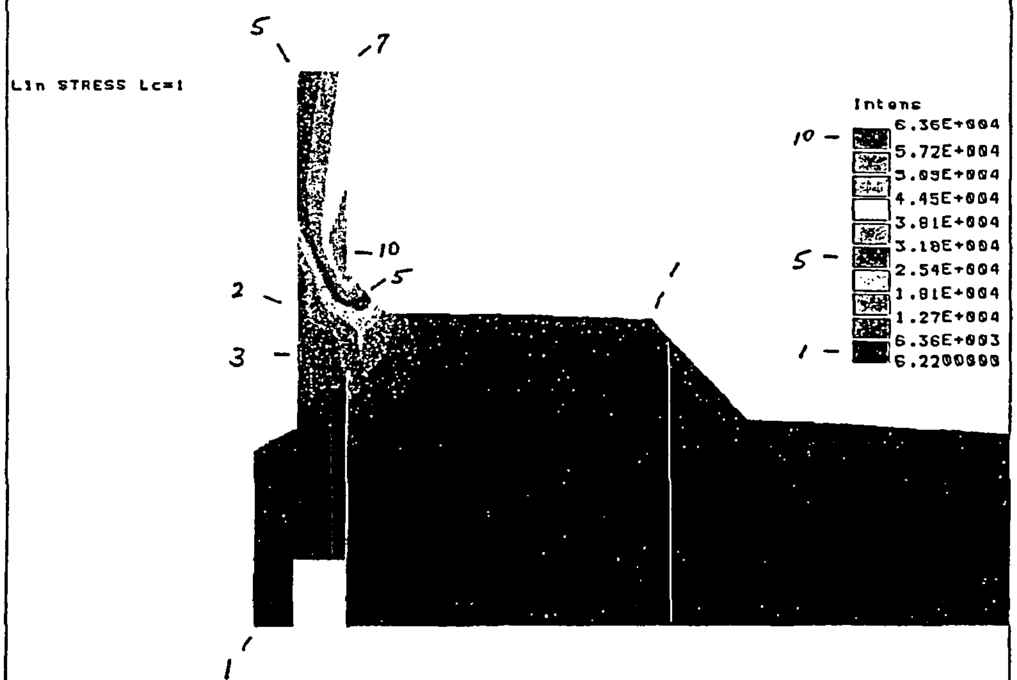

Figure 8-8 — Stress Intensities for Unit Lateral Force (Case 3).

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: CQL	Date: 1/14/98	Project No.: AES 97103213-1Q
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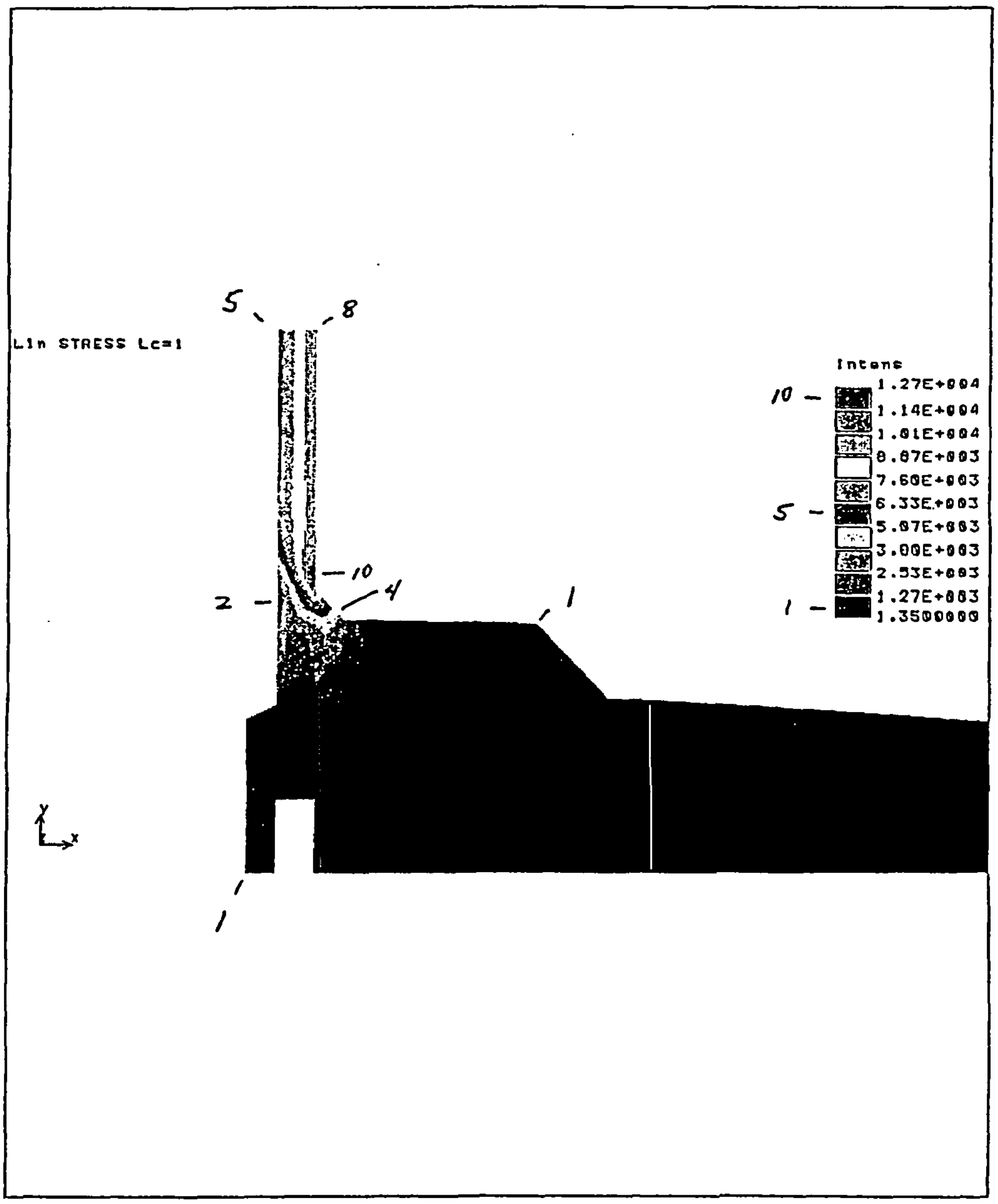

Figure 8-9 — Stress Intensities for Unit Bending Moment (Case 4).

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
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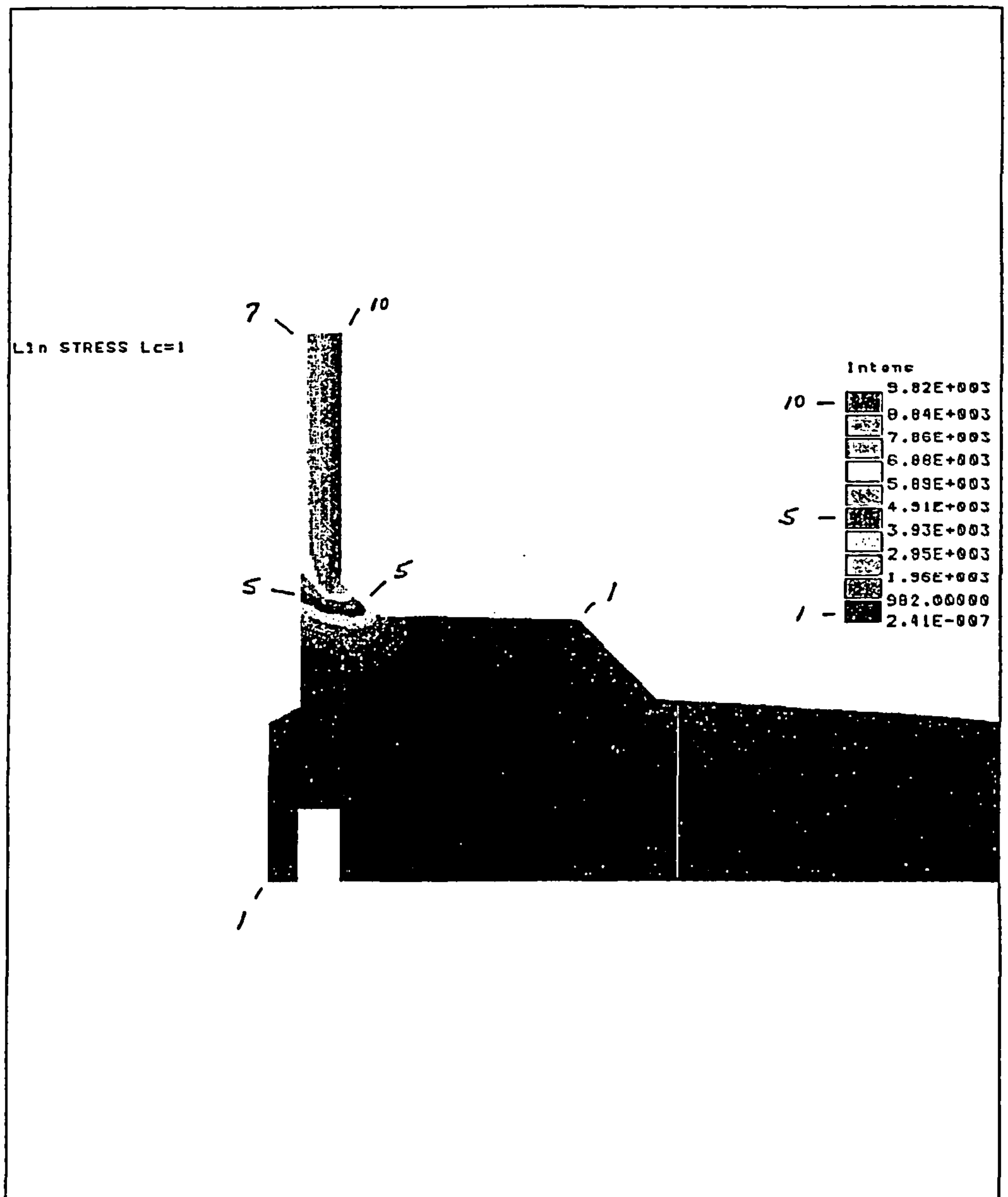

Figure 8-10 — Stress Intensities for Unit Torsion (Case 5).

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
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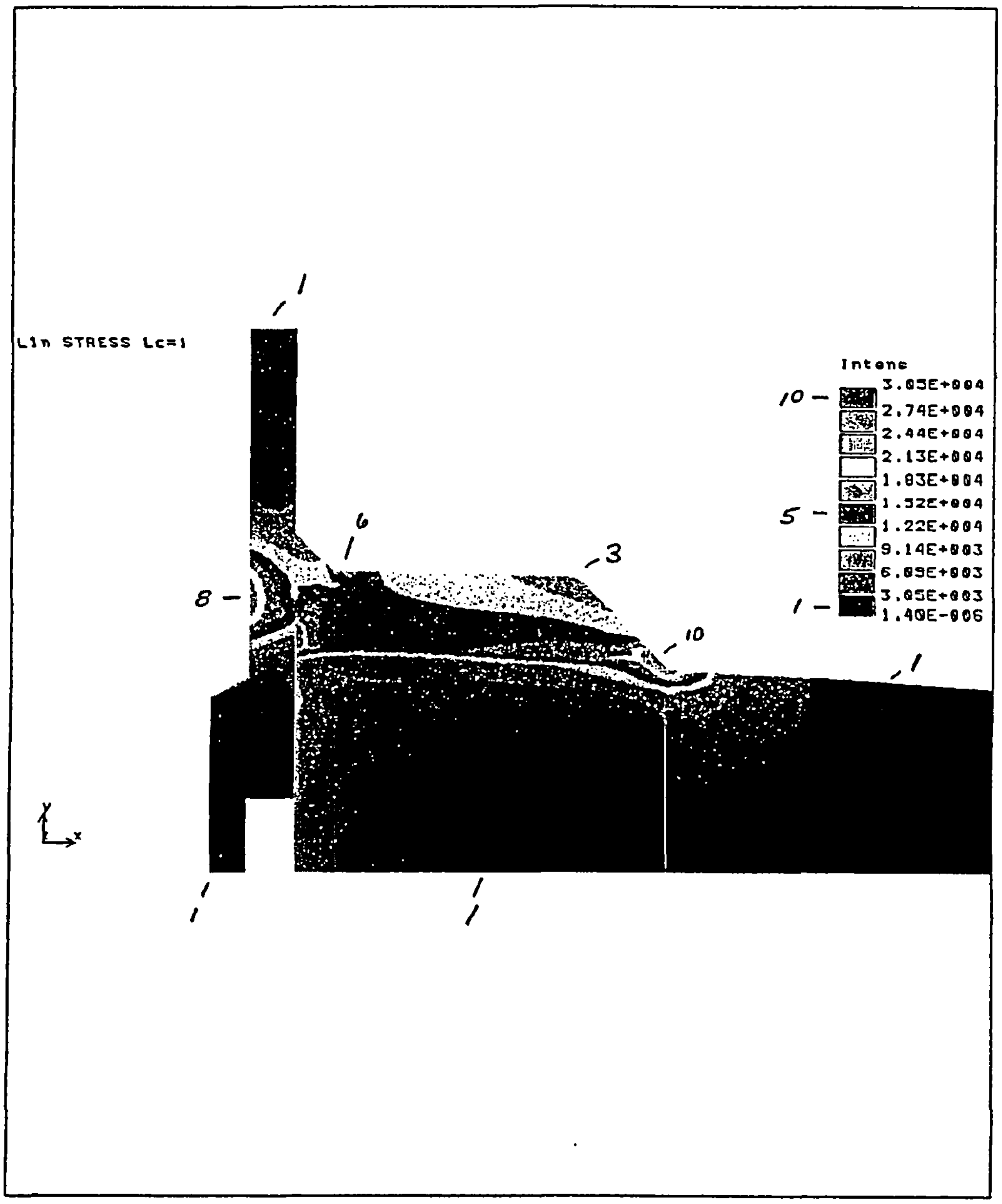

Figure 8-11 — Stress Intensities for 653°F Isothermal Condition (Case 6).

Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: CQC	Date: 1/14/98	Project No.: AES 97103213-1Q
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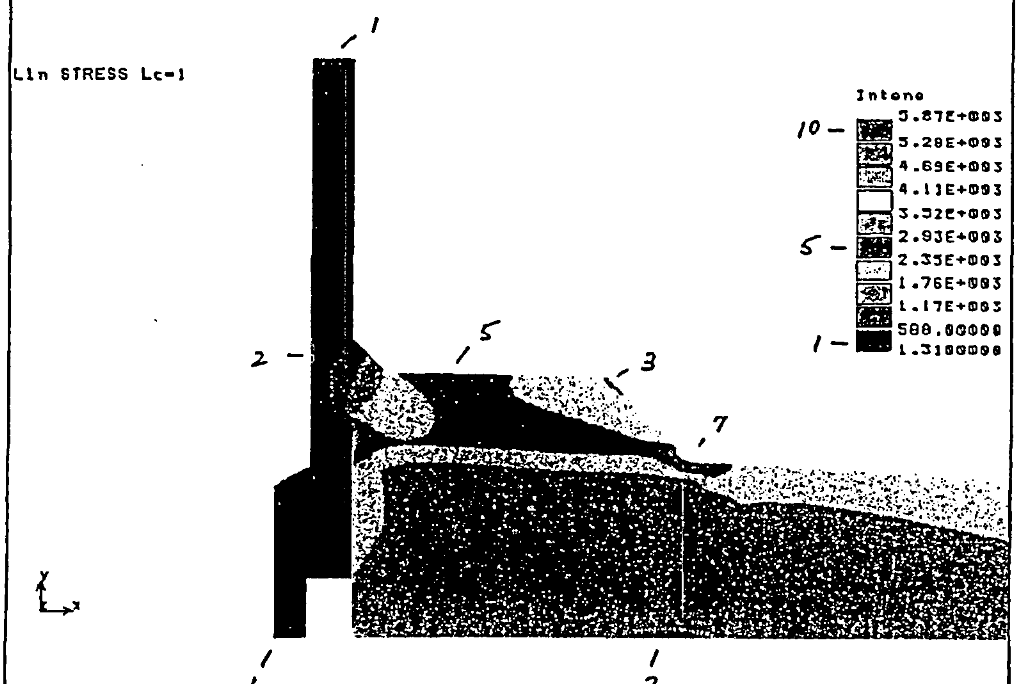

Figure 8-12 — Stress Intensities for +200°F Temperature Ramp Transient (Case 7).

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: CAL	Date: 1/14/98	Project No.: AES 97103213-1Q
	Revision No.: 0	Document Control No.: I-2	Sheet No.: 64 of 66

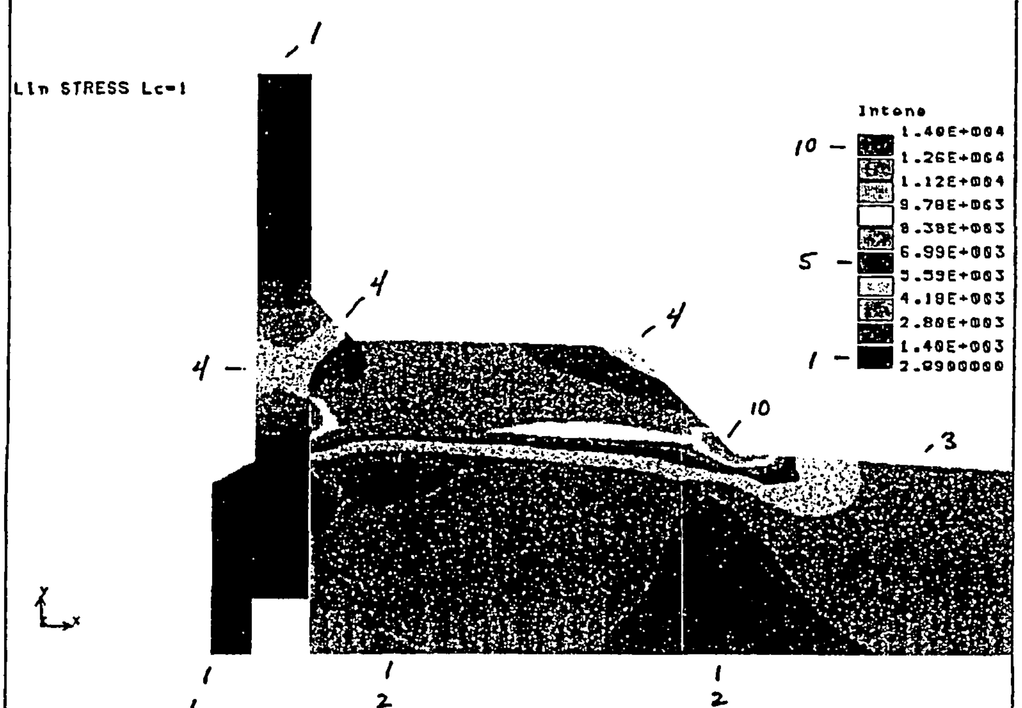

Figure 8-13 — Stress Intensities for Cooldown with Stratification Transient (Case 8).

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: CRC	Date: 1/14/98	Project No.: AES 97103213-1Q
	Revision No.: 0	Document Control No.: I-2	Sheet No.: 65 of 66

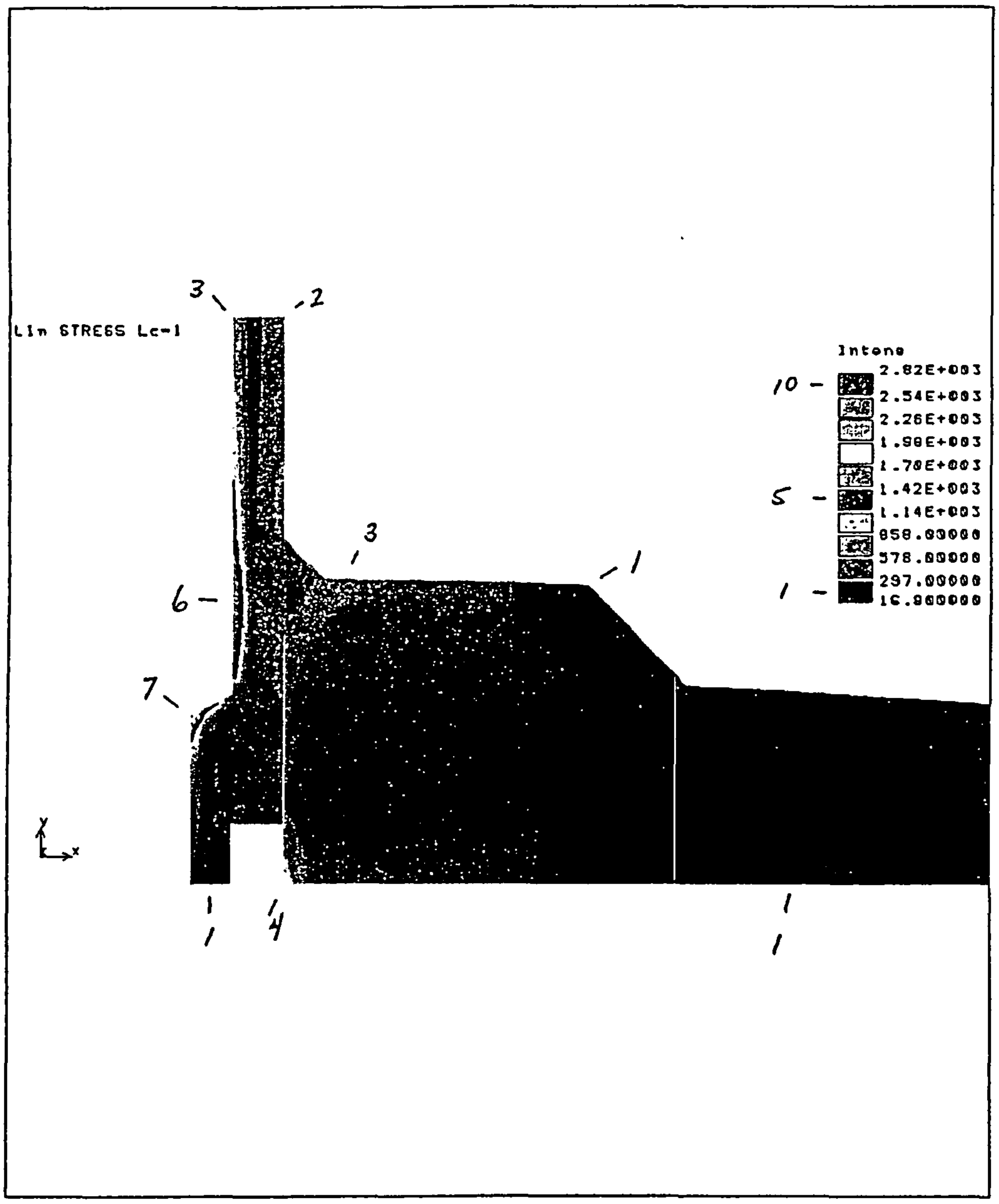

Figure 8-14 — Stress Intensities for +20°F Temperature Step Change Transient (Case 9).

Calculation No.: AES-C-3213-1	Made by: *(signature)*	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: *(signature)*	Date: 1/14/98	Project No.: AES 97103213-1Q
	Revision No.: 0	Document Control No.: I-2	Sheet No.: 66 of 66

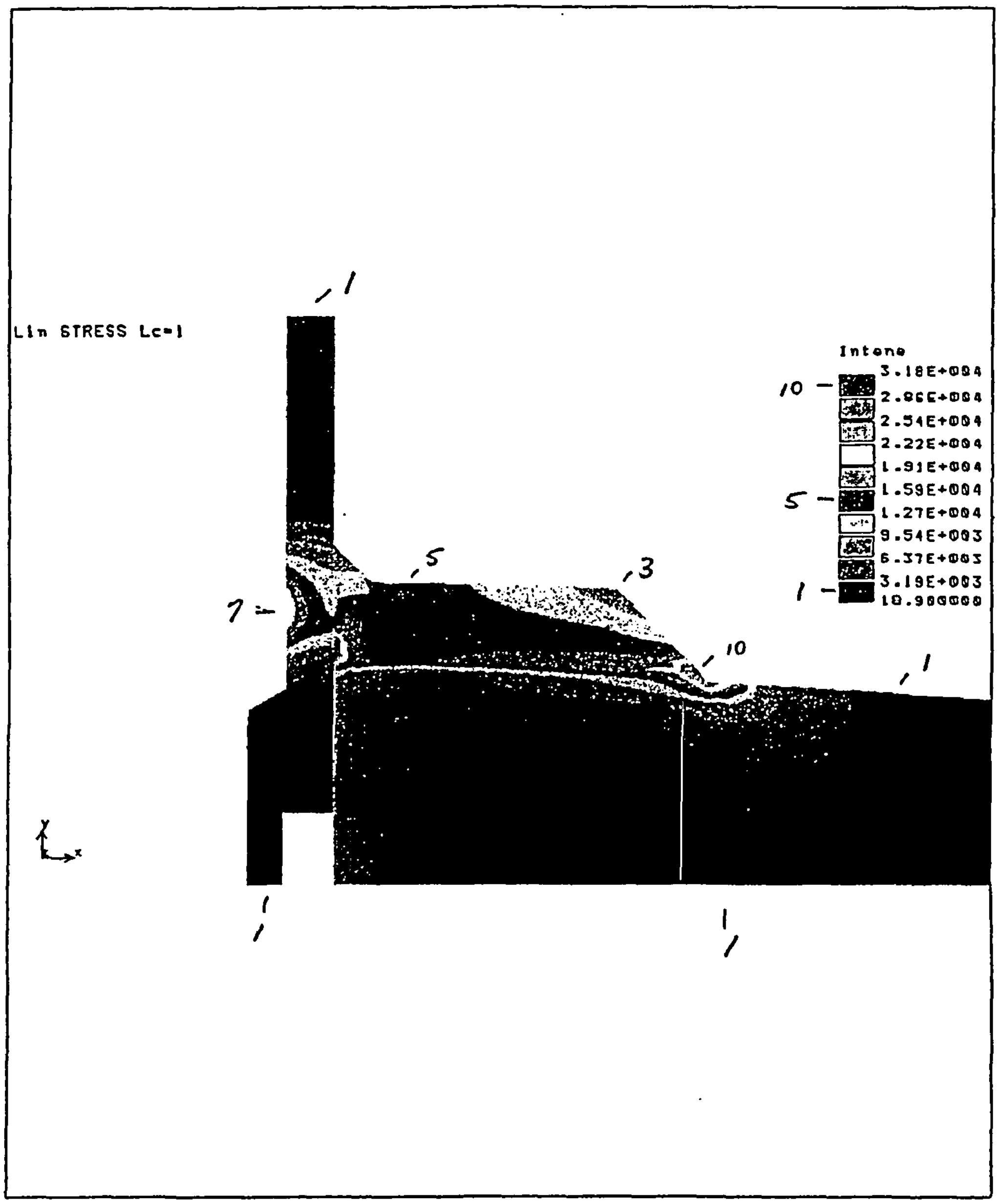

Figure 8-15— Stress Intensities for Temperature Loss of Flow Transient at t = 50s (Case 10).

Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: [signature]	Date: 1/14/98	Project No.: AES 97103213-1Q
	Revision No.: 0	Document Control No.: I-2	Sheet No.: A-1 of A-12

Appendix A

SUMMARY OF STRESSES FOR UNIT LOAD CASES

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: RQL	Date: 1/14/98	Project No.: AES 97103213-1Q
	Revision No.: 0	Document Control No.: I-2	Sheet No.: A-2 of A-12

INPUT DATA - UNIT STRESS SOLUTIONS

LOAD CASE	SECT	NODE	COORDINATE X (in)	Y (in)	s (in)	SIGX (psi)	SIGY (psi)	SIGZ (psi)	SIGXY (psi)	SIGXZ (psi)	SIGYZ (psi)
P	1	258	0.3070	56.080	0.000	-1729	1580	5273	0	0	0
2500 psia		259	0.3797	56.080	0.073	-1247	1239	3656	0	0	0
		260	0.4523	56.080	0.145	-482	1264	2973	0	0	0
		261	0.5250	56.080	0.218	-199	1197	2467	0	0	0
	PM	-				-898	1297	3500	0	0	0
	PB	258				-852	141	1324	0	0	0
		261				852	-141	-1324	0	0	0
	2	178	0.3070	52.934	0.000	-1241	1490	12072	-770	0	0
		179	0.3797	52.934	0.073	-500	523	8856	-1166	0	0
		180	0.4523	52.934	0.145	473	870	7461	-1501	0	0
		181	0.5250	52.934	0.218	987	1921	6718	-1629	0	0
	PM	-				-51	1033	8570	-1289	0	0
	PB	178				-1195	-284	2556	447	0	0
		181				1195	284	-2556	-447	0	0
	3	162	0.3070	52.623	0.000	481	-11124	15918	-486	0	0
		167	0.3797	52.701	0.106	589	-4346	13557	-2315	0	0
		172	0.4523	52.779	0.213	1355	499	11083	-2755	0	0
		177	0.5250	52.856	0.319	1666	2266	8538	-2179	0	0
		315	0.5863	52.871	0.373	1644	1967	7294	-1786	0	0
	PM	-				1645	-1663	11840	-2137	0	0
	PB	162				-936	-6683	4268	600	0	0
		315				936	6683	-4268	-600	0	0
	4	158	0.3070	52.546	0.000	288	-10097	14179	1197	0	0
		163	0.3797	52.623	0.106	2769	-5821	14328	-1023	0	0
		168	0.4523	52.701	0.213	2838	345	13017	-2905	0	0
		173	0.5250	52.779	0.319	3071	2260	10454	-2608	0	0
		312	0.5872	52.801	0.379	3474	2249	9139	-2427	0	0
		314	0.6476	52.808	0.430	5097	2105	8693	-2385	0	0
	PM	-				3928	-1277	12630	-1379	0	0
	PB	158				-1987	-6717	2809	1585	0	0
		314				1987	6717	-2809	-1585	0	0

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Calculation No.: AES-C-3213-1	Made by: RLL	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: CQL	Date: 1/14/98	Project No.: AES 97103213-1Q
	Revision No.: 0	Document Control No.: I-2	Sheet No.: A-3 of A-12

INPUT DATA - UNIT STRESS SOLUTIONS

LOAD CASE	SECT	NODE	COORDINATE X (in)	Y (in)	s (in)	SIGX (psi)	SIGY (psi)	SIGZ (psi)	SIGXY (psi)	SIGXZ (psi)	SIGYZ (psi)
FA	1	258	0.3070	56.080	0.000	0	1755	-1	0	0	0
1000 LBS		259	0.3797	56.080	0.073	0	1755	0	0	0	0
		260	0.4523	56.080	0.145	0	1755	-1	0	0	0
		261	0.5250	56.080	0.218	0	1755	-1	0	0	0
	PM	-				0	1755	-1	0	0	0
	PB	258				0	0	0	0	0	0
		261				0	0	0	0	0	0
	2	178	0.3070	52.934	0.000	135	866	898	-113	0	0
		179	0.3797	52.934	0.073	259	1211	844	-199	0	0
		180	0.4523	52.934	0.145	448	1572	897	-392	0	0
		181	0.5250	52.934	0.218	674	2487	1142	-750	0	0
	PM	-				370	1486	921	-341	0	0
	PB	178				-274	-753	-113	314	0	0
		181				274	753	113	-314	0	0
	3	162	0.3070	52.623	0.000	47	570	369	-12	0	0
		167	0.3797	52.701	0.106	102	653	482	-107	0	0
		172	0.4523	52.779	0.213	186	1077	637	-293	0	0
		177	0.5250	52.856	0.319	442	1609	846	-578	0	0
		315	0.5863	52.871	0.373	834	1010	764	-980	0	0
	PM	-				243	927	571	-322	0	0
	PB	162				-293	-468	-220	416	0	0
		315				293	468	220	-416	0	0
	4	158	0.3070	52.546	0.000	6	585	171	-11	0	0
		163	0.3797	52.623	0.106	117	512	299	-71	0	0
		168	0.4523	52.701	0.213	168	768	460	-286	0	0
		173	0.5250	52.779	0.319	267	1095	591	-475	0	0
		312	0.5872	52.801	0.379	477	786	541	-646	0	0
		314	0.6476	52.808	0.430	645	705	574	-642	0	0
	PM	-				220	668	379	-317	0	0
	PB	158				-269	-217	-216	365	0	0
		314				269	217	216	-365	0	0

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: RCC	Date: 1/14/98	Project No.: AES 97103213-1Q
	Revision No.: 0	Document Control No.: I-2	Sheet No.: A-4 of A-12

INPUT DATA - UNIT STRESS SOLUTIONS

			COORDINATE								
			X	Y	s	SIGX	SIGY	SIGZ	SIGXY	SIGXZ	SIGYZ
LOAD CASE	SECT	NODE	(in)	(in)	(in)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)
FL	1	258	0.3070	56.080	0.000	537	-10535	208	181	0	0
1000 lbs		259	0.3797	56.080	0.073	36	-13301	29	237	0	0
		260	0.4523	56.080	0.145	18	-15866	-7	213	0	0
		261	0.5250	56.080	0.218	-485	-18629	-188	133	0	0
	PM	-				26	-14582	10	157	0	0
	PB	258				511	4047	198	24	0	0
		261				-511	-4047	-198	-24	0	0
	2	178	0.3070	52.934	0.000	790	-6891	-7064	932	0	0
		179	0.3797	52.934	0.073	-5514	-23323	-12069	2231	0	0
		180	0.4523	52.934	0.145	-8491	-36771	-15841	6407	0	0
		181	0.5250	52.934	0.218	-21457	-64171	-26255	13319	0	0
	PM	-				-10333	-35531	-16659	7126	0	0
	PB	178				11124	28640	9596	-6194	0	0
		181				-11124	-28640	-9596	6194	0	0
	3	162	0.3070	52.623	0.000	-982	-13890	-3561	-1089	0	0
		167	0.3797	52.701	0.106	-924	-13420	-4793	-828	0	0
		172	0.4523	52.779	0.213	-3076	-22558	-8985	2631	0	0
		177	0.5250	52.856	0.319	-8130	-38593	-15465	11901	0	0
		315	0.5863	52.871	0.373	-20692	-18581	-13689	17380	0	0
	PM	-				-10837	-16235	-8625	8145	0	0
	PB	162				9855	2346	5064	-9234	0	0
		315				-9855	-2346	-5064	9234	0	0
	4	158	0.3070	52.546	0.000	-13	-13602	-178	-237	0	0
		163	0.3797	52.623	0.106	169	-10649	-673	-768	0	0
		168	0.4523	52.701	0.213	-1269	-14653	-4380	1960	0	0
		173	0.5250	52.779	0.319	-3880	-22586	-8371	7465	0	0
		312	0.5872	52.801	0.379	-6348	-14774	-7037	14080	0	0
		314	0.6476	52.808	0.430	-16303	-16404	-11350	11890	0	0
	PM	-				-8158	-15003	-5764	5826	0	0
	PB	158				8145	1401	5586	-6064	0	0
		314				-8145	-1401	-5586	6064	0	0

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: CWC	Date: 1/14/98	Project No.: AES 97103213-1Q
	Revision No.: 0	Document Control No.: I-2	Sheet No.: A-5 of A-12

INPUT DATA - UNIT STRESS SOLUTIONS

			COORDINATE								
			X	Y	s	SIGX	SIGY	SIGZ	SIGXY	SIGXZ	SIGYZ
LOAD CASE	SECT	NODE	(in)	(in)	(in)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)
MB	1	258	0.3070	56.080	0.000	-290	5708	-111	-1	0	0
1000 in-lbs		259	0.3797	56.080	0.073	-11	7202	1	-1	0	0
		260	0.4523	56.080	0.145	-12	8575	-12	-1	0	0
		261	0.5250	56.080	0.218	269	10074	112	-1	0	0
	PM	-				-10	7891	0	-1	0	0
	PB	258				-279	-2183	-112	0	0	0
		261				279	2183	112	0	0	0
	2	178	0.3070	52.934	0.000	-142	1777	1378	-129	0	0
		179	0.3797	52.934	0.073	1045	4864	2314	-361	0	0
		180	0.4523	52.934	0.145	1600	7388	3019	-1165	0	0
		181	0.5250	52.934	0.218	4066	12506	5027	-2507	0	0
	PM	-				1962	7142	3203	-1318	0	0
	PB	178				-2104	-5365	-1825	1189	0	0
		181				2104	5365	1825	-1189	0	0
	3	162	0.3070	52.623	0.000	225	3023	722	216	0	0
		167	0.3797	52.701	0.106	159	2796	903	182	0	0
		172	0.4523	52.779	0.213	539	4484	1705	-460	0	0
		177	0.5250	52.856	0.319	1515	7496	2979	-2230	0	0
		315	0.5863	52.871	0.373	3810	3456	2609	-3253	0	0
	PM	-				2017	3239	1666	-1519	0	0
	PB	162				-1792	-217	-944	1735	0	0
		315				1792	217	944	-1735	0	0
	4	158	0.3070	52.546	0.000	10	2894	11	36	0	0
		163	0.3797	52.623	0.106	-70	2213	64	156	0	0
		168	0.4523	52.701	0.213	185	2903	788	-353	0	0
		173	0.5250	52.779	0.319	672	4379	1575	-1391	0	0
		312	0.5872	52.801	0.379	1076	2753	1298	-2631	0	0
		314	0.6476	52.808	0.430	2866	2979	2101	-2165	0	0
	PM	-				1438	2937	1056	-1065	0	0
	PB	158				-1428	-42	-1045	1100	0	0
		314				1428	42	1045	-1100	0	0

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SCE No. M-DSC-354, Rev. 1
SHEET A-6 OF ____

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: CQL	Date: 1/14/98	Project No.: AES 97103213-1Q
	Revision No.: 0	Document Control No.: I-2	Sheet No.: A-6 of A-12

INPUT DATA - UNIT STRESS SOLUTIONS

LOAD CASE	SECT	NODE	COORDINATE X (in)	COORDINATE Y (in)	s (in)	SIGX (psi)	SIGY (psi)	SIGZ (psi)	SIGXY (psi)	SIGXZ (psi)	SIGYZ (psi)
MT	1	258	0.3070	56.080	0.000	0	0	0	0	2	3278
1000 in-lbs		259	0.3797	56.080	0.073	0	0	0	0	2	3627
		260	0.4523	56.080	0.145	0	0	0	0	2	4324
		261	0.5250	56.080	0.218	0	0	0	0	1	4672
	PM	-				0	0	0	0	2	3975
	PB	258				0	0	0	0	1	-697
		261				0	0	0	0	-1	697
	2	178	0.3070	52.934	0.000	0	0	0	0	-200	2649
		179	0.3797	52.934	0.073	0	0	0	0	-360	2988
		180	0.4523	52.934	0.145	0	0	0	0	-816	3926
		181	0.5250	52.934	0.218	0	0	0	0	-1556	3960
	PM	-				0	0	0	0	-878	3305
	PB	178				0	0	0	0	678	-656
		181				0	0	0	0	-678	656
	3	162	0.3070	52.623	0.000	0	0	0	0	-147	633
		167	0.3797	52.701	0.106	0	0	0	0	-389	1116
		172	0.4523	52.779	0.213	0	0	0	0	-904	1859
		177	0.5250	52.856	0.319	0	0	0	0	-1715	2711
		315	0.5863	52.871	0.373	0	0	0	0	-2031	2265
	PM	-				0	0	0	0	-1089	1449
	PB	162				0	0	0	0	942	-816
		315				0	0	0	0	-942	816
	4	158	0.3070	52.546	0.000	0	0	0	0	-111	329
		163	0.3797	52.623	0.106	0	0	0	0	-285	649
		168	0.4523	52.701	0.213	0	0	0	0	-694	1233
		173	0.5250	52.779	0.319	0	0	0	0	-1161	1755
		312	0.5872	52.801	0.379	0	0	0	0	-1705	1976
		314	0.6476	52.808	0.430	0	0	0	0	-1609	1513
	PM	-				0	0	0	0	-860	921
	PB	158				0	0	0	0	749	-592
		314				0	0	0	0	-749	592

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: CQL	Date: 1/14/98	Project No.: AES 97103213-1Q
	Revision No.: 0	Document Control No.: I-2	Sheet No.: A-7 of A-12

INPUT DATA - UNIT STRESS SOLUTIONS

LOAD CASE	SECT	NODE	COORDINATE X (in)	Y (in)	s (in)	SIGX (psi)	SIGY (psi)	SIGZ (psi)	SIGXY (psi)	SIGXZ (psi)	SIGYZ (psi)
THER1	1	258	0.3070	56.080	0.000	0	0	0	0	0	0
Isothermal		259	0.3797	56.080	0.073	0	0	0	0	0	0
T=653F		260	0.4523	56.080	0.145	0	0	0	0	0	0
		261	0.5250	56.080	0.218	0	0	0	0	0	0
	PM	-				0	0	0	0	0	0
	PB	258				0	0	0	0	0	0
		261				0	0	0	0	0	0
	2	178	0.3070	52.934	0.000	-574	-681	-7892	825	0	0
		179	0.3797	52.934	0.073	-839	331	-5953	1234	0	0
		180	0.4523	52.934	0.145	-979	377	-4988	1513	0	0
		181	0.5250	52.934	0.218	-1172	-155	-4491	1481	0	0
	PM	-				-897	97	-5711	1300	0	0
	PB	178				280	-221	-1650	-349	0	0
		181				-280	221	1650	349	0	0
	3	162	0.3070	52.623	0.000	-2361	10056	-14514	242	0	0
		167	0.3797	52.701	0.106	-2566	4313	-12259	1564	0	0
		172	0.4523	52.779	0.213	-3232	830	-9818	2315	0	0
		177	0.5250	52.856	0.319	-2897	-1145	-7288	2275	0	0
		315	0.5863	52.871	0.373	-2358	-1776	-6334	1952	0	0
	PM	-				-3402	2183	-10710	1766	0	0
	PB	162				631	5672	-3970	-1050	0	0
		315				-631	-5672	3970	1050	0	0
	4	158	0.3070	52.546	0.000	-2306	8954	-13761	-1138	0	0
		163	0.3797	52.623	0.106	-4056	5113	-13432	419	0	0
		168	0.4523	52.701	0.213	-4927	753	-12115	1766	0	0
		173	0.5250	52.779	0.319	-5209	-826	-9794	2429	0	0
		312	0.5872	52.801	0.379	-5365	-1911	-8963	3003	0	0
		314	0.6476	52.808	0.430	-7797	-3063	-9283	3844	0	0
	PM	-				-5770	1559	-12610	973	0	0
	PB	158				2484	5603	-2364	-2147	0	0
		314				-2484	-5603	2364	2147	0	0

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: CQC	Date: 1/14/98	Project No.: AES 97103213-1Q
	Revision No.: 0	Document Control No.: I-2	Sheet No.: A-8 of A-12

INPUT DATA - UNIT STRESS SOLUTIONS

LOAD CASE	SECT	NODE	COORDINATE X (in)	COORDINATE Y (in)	s (in)	SIGX (psi)	SIGY (psi)	SIGZ (psi)	SIGXY (psi)	SIGXZ (psi)	SIGYZ (psi)
THER2	1	258	0.3070	56.080	0.000	-4	-62	-61	0	0	0
Heatup		259	0.3797	56.080	0.073	-5	-9	-3	0	0	0
+200F/Hr		260	0.4523	56.080	0.145	-3	17	21	0	0	0
t = 3600s		261	0.5250	56.080	0.218	-2	24	24	0	0	0
	PM	-				-4	-4	0	0	0	0
	PB	258				-1	-42	-41	0	0	0
		261				1	42	41	0	0	0
	2	178	0.3070	52.934	0.000	-14	-626	-323	-17	0	0
		179	0.3797	52.934	0.073	7	-218	124	-30	0	0
		180	0.4523	52.934	0.145	40	75	403	-65	0	0
		181	0.5250	52.934	0.218	109	395	638	-143	0	0
	PM	-				32	-86	228	-59	0	0
	PB	178				-59	-497	-468	61	0	0
		181				59	497	468	-61	0	0
	3	162	0.3070	52.623	0.000	-34	-500	-330	21	0	0
		167	0.3797	52.701	0.106	38	-230	246	40	0	0
		172	0.4523	52.779	0.213	109	-53	604	-38	0	0
		177	0.5250	52.856	0.319	182	263	835	-152	0	0
		315	0.5863	52.871	0.373	259	231	996	-241	0	0
	PM	-				125	-83	511	-52	0	0
	PB	162				-175	-384	-667	153	0	0
		315				175	384	667	-153	0	0
	4	158	0.3070	52.546	0.000	-41	-471	-361	7	0	0
		163	0.3797	52.623	0.106	-33	-213	209	44	0	0
		168	0.4523	52.701	0.213	181	-112	669	34	0	0
		173	0.5250	52.779	0.319	284	72	949	-135	0	0
		312	0.5872	52.801	0.379	365	147	1154	-267	0	0
		314	0.6476	52.808	0.430	582	245	1404	-363	0	0
	PM	-				218	-82	710	-48	0	0
	PB	158				-355	-288	-900	187	0	0
		314				355	288	900	-187	0	0

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: RCC	Date: 1/14/98	Project No.: AES 97103213-1Q
	Revision No.: 0	Document Control No.: I-2	Sheet No.: A-9 of A-12

INPUT DATA - UNIT STRESS SOLUTIONS

			COORDINATE								
			X	Y	s	SIGX	SIGY	SIGZ	SIGXY	SIGXZ	SIGYZ
LOAD CASE	SECT	NODE	(in)	(in)	(in)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)
THER3	1	258	0.3070	56.080	0.000	10	136	133	0	0	0
Ther Strat		259	0.3797	56.080	0.073	10	21	6	0	0	0
t=6264s		260	0.4523	56.080	0.145	8	-37	-46	0	0	0
		261	0.5250	56.080	0.218	4	-53	-54	0	0	0
	PM	-				8	8	0	0	0	0
	PB	258				3	93	91	0	0	0
		261				-3	-93	-91	0	0	0
	2	178	0.3070	52.934	0.000	-82	1234	-847	199	0	0
		179	0.3797	52.934	0.073	-181	542	-1443	309	0	0
		180	0.4523	52.934	0.145	-281	-89	-1862	441	0	0
		181	0.5250	52.934	0.218	-468	-893	-2277	604	0	0
	PM	-				-246	208	-1622	384	0	0
	PB	178				184	1041	698	-202	0	0
		181				-184	-1041	-698	202	0	0
	3	162	0.3070	52.623	0.000	-391	3074	-2137	2	0	0
		167	0.3797	52.701	0.106	-587	1351	-2952	220	0	0
		172	0.4523	52.779	0.213	-873	278	-3252	540	0	0
		177	0.5250	52.856	0.319	-968	-801	-3258	780	0	0
		315	0.5863	52.871	0.373	-1029	-855	-3421	911	0	0
	PM	-				-944	611	-3223	461	0	0
	PB	162				506	1957	675	-540	0	0
		315				-506	-1957	-675	540	0	0
	4	158	0.3070	52.546	0.000	-364	2794	-1920	-239	0	0
		163	0.3797	52.623	0.106	-726	1472	-3101	-14	0	0
		168	0.4523	52.701	0.213	-1366	393	-3846	273	0	0
		173	0.5250	52.779	0.319	-1647	-320	-4001	773	0	0
		312	0.5872	52.801	0.379	-1854	-697	-4284	1175	0	0
		314	0.6476	52.808	0.430	-2805	-1138	-4895	1549	0	0
	PM	-				-1613	487	-3944	298	0	0
	PB	158				1264	1733	1499	-830	0	0
		314				-1264	-1733	-1499	830	0	0

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: CQL	Date: 1/14/98	Project No.: AES 97103213-1Q
	Revision No.: 0	Document Control No.: I-2	Sheet No.: A-10 of A-12

INPUT DATA - UNIT STRESS SOLUTIONS

LOAD CASE	SECT	NODE	COORDINATE X (in)	Y (in)	s (in)	SIGX (psi)	SIGY (psi)	SIGZ (psi)	SIGXY (psi)	SIGXZ (psi)	SIGYZ (psi)
THER4	1	258	0.3070	56.080	0.000	-65	-920	-905	0	0	0
Step Change		259	0.3797	56.080	0.073	-72	-147	-50	0	0	0
ΔT= +20F		260	0.4523	56.080	0.145	-52	256	314	0	0	0
t = 8s		261	0.5250	56.080	0.218	-27	369	372	0	0	0
	PM	-				-57	-56	-1	0	0	0
	PB	258				-22	-638	-620	0	0	0
		261				22	638	620	0	0	0
	2	178	0.3070	52.934	0.000	-89	-1251	-1386	40	0	0
		179	0.3797	52.934	0.073	-88	-304	-320	50	0	0
		180	0.4523	52.934	0.145	-39	242	218	21	0	0
		181	0.5250	52.934	0.218	28	612	480	-73	0	0
	PM	-				-53	-127	-185	18	0	0
	PB	178				-62	-910	-908	54	0	0
		181				62	910	908	-54	0	0
	3	162	0.3070	52.623	0.000	-204	-688	-1831	-7	0	0
		167	0.3797	52.701	0.106	-222	-141	-701	72	0	0
		172	0.4523	52.779	0.213	-230	139	-45	75	0	0
		177	0.5250	52.856	0.319	-104	351	363	-4	0	0
		315	0.5863	52.871	0.373	23	119	447	-89	0	0
	PM	-				-193	-12	-324	30	0	0
	PB	162				-91	-439	-1106	35	0	0
		315				91	439	1106	-35	0	0
	4	158	0.3070	52.546	0.000	-188	-794	-1799	-67	0	0
		163	0.3797	52.623	0.106	-313	-115	-767	6	0	0
		168	0.4523	52.701	0.213	-275	94	-147	76	0	0
		173	0.5250	52.779	0.319	-203	220	243	18	0	0
		312	0.5872	52.801	0.379	-123	84	365	-16	0	0
		314	0.6476	52.808	0.430	-162	-43	400	52	0	0
	PM	-				-245	-31	-258	1	0	0
	PB	158				-75	-303	-1040	-17	0	0
		314				75	303	1040	17	0	0

Calculation No.: AES-C-3213-1	Made by: Rcc	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: CQL	Date: 1/14/98	Project No.: AES 97103213-1Q
	Revision No.: 0	Document Control No.: I-2	Sheet No.: A-11 of A-12

INPUT DATA - UNIT STRESS SOLUTIONS

LOAD CASE	SECT	NODE	COORDINATE X (in)	Y (in)	s (in)	SIGX (psi)	SIGY (psi)	SIGZ (psi)	SIGXY (psi)	SIGXZ (psi)	SIGYZ (psi)
THER5	1	258	0.3070	56.080	0.000	60	853	839	0	0	0
Loss of Flow		259	0.3797	56.080	0.073	66	129	39	0	0	0
ΔT=-40F		260	0.4523	56.080	0.145	48	-235	-288	0	0	0
ΔT= -20F		261	0.5250	56.080	0.218	24	-334	-337	0	0	0
t = 50s											
	PM	-				52	51	1	0	0	0
	PB	258				20	585	569	0	0	0
		261				-20	-585	-569	0	0	0
	2	178	0.3070	52.934	0.000	-435	1017	-5733	735	0	0
		179	0.3797	52.934	0.073	-696	752	-5296	1112	0	0
		180	0.4523	52.934	0.145	-894	69	-5123	1422	0	0
		181	0.5250	52.934	0.218	-1187	-1011	-5103	1541	0	0
	PM	-				-800	275	-5279	1224	0	0
	PB	178				360	1020	-304	-418	0	0
		181				-360	-1020	304	418	0	0
	3	162	0.3070	52.623	0.000	-1964	10306	-11442	213	0	0
		167	0.3797	52.701	0.106	-2197	4277	-10893	1346	0	0
		172	0.4523	52.779	0.213	-2860	680	-9531	2099	0	0
		177	0.5250	52.856	0.319	-2720	-1583	-7755	2221	0	0
		315	0.5863	52.871	0.373	-2400	-1926	-7103	2070	0	0
	PM	-				-3063	2090	-10020	1644	0	0
	PB	162				803	5932	-2094	-1121	0	0
		315				-803	-5932	2094	1121	0	0
	4	158	0.3070	52.546	0.000	-1922	9365	-10751	-993	0	0
		163	0.3797	52.623	0.106	-3431	4981	-11888	347	0	0
		168	0.4523	52.701	0.213	-4447	701	-11621	1535	0	0
		173	0.5250	52.779	0.319	-4849	-1012	-10067	2336	0	0
		312	0.5872	52.801	0.379	-5123	-1949	-9590	2999	0	0
		314	0.6476	52.808	0.430	-7495	-2973	-10138	3788	0	0
	PM	-				-5278	1534	-11600	940	0	0
	PB	158				2641	5666	-467	-2119	0	0
		314				-2641	-5666	467	2119	0	0

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: CAL	Date: 1/14/98	Project No.: AES 97103213-1Q
	Revision No.: 0	Document Control No.: I-2	Sheet No.: A-12 of A-12

INPUT DATA - UNIT STRESS SOLUTIONS

LOAD CASE	SECT	NODE	COORDINATE X (in)	Y (in)	s (in)	SIGX (psi)	SIGY (psi)	SIGZ (psi)	SIGXY (psi)	SIGXZ (psi)	SIGYZ (psi)
THER5	1	258	0.3070	56.080	0.000	-3	-48	-47	0	0	0
Loss of Flow		259	0.3797	56.080	0.073	-4	-7	-2	0	0	0
ΔT= -40F		260	0.4523	56.080	0.145	-3	13	16	0	0	0
ΔT= -20F		261	0.5250	56.080	0.218	-1	19	19	0	0	0
t = 2000s											
	PM	-				-3	-3	0	0	0	0
	PB	258				-1	-33	-32	0	0	0
		261				1	33	32	0	0	0
	2	178	0.3070	52.934	0.000	-585	-1126	-8134	814	0	0
		179	0.3797	52.934	0.073	-836	178	-5874	1214	0	0
		180	0.4523	52.934	0.145	-952	431	-4710	1469	0	0
		181	0.5250	52.934	0.218	-1097	124	-4046	1383	0	0
	PM	-				-877	36	-5558	1261	0	0
	PB	178				239	-573	-1985	-307	0	0
		181				-239	573	1985	307	0	0
	3	162	0.3070	52.623	0.000	-2388	9711	-14768	257	0	0
		167	0.3797	52.701	0.106	-2543	4156	-12102	1594	0	0
		172	0.4523	52.779	0.213	-3161	795	-9405	2291	0	0
		177	0.5250	52.856	0.319	-2773	-960	-6708	2171	0	0
		315	0.5863	52.871	0.373	-2180	-1616	-5641	1785	0	0
	PM	-				-3319	2127	-10360	1732	0	0
	PB	162				509	5407	-4446	-944	0	0
		315				-509	-5407	4446	944	0	0
	4	158	0.3070	52.546	0.000	-2338	8628	-14036	-1134	0	0
		163	0.3797	52.623	0.106	-4084	4968	-13302	450	0	0
		168	0.4523	52.701	0.213	-4807	676	-11658	1791	0	0
		173	0.5250	52.779	0.319	-5017	-775	-9138	2337	0	0
		312	0.5872	52.801	0.379	-5116	-1810	-8161	2819	0	0
		314	0.6476	52.808	0.430	-7400	-2896	-8306	3595	0	0
	PM	-				-5624	1503	-11680	940	0	0
	PB	158				2238	5406	-3002	-2019	0	0
		314				-2238	-5406	3002	2019	0	0

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: CQL	Date: 1/14/98	Project No.: AES 97103213-1Q
	Revision No.: 0	Document Control No.: I-2	Sheet No.: B-1 of B-11

Appendix B

LOAD COMBINATION STRESS SUMMARY

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: CQL	Date: 1/14/98	Project No.: AES 97103213-1Q
	Revision No.: 0	Document Control No.: I-2	Sheet No.: B-2 of B-11

COMBINED STRESSES

DESIGN LOADING CONDITION (PD+DW+OBE)

							THER1	THER2	THER3	THER4	THER5	THER5
							T=653F	200F/Hr	STRAT	ΔT=20F	-40F,-20F	-40F,-20F
LOAD CASE =		P	FA	FL	MB	MT	t=0s	t=3600s	t=6264s	t=8s	t=50s	t=2000s
LOAD FACTOR =		1.000	0.035	0.046	0.336	0.120	0.000	0.000	0.000	0.000	0.000	0.000
		s	SIGX	SIGY	SIGZ	SIGXY	SIGZX	SIGYZ	S1	S2	S3	S INT
SECTION	NODE	(in)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)
1	258	0.000	-1801	3074	5245	8	0	393	5314	3005	-1801	7115
	259	0.073	-1249	3108	3657	11	0	435	3897	2868	-1249	5146
	260	0.145	-485	3477	2969	10	0	519	3801	2645	-485	4286
	261	0.218	-131	3786	2496	6	0	561	3996	2286	-131	4127
PM	-		-900	3339	3501	7	0	477	3904	2936	-900	4803
PB	258		-923	-406	1296	1	0	-84	1300	-410	-923	2222
	261		923	406	-1296	-1	0	84	923	410	-1300	2222
PM+PB	258		-1822	2933	4796	8	0	393	4876	2853	-1822	6698
	261		23	3745	2205	6	0	561	3928	2023	23	3905
2	178	0.000	-1248	1800	12241	-774	-24	318	12251	1976	-1433	13684
	179	0.073	-393	1127	9108	-1192	-43	359	9125	1765	-1049	10174
	180	0.145	635	1716	7778	-1611	-98	471	7822	2836	-528	8350
	181	0.218	1390	3259	7240	-1885	-187	475	7328	4341	219	7108
PL	-		146	1850	8912	-1416	-105	397	8938	2626	-656	9594
PB	178		-1400	-796	2380	573	81	-79	2384	-451	-1748	4132
	181		1400	796	-2380	-573	-81	79	1748	451	-2384	4132
PL+PB	178		-1254	1055	11292	-843	-24	318	11302	1320	-1530	12832
	181		1545	2646	6532	-1989	-187	475	6632	4061	29	6603
3	162	0.000	513	-10727	16010	-464	-18	76	16010	532	-10746	26756
	167	0.106	604	-4000	13657	-2296	-47	134	13658	1552	-4950	18608
	172	0.213	1401	1006	11265	-2799	-108	223	11273	4002	-1603	12876
	177	0.319	1816	3065	8857	-2401	-206	325	8894	4884	-40	8934
	315	0.373	2001	2308	7567	-2114	-244	272	7607	4235	35	7572
PL	-		1833	-1289	12023	-2284	-131	174	12028	3034	-2495	14523
PB	162		-1095	-6664	4176	772	113	-98	4179	-992	-6771	10950
	315		1095	6664	-4176	-772	-113	98	6771	992	-4179	10950
PL+PB	162		738	-7953	16199	-1512	-18	76	16199	993	-8209	24408
	315		2928	5375	7847	-3056	-244	272	8059	7231	859	7200
4	158	0.000	290	-9730	14180	1198	-13	39	14180	432	-9871	24052
	163	0.106	2757	-5549	14329	-1008	-34	78	14330	2878	-5670	20000
	168	0.213	2847	674	13097	-2943	-83	148	13100	4895	-1378	14477
	173	0.319	3128	2731	10618	-2748	-139	211	10631	5673	174	10457
	312	0.379	3560	2522	9270	-2686	-205	237	9298	5750	305	8993
	314	0.430	5332	2376	8896	-2588	-193	182	8929	6803	873	8055
PL	-		4044	-957	12733	-1480	-103	111	12735	4447	-1363	14098
PB	158		-2102	-6674	2707	1689	90	-71	2709	-1547	-7231	9940
	314		2102	6674	-2707	-1689	-90	71	7231	1547	-2709	9940
PL+PB	158		1942	-7631	15440	209	-13	39	15440	1947	-7636	23076
	314		6145	5717	10026	-3168	-193	182	10097	9036	2756	7341

Calculation No.: AES-C-3213-1	Made by: RLL	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: CQL	Date: 1/14/98	Project No.: AES 97103213-1Q
	Revision No.: 0	Document Control No.: I-2	Sheet No.: B-3 of B-11

COMBINED STRESSES

NORMAL & UPSET CONDITION (P+DW+OBE+THER)

NORMAL HEATUP/COOLDOWN

							THER1	THER2	THER3	THER4	THER5	THER5
							T=653F	200F/Hr	STRAT	ΔT=20F	-40F,-20F	-40F,-20F
LOAD CASE =		P	FA	FL	MB	MT	t=0s	t=3600s	t=6264s	t=8s	t=50s	t=2000s
LOAD FACTOR =		1.000	0.035	0.046	0.336	0.120	1.000	1.000	0.000	0.000	0.000	0.000
		s	SIGX	SIGY	SIGZ	SIGXY	SIGZX	SIGYZ	S1	S2	S3	S INT
SECTION	NODE	(in)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)
1	258	0.000	-1806	3013	5184	8	0	393	5253	2944	-1806	7059
	259	0.073	-1254	3099	3654	11	0	435	3893	2860	-1254	5147
	260	0.145	-489	3494	2990	10	0	519	3819	2665	-489	4308
	261	0.218	-133	3810	2520	6	0	561	4020	2311	-133	4153
PM	-		-903	3335	3501	7	0	477	3902	2934	-904	4806
PB	258		-924	-448	1254	1	0	-84	1258	-453	-924	2183
	261		924	448	-1254	-1	0	84	924	453	-1258	2183
PM+PB	258		-1828	2887	4755	8	0	393	4834	2807	-1828	6662
	261		21	3784	2246	6	0	561	3966	2063	21	3946
2	178	0.000	-1836	493	4026	34	-24	318	4054	465	-1837	5891
	179	0.073	-1226	1240	3279	12	-43	359	3340	1179	-1226	4567
	180	0.145	-303	2168	3193	-164	-98	471	3382	1990	-316	3698
	181	0.218	327	3499	3387	-547	-187	475	4000	2981	232	3768
PL	-		-720	1861	3429	-175	-105	397	3528	1775	-733	4262
PB	178		-1179	-1513	262	284	81	-79	269	-1017	-1682	1951
	181		1179	1513	-262	-284	-81	79	1682	1017	-269	1951
PL+PB	178		-1899	348	3691	110	-24	318	3721	323	-1905	5626
	181		459	3374	3167	-459	-187	475	3824	2792	384	3440
3	162	0.000	-1882	-1171	1166	-201	-18	76	1169	-1121	-1935	3104
	167	0.106	-1924	83	1644	-691	-47	134	1659	283	-2139	3798
	172	0.213	-1723	1783	2050	-522	-108	223	2210	1700	-1800	4011
	177	0.319	-899	2183	2404	-278	-206	325	2668	1954	-933	3601
	315	0.373	-98	764	2229	-403	-244	272	2319	840	-264	2583
PL	-		-1444	811	1824	-570	-131	174	1869	904	-1582	3451
PB	162		-639	-1377	-461	-125	113	-98	-385	-688	-1404	1019
	315		639	1377	461	125	-113	98	1404	688	385	1019
PL+PB	162		-2083	-565	1363	-695	-18	76	1366	-299	-2353	3719
	315		-805	2188	2284	-445	-244	272	2579	1971	-882	3461
4	158	0.000	-2057	-1247	59	67	-13	39	60	-1243	-2063	2123
	163	0.106	-1332	-649	1107	-544	-34	78	1111	-352	-1633	2744
	168	0.213	-1899	1314	1651	-1144	-83	148	1832	1498	-2264	4097
	173	0.319	-1797	1977	1773	-454	-139	211	2163	1645	-1854	4017
	312	0.379	-1439	758	1461	49	-205	237	1545	691	-1456	3000
	314	0.430	-1883	-442	1018	894	-193	182	1043	-21	-2330	3373
PL	-		-1508	520	832	-555	-103	111	906	590	-1652	2558
PB	158		27	-1359	-557	-272	90	-71	94	-569	-1414	1508
	314		-27	1359	557	272	-90	71	1414	569	-94	1508
PL+PB	158		-1481	-840	276	-827	-13	39	279	-276	-2047	2326
	314		-1535	1879	1389	-283	-193	182	1970	1332	-1569	3539

NOTE: PM, PL, PB, PM+PB AND PL+PB CONTAINS SECONDARY STRESS Q

APTECH® ENGINEERING SERVICES, INC.

SCE No. M-DSC-354, Rev. 1
SHEET B-4 OF ____

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: CQC	Date: 1/14/98	Project No.: AES 97103213-1Q
	Revision No.: 0	Document Control No.: I-2	Sheet No.: B-4 of B-11

COMBINED STRESSES

NORMAL & UPSET CONDITION (P+DW+OBE+THER)

NORMAL HEATUP/COOLDOWN

							THER1	THER2	THER3	THER4	THER5	THER5
							T=653F	200F/Hr	STRAT	ΔT=20F	-40F,-20F	-40F,-20F
LOAD CASE =		P	FA	FL	MB	MT	t=0s	t=3600s	t=6264s	t=8s	t=50s	t=2000s
LOAD FACTOR =		1.000	0.035	0.046	0.336	0.120	1.000	-1.000	0.000	0.000	0.000	0.000
		s	SIGX	SIGY	SIGZ	SIGXY	SIGZX	SIGYZ	S1	S2	S3	S INT
SECTION	NODE	(in)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)
1	258	0.000	-1797	3136	5305	8	0	393	5375	3067	-1797	7171
	259	0.073	-1244	3118	3660	11	0	435	3902	2876	-1244	5146
	260	0.145	-482	3460	2948	10	0	519	3783	2626	-482	4264
	261	0.218	-129	3762	2471	6	0	561	3971	2262	-129	4101
PM	-		-896	3343	3501	7	0	477	3905	2938	-896	4801
PB	258		-921	-364	1337	1	0	-84	1341	-368	-921	2262
	261		921	364	-1337	-1	0	84	921	368	-1341	2262
PM+PB	258		-1817	2979	4837	8	0	393	4917	2899	-1817	6734
	261		25	3706	2164	6	0	561	3889	1982	25	3863
2	178	0.000	-1808	1746	4672	67	-24	318	4707	1713	-1810	6516
	179	0.073	-1240	1676	3031	72	-43	359	3120	1589	-1242	4362
	180	0.145	-384	2018	2387	-33	-98	471	2712	1697	-388	3100
	181	0.218	109	2709	2111	-260	-187	475	3006	1850	74	2933
PL	-		-783	2034	2973	-57	-105	397	3122	1889	-787	3909
PB	178		-1061	-520	1199	162	81	-79	1205	-477	-1110	2315
	181		1061	520	-1199	-162	-81	79	1110	477	-1205	2315
PL+PB	178		-1844	1514	4172	105	-24	318	4209	1479	-1848	6057
	181		277	2554	1774	-220	-187	475	2809	1554	242	2567
3	162	0.000	-1814	-170	1826	-243	-18	76	1829	-138	-1850	3678
	167	0.106	-1999	542	1151	-772	-47	134	1197	713	-2215	3412
	172	0.213	-1940	1888	843	-445	-108	223	1987	797	-1993	3980
	177	0.319	-1263	1656	735	26	-206	325	1760	653	-1285	3045
	315	0.373	-615	301	238	79	-244	272	553	73	-702	1255
PL	-		-1695	977	802	-466	-131	174	1161	701	-1777	2938
PB	162		-289	-608	873	-431	113	-98	898	-14	-908	1806
	315		289	608	-873	431	-113	98	908	14	-898	1806
PL+PB	162		-1984	369	1675	-897	-18	76	1681	666	-2287	3968
	315		-1405	1585	-71	-35	-244	272	1630	-73	-1448	3078
4	158	0.000	-1975	-304	781	53	-13	39	783	-304	-1977	2759
	163	0.106	-1265	-223	689	-633	-34	78	701	64	-1564	2265
	168	0.213	-2261	1538	313	-1212	-83	148	1909	297	-2615	4525
	173	0.319	-2366	1833	-125	-185	-139	211	1865	-141	-2381	4246
	312	0.379	-2170	464	-846	584	-205	237	613	-829	-2335	2948
	314	0.430	-3047	-933	-1791	1620	-193	182	-53	-1763	-3954	3901
PL	-		-1945	684	-587	-458	-103	111	773	-594	-2027	2801
PB	158		737	-783	1243	-645	90	-71	1282	936	-1021	2303
	314		-737	783	-1243	645	-90	71	1021	-936	-1282	2303
PL+PB	158		-1207	-99	656	-1103	-13	39	674	564	-1888	2562
	314		-2682	1467	-1830	187	-193	182	1485	-1794	-2736	4221

NOTE: PM, PL, PB, PM+PB AND PL+PB CONTAINS SECONDARY STRESS Q

QAE17
REV 8/96

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: RQC	Date: 1/14/98	Project No.: AES 97103213-1Q
	Revision No.: 0	Document Control No.: I-2	Sheet No.: B-5 of B-11

COMBINED STRESSES

NORMAL & UPSET CONDITION (P+DW+OBE+THER)

COOLDOWN WITH STRATIFICATION

							THER1 T=653F	THER2 200F/Hr	THER3 STRAT	THER4 ΔT=20F	THER5 -40F,-20F	THER5 -40F,-20F
LOAD CASE =		P	FA	FL	MB	MT	t=0s	t=3600s	t=6264s	t=8s	t=50s	t=2000s
LOAD FACTOR =		1.000	0.035	0.046	0.336	0.120	0.000	0.000	1.000	0.000	0.000	0.000
		s	SIGX	SIGY	SIGZ	SIGXY	SIGZX	SIGYZ	S1	S2	S3	S INT
SECTION	NODE	(in)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)
1	258	0.000	-1792	3210	5378	8	0	393	5447	3141	-1792	7239
	259	0.073	-1238	3129	3664	11	0	435	3907	2885	-1238	5145
	260	0.145	-478	3440	2923	10	0	519	3761	2602	-478	4239
	261	0.218	-127	3733	2442	6	0	561	3942	2232	-127	4070
PM	-		-891	3347	3501	7	0	477	3907	2941	-891	4799
PB	258		-919	-313	1386	1	0	-84	1390	-317	-919	2310
	261		919	313	-1386	-1	0	84	919	317	-1390	2310
PM+PB	258		-1811	3034	4887	8	0	393	4967	2954	-1811	6778
	261		28	3660	2115	6	0	561	3842	1933	28	3814
2	178	0.000	-1330	3035	11394	-575	-24	318	11406	3097	-1404	12811
	179	0.073	-574	1668	7665	-883	-43	359	7687	1952	-881	8568
	180	0.145	354	1627	5916	-1170	-98	471	5977	2266	-346	6322
	181	0.218	922	2365	4963	-1280	-187	475	5092	2985	172	4920
PL	-		-100	2058	7290	-1032	-105	397	7324	2438	-515	7839
PB	178		-1216	245	3079	370	81	-79	3082	333	-1306	4388
	181		1216	-245	-3079	-370	-81	79	1306	-333	-3082	4388
PL+PB	178		-1316	2303	10368	-662	-24	318	10381	2408	-1433	11814
	181		1115	1813	4211	-1403	-187	475	4379	2747	14	4366
3	162	0.000	122	-7652	13873	-462	-18	76	13873	149	-7680	21553
	167	0.106	17	-2649	10705	-2075	-47	134	10707	1149	-3783	14490
	172	0.213	528	1284	8013	-2259	-108	223	8025	3184	-1385	9410
	177	0.319	848	2264	5600	-1621	-206	325	5663	3261	-212	5875
	315	0.373	973	1454	4146	-1204	-244	272	4221	2366	-14	4235
PL	-		889	-678	8800	-1823	-131	174	8807	2084	-1879	10686
PB	162		-589	-4707	4851	232	113	-98	4854	-578	-4721	9576
	315		589	4707	-4851	-232	-113	98	4721	578	-4854	9576
PL+PB	162		300	-5385	13651	-1591	-18	76	13651	715	-5801	19452
	315		1479	4029	3949	-2055	-244	272	5269	3855	334	4935
4	158	0.000	-74	-6936	12260	959	-13	39	12260	57	-7067	19327
	163	0.106	2031	-4078	11229	-1022	-34	78	11229	2197	-4244	15474
	168	0.213	1481	1066	9251	-2670	-83	148	9256	3947	-1405	10661
	173	0.319	1482	2411	6617	-1976	-139	211	6641	3952	-83	6724
	312	0.379	1707	1825	4986	-1512	-205	237	5042	3223	253	4789
	314	0.430	2527	1238	4002	-1039	-193	182	4071	3037	659	3413
PL	-		2431	-470	8789	-1182	-103	111	8792	2848	-892	9684
PB	158		-838	-4941	4206	858	90	-71	4208	-667	-5114	9323
	314		838	4941	-4206	-858	-90	71	5114	667	-4208	9323
PL+PB	158		1593	-5412	12995	-324	-13	39	12995	1608	-5427	18422
	314		3268	4471	4583	-2041	-193	182	6044	4537	1742	4302

NOTE: PM, PL, PB, PM+PB AND PL+PB CONTAINS SECONDARY STRESS Q

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: CQL	Date: 1/14/98	Project No.: AES 97103213-1Q
	Revision No.: 0	Document Control No.: I-2	Sheet No.: B-6 of B-11

COMBINED STRESSES

NORMAL & UPSET CONDITION (P+DW+OBE+THER)

STEP CHANGE CONDITION

							THER1	THER2	THER3	THER4	THER5	THER5
							T=653F	200F/Hr	STRAT	ΔT=20F	-40F,-20F	-40F,-20F
LOAD CASE =		P	FA	FL	MB	MT	t=0s	t=3600s	t=6264s	t=8s	t=50s	t=2000s
LOAD FACTOR =		1.000	0.035	0.046	0.336	0.120	1.000	0.000	0.000	1.000	0.000	0.000
		s	SIGX	SIGY	SIGZ	SIGXY	SIGZX	SIGYZ	S1	S2	S3	S INT
SECTION	NODE	(in)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)
1	258	0.000	-1867	2155	4340	8	0	393	4409	2086	-1867	6275
	259	0.073	-1320	2961	3607	11	0	435	3826	2742	-1320	5146
	260	0.145	-538	3733	3284	9	0	519	4074	2943	-538	4611
	261	0.218	-158	4155	2868	6	0	561	4365	2658	-158	4523
PM	-		-956	3283	3500	7	0	477	3881	2902	-956	4837
PB	258		-944	-1044	675	1	0	-84	679	-944	-1048	1727
	261		944	1044	-675	-1	0	84	1048	944	-679	1727
PM+PB	258		-1901	2239	4175	8	0	393	4252	2163	-1901	6153
	261		-12	4327	2825	6	0	561	4513	2639	-12	4526
2	178	0.000	-1911	-132	2963	90	-24	318	2995	-159	-1916	4911
	179	0.073	-1321	1154	2835	92	-43	359	2909	1085	-1325	4234
	180	0.145	-383	2335	3008	-77	-98	471	3255	2093	-387	3642
	181	0.218	246	3716	3229	-476	-187	475	4073	2941	177	3896
PL	-		-804	1820	3016	-98	-105	397	3140	1702	-810	3950
PB	178		-1182	-1926	-178	277	81	-79	-169	-1093	-2023	1854
	181		1182	1926	178	-277	-81	79	2023	1093	169	1854
PL+PB	178		-1986	-106	2838	179	-24	318	2872	-122	-2003	4876
	181		377	3746	3194	-375	-187	475	4067	2921	330	3738
3	162	0.000	-2053	-1359	-336	-229	-18	76	-329	-1296	-2121	1792
	167	0.106	-2183	172	697	-660	-47	134	746	294	-2356	3102
	172	0.213	-2061	1974	1402	-408	-108	223	2094	1325	-2104	4198
	177	0.319	-1185	2271	1932	-130	-206	325	2481	1739	-1202	3683
	315	0.373	-333	651	1680	-251	-244	272	1789	617	-409	2198
PL	-		-1762	882	989	-487	-131	174	1175	786	-1852	3027
PB	162		-556	-1431	-900	-243	113	-98	-452	-933	-1501	1049
	315		556	1431	900	243	-113	98	1501	933	452	1049
PL+PB	162		-2318	-549	89	-730	-18	76	105	-302	-2580	2685
	315		-1206	2313	1889	-245	-244	272	2475	1760	-1239	3714
4	158	0.000	-2204	-1570	-1379	-7	-13	39	-1371	-1577	-2204	834
	163	0.106	-1611	-552	131	-582	-34	78	147	-311	-1869	2016
	168	0.213	-2355	1520	835	-1102	-83	148	1839	808	-2647	4485
	173	0.319	-2284	2125	1067	-302	-139	211	2188	1029	-2309	4497
	312	0.379	-1927	695	673	301	-205	237	923	498	-1982	2905
	314	0.430	-2627	-731	14	1308	-193	182	73	-103	-3314	3388
PL	-		-1972	571	-135	-505	-103	111	688	-152	-2072	2760
PB	158		308	-1374	-697	-476	90	-71	443	-704	-1502	1945
	314		-308	1374	697	476	-90	71	1502	704	-443	1945
PL+PB	158		-1664	-803	-832	-981	-13	39	-159	-834	-2305	2146
	314		-2280	1945	562	-30	-193	182	1969	551	-2293	4262

NOTE: PM, PL, PB, PM+PB AND PL+PB CONTAINS SECONDARY STRESS Q

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: CAC	Date: 1/14/98	Project No.: AES 97103213-1Q
	Revision No.: 0	Document Control No.: I-2	Sheet No.: B-7 of B-11

COMBINED STRESSES

NORMAL & UPSET CONDITION (P+DW+OBE+THER)

STEP CHANGE CONDITION

							THER1	THER2	THER3	THER4	THER5	THER5
							T=653F	200F/Hr	STRAT	ΔT=20F	-40F,-20F	-40F,-20F
LOAD CASE =		P	FA	FL	MB	MT	t=0s	t=3600s	t=6264s	t=8s	t=50s	t=2000s
LOAD FACTOR =		1.000	0.035	0.046	0.336	0.120	1.000	0.000	0.000	-1.000	0.000	0.000
		s	SIGX	SIGY	SIGZ	SIGXY	SIGZX	SIGYZ	S1	S2	S3	S INT
SECTION	NODE	(in)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)
1	258	0.000	-1736	3994	6149	8	0	393	6219	3925	-1736	7955
	259	0.073	-1177	3256	3708	11	0	435	3972	2991	-1177	5149
	260	0.145	-433	3221	2655	10	0	519	3529	2347	-433	3962
	261	0.218	-104	3417	2124	6	0	561	3626	1915	-104	3731
PM	-		-843	3395	3501	7	0	477	3928	2968	-843	4771
PB	258		-901	232	1916	1	0	-84	1920	228	-901	2821
	261		901	-232	-1916	-1	0	84	901	-228	-1920	2821
PM+PB	258		-1744	3626	5417	8	0	393	5500	3544	-1744	7244
	261		58	3163	1585	6	0	561	3342	1407	58	3284
2	178	0.000	-1734	2370	5735	11	-24	318	5765	2341	-1734	7499
	179	0.073	-1145	1762	3474	-8	-43	359	3547	1690	-1145	4692
	180	0.145	-305	1851	2572	-119	-98	471	2811	1620	-313	3124
	181	0.218	190	2492	2269	-331	-187	475	2920	1894	137	2783
PL	-		-699	2074	3386	-134	-105	397	3501	1967	-707	4208
PB	178		-1058	-107	1639	169	81	-79	1644	-80	-1091	2735
	181		1058	107	-1639	-169	-81	79	1091	80	-1644	2735
PL+PB	178		-1757	1967	5024	35	-24	318	5057	1935	-1758	6815
	181		359	2181	1747	-304	-187	475	2545	1442	301	2244
3	162	0.000	-1644	17	3327	-215	-18	76	3329	43	-1672	5001
	167	0.106	-1740	453	2099	-804	-47	134	2113	702	-2003	4116
	172	0.213	-1601	1696	1491	-559	-108	223	1921	1361	-1695	3616
	177	0.319	-977	1569	1207	-123	-206	325	1776	1022	-999	2775
	315	0.373	-379	414	787	-73	-244	272	976	274	-429	1405
PL	-		-1377	906	1637	-548	-131	174	1698	972	-1504	3202
PB	162		-373	-554	1312	-313	113	-98	1327	-153	-789	2117
	315		373	554	-1312	313	-113	98	789	153	-1327	2117
PL+PB	162		-1750	353	2949	-861	-18	76	2952	658	-2057	5009
	315		-1004	1460	325	-235	-244	272	1553	288	-1061	2614
4	158	0.000	-1828	18	2218	128	-13	39	2219	27	-1837	4056
	163	0.106	-986	-321	1665	-595	-34	78	1670	24	-1335	3005
	168	0.213	-1805	1333	1129	-1254	-83	148	1813	1089	-2245	4058
	173	0.319	-1878	1685	581	-337	-139	211	1759	544	-1916	3675
	312	0.379	-1681	528	-57	332	-205	237	639	-87	-1763	2402
	314	0.430	-2303	-644	-787	1205	-193	182	-4	-763	-2966	2962
PL	-		-1481	633	381	-508	-103	111	790	342	-1600	2390
PB	158		457	-769	1383	-441	90	-71	1398	585	-912	2310
	314		-457	769	-1383	441	-90	71	912	-585	-1398	2310
PL+PB	158		-1024	-136	1764	-949	-13	39	1766	466	-1628	3393
	314		-1938	1401	-1002	-67	-193	182	1417	-979	-1977	3393

NOTE: PM, PL, PB, PM+PB AND PL+PB CONTAINS SECONDARY STRESS Q

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: CQL	Date: 1/14/98	Project No.: AES 97103213-1Q
	Revision No.: 0	Document Control No.: I-2	Sheet No.: B-8 of B-11

COMBINED STRESSES

NORMAL & UPSET CONDITION (P+DW+OBE+THER)

REACTOR TRIP CONDITION - LOSS OF FLOW

							THER1	THER2	THER3	THER4	THER5	THER5
							T=653F	200F/Hr	STRAT	ΔT=20F	-40F,-20F	-40F,-20F
LOAD CASE =		P	FA	FL	MB	MT	t=0s	t=3600s	t=6264s	t=8s	t=50s	t=2000s
LOAD FACTOR =		1.000	0.035	0.046	0.336	0.120	0.000	0.000	0.000	0.000	1.000	0.000
		s	SIGX	SIGY	SIGZ	SIGXY	SIGZX	SIGYZ	S1	S2	S3	S INT
SECTION	NODE	(in)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)
1	258	0.000	-1741	3928	6084	8	0	393	6153	3858	-1741	7894
	259	0.073	-1183	3237	3697	11	0	435	3959	2975	-1183	5142
	260	0.145	-437	3242	2681	10	0	519	3552	2372	-437	3989
	261	0.218	-107	3452	2158	6	0	561	3661	1949	-107	3768
PM	-		-848	3390	3501	7	0	477	3926	2965	-848	4774
PB	258		-903	179	1864	1	0	-84	1868	175	-903	2771
	261		903	-179	-1864	-1	0	84	903	-175	-1868	2771
PM+PB	258		-1750	3569	5365	8	0	393	5448	3487	-1750	7198
	261		55	3211	1637	6	0	561	3390	1458	55	3335
2	178	0.000	-1683	2817	6508	-39	-24	318	6535	2790	-1683	8218
	179	0.073	-1090	1879	3811	-80	-43	359	3877	1816	-1092	4968
	180	0.145	-259	1785	2655	-189	-98	471	2870	1588	-277	3147
	181	0.218	203	2247	2136	-344	-187	475	2728	1718	141	2587
PL	-		-655	2125	3633	-192	-105	397	3736	2037	-669	4405
PB	178		-1040	224	2077	155	81	-79	2082	240	-1061	3143
	181		1040	-224	-2077	-155	-81	79	1061	-240	-2082	3143
PL+PB	178		-1695	2349	5709	-37	-24	318	5739	2320	-1695	7435
	181		385	1901	1556	-347	-187	475	2313	1225	304	2009
3	162	0.000	-1451	-421	4568	-251	-18	76	4569	-365	-1509	6078
	167	0.106	-1593	276	2764	-950	-47	134	2773	665	-1991	4764
	172	0.213	-1459	1686	1734	-700	-108	223	2031	1539	-1609	3639
	177	0.319	-904	1482	1103	-180	-206	325	1695	920	-934	2629
	315	0.373	-399	382	464	-45	-244	272	739	172	-463	1203
PL	-		-1230	801	2003	-640	-131	174	2044	947	-1417	3460
PB	162		-293	-732	2082	-349	113	-98	2092	-110	-925	3017
	315		293	732	-2082	349	-113	98	925	110	-2092	3017
PL+PB	162		-1523	69	4085	-989	-18	76	4087	541	-1996	6083
	315		-938	1533	-79	-291	-244	272	1620	-83	-1020	2640
4	158	0.000	-1632	-365	3429	205	-13	39	3430	-333	-1664	5094
	163	0.106	-673	-569	2441	-661	-34	78	2444	40	-1285	3729
	168	0.213	-1599	1375	1476	-1408	-83	148	1991	1421	-2160	4151
	173	0.319	-1721	1719	552	-412	-139	211	1808	517	-1776	3584
	312	0.379	-1562	574	-320	313	-205	237	663	-322	-1650	2312
	314	0.430	-2163	-597	-1242	1201	-193	182	57	-1205	-2854	2911
PL	-		-1234	577	1133	-540	-103	111	1175	686	-1385	2560
PB	158		539	-1008	2240	-430	90	-71	2248	644	-1121	3369
	314		-539	1008	-2240	430	-90	71	1121	-644	-2248	3369
PL+PB	158		-695	-431	3373	-970	-13	39	3374	415	-1542	4916
	314		-1774	1585	-1108	-109	-193	182	1602	-1071	-1827	3429

NOTE: PM, PL, PB, PM+PB AND PL+PB CONTAINS SECONDARY STRESS Q

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: RQL	Date: 1/14/98	Project No.: AES 97103213-1Q
	Revision No.: 0	Document Control No.: I-2	Sheet No.: B-9 of B-11

COMBINED STRESSES

NORMAL & UPSET CONDITION (P+DW+OBE+THER)

REACTOR TRIP CONDITION - LOSS OF FLOW

							THER1	THER2	THER3	THER4	THER5	THER5
							T=653F	200F/Hr	STRAT	ΔT=20F	-40F,-20F	-40F,-20F
LOAD CASE =		P	FA	FL	MB	MT	t=0s	t=3600s	t=6264s	t=8s	t=50s	t=2000s
LOAD FACTOR =		1.000	0.035	0.046	0.336	0.120	0.000	0.000	0.000	0.000	0.000	1.000
		s	SIGX	SIGY	SIGZ	SIGXY	SIGZX	SIGYZ	S1	S2	S3	S_INT
SECTION	NODE	(in)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)
1	258	0.000	-1805	3027	5198	8	0	393	5267	2958	-1805	7072
	259	0.073	-1252	3101	3655	11	0	435	3894	2862	-1252	5146
	260	0.145	-488	3490	2985	10	0	519	3815	2661	-488	4303
	261	0.218	-132	3805	2515	6	0	561	4014	2305	-132	4147
PM	-		-903	3336	3501	7	0	477	3902	2934	-903	4805
PB	258		-924	-439	1264	1	0	-84	1268	-443	-924	2192
	261		924	439	-1264	-1	0	84	924	443	-1268	2192
PM+PB	258		-1826	2897	4764	8	0	393	4844	2818	-1826	6670
	261		21	3775	2237	6	0	561	3958	2054	21	3936
2	178	0.000	-1833	674	4107	40	-24	318	4136	646	-1834	5970
	179	0.073	-1229	1304	3234	22	-43	359	3298	1240	-1230	4528
	180	0.145	-317	2147	3068	-142	-98	471	3272	1952	-327	3599
	181	0.218	293	3383	3194	-502	-187	475	3846	2815	209	3637
PL	-		-731	1885	3354	-155	-105	397	3459	1792	-742	4201
PB	178		-1161	-1369	395	266	81	-79	402	-980	-1556	1958
	181		1161	1369	-395	-266	-81	79	1556	980	-402	1958
PL+PB	178		-1892	517	3749	111	-24	318	3780	492	-1897	5678
	181		430	3255	2959	-421	-187	475	3667	2613	363	3304
3	162	0.000	-1875	-1016	1241	-207	-18	76	1244	-971	-1923	3167
	167	0.106	-1939	155	1555	-702	-47	134	1572	352	-2153	3724
	172	0.213	-1760	1800	1860	-508	-108	223	2102	1630	-1833	3935
	177	0.319	-957	2105	2149	-230	-206	325	2480	1801	-985	3466
	315	0.373	-178	693	1927	-329	-244	272	2027	712	-298	2326
PL	-		-1486	838	1663	-552	-131	174	1717	910	-1613	3330
PB	162		-586	-1257	-270	-172	113	-98	-212	-598	-1303	1091
	315		586	1257	270	172	-113	98	1303	598	212	1091
PL+PB	162		-2072	-419	1393	-723	-18	76	1397	-151	-2344	3741
	315		-900	2095	1933	-380	-244	272	2360	1731	-963	3323
4	158	0.000	-2048	-1102	144	64	-13	39	146	-1099	-2052	2198
	163	0.106	-1327	-581	1028	-558	-34	78	1033	-288	-1625	2658
	168	0.213	-1959	1350	1438	-1152	-83	148	1790	1360	-2321	4111
	173	0.319	-1889	1956	1481	-411	-139	211	2083	1401	-1936	4019
	312	0.379	-1555	713	1109	133	-205	237	1226	621	-1581	2807
	314	0.430	-2068	-520	591	1007	-193	182	620	-33	-2585	3205
PL	-		-1580	546	1053	-540	-103	111	1096	634	-1712	2808
PB	158		136	-1268	-295	-330	90	-71	231	-313	-1345	1575
	314		-136	1268	295	330	-90	71	1345	313	-231	1575
PL+PB	158		-1444	-722	758	-870	-13	39	760	-143	-2025	2785
	314		-1717	1814	1348	-209	-193	182	1896	1290	-1740	3635
NOTE: PM, PL, PB, PM+PB AND PL+PB CONTAINS SECONDARY STRESS Q												

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: CQL	Date: 1/14/98	Project No.: AES 97103213-1Q
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COMBINED STRESSES

FAULTED CONDITION (PD+DW+DBE)

							THER1 T=653F	THER2 200F/Hr	THER3 STRAT	THER4 ΔT=20F	THER5 -40F,-20F	THER5 -40F,-20F
LOAD CASE =		P	FA	FL	MB	MT	t=0s	t=3600s	t=6264s	t=8s	t=50s	t=2000s
LOAD FACTOR =		1.000	0.045	0.092	0.629	0.240	0.000	0.000	0.000	0.000	0.000	0.000
		s	SIGX	SIGY	SIGZ	SIGXY	SIGZX	SIGYZ	S1	S2	S3	S INT
SECTION	NODE	(in)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)
1	258	0.000	-1861	4280	5222	16	1	787	5668	3834	-1861	7529
	259	0.073	-1250	4624	3659	21	1	871	5137	3146	-1251	6387
	260	0.145	-488	5277	2965	19	0	1038	5675	2568	-488	6163
	261	0.218	-75	5898	2520	12	0	1121	6237	2182	-75	6311
PM	-		-902	4998	3501	14	0	954	5462	3037	-902	6364
PB	258		-981	-860	1272	2	0	-167	1285	-873	-981	2266
	261		981	860	-1272	-2	0	167	981	873	-1285	2266
PM+PB	258		-1883	4138	4773	16	1	787	5304	3607	-1883	7187
	261		80	5857	2229	12	0	1121	6176	1911	80	6096
2	178	0.000	-1252	2013	12329	-770	-48	636	12369	2146	-1425	13794
	179	0.073	-338	1491	9239	-1197	-86	717	9309	2019	-936	10245
	180	0.145	718	2205	7943	-1662	-196	942	8124	3116	-374	8498
	181	0.218	1601	3996	7516	-2014	-373	950	7891	4770	452	7439
PL	-		249	2323	9093	-1478	-211	793	9202	2987	-523	9724
PB	178		-1507	-1058	2286	639	163	-157	2298	-605	-1972	4270
	181		1507	1058	-2286	-639	-163	157	1972	605	-2298	4270
PL+PB	178		-1258	1266	11379	-839	-48	636	11420	1480	-1513	12933
	181		1756	3381	6807	-2117	-373	950	7228	4423	292	6936
3	162	0.000	534	-10474	16061	-451	-35	152	16062	552	-10494	26556
	167	0.106	609	-3792	13705	-2282	-93	268	13711	1575	-4764	18474
	172	0.213	1419	1293	11357	-2816	-217	446	11390	4142	-1462	12852
	177	0.319	1890	3502	9027	-2512	-412	651	9181	5181	57	9123
	315	0.373	2174	2476	7710	-2278	-487	544	7873	4445	43	7831
PL	-		1928	-1077	12120	-2357	-261	348	12140	3203	-2373	14512
PB	162		-1170	-6625	4130	860	226	-196	4142	-1045	-6762	10904
	315		1170	6625	-4130	-860	-226	196	6762	1045	-4142	10904
PL+PB	162		758	-7702	16250	-1498	-35	152	16252	1015	-7960	24212
	315		3098	5547	7989	-3217	-487	544	8611	7145	879	7732
4	158	0.000	293	-9502	14177	1198	-27	79	14177	437	-9646	23824
	163	0.106	2746	-5386	14320	-998	-68	156	14322	2866	-5507	19829
	168	0.213	2845	858	13131	-2959	-167	296	13144	4962	-1272	14415
	173	0.319	3149	2986	10701	-2817	-279	421	10752	5836	248	10504
	312	0.379	3588	2657	9332	-2816	-409	474	9444	5866	267	9176
	314	0.430	5429	2501	8996	-2682	-386	363	9124	6893	908	8216
PL	-		4092	-780	12781	-1527	-206	221	12791	4523	-1221	14012
PB	158		-2148	-6624	2656	1736	180	-142	2663	-1558	-7222	9886
	314		2148	6624	-2656	-1736	-180	142	7222	1558	-2663	9886
PL+PB	158		1944	-7405	15437	209	-27	79	15437	1948	-7409	22847
	314		6240	5844	10125	-3263	-386	363	10386	9050	2773	7613

Calculation No.: AES-C-3213-1	Made by: RLC	Date: 1/14/98	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: CRC	Date: 1/14/98	Project No.: AES 97103213-1Q
	Revision No.: 0	Document Control No.: I-2	Sheet No.: B-11 of B-11

COMBINED STRESSES

TEST CONDITION (P+DW)

							THER1	THER2	THER3	THER4	THER5	THER5
							T=653F	200F/Hr	STRAT	ΔT=20F	-40F,-20F	-40F,-20F
LOAD CASE =		P	FA	FL	MB	MT	t=0s	t=3600s	t=6264s	t=8s	t=50s	t=2000s
LOAD FACTOR =		1.250	0.025	0.000	0.060	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		s	SIGX	SIGY	SIGZ	SIGXY	SIGZX	SIGYZ	S1	S2	S3	S_INT
SECTION	NODE	(in)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)	(psi)
1	258	0.000	-2178	2361	6584	0	0	0	6584	2361	-2178	8762
	259	0.073	-1559	2025	4570	0	0	0	4570	2025	-1559	6128
	260	0.145	-603	2139	3716	0	0	0	3716	2139	-603	4319
	261	0.218	-233	2144	3090	0	0	0	3090	2144	-233	3323
PM	-		-1122	2139	4375	0	0	0	4375	2139	-1122	5498
PB	258		-1082	46	1648	0	0	0	1648	46	-1082	2730
	261		1082	-46	-1648	0	0	0	1082	-46	-1648	2730
PM+PB	258		-2205	2184	6023	0	0	0	6023	2184	-2205	8228
	261		-40	2093	2727	0	0	0	2727	2093	-40	2767
2	178	0.000	-1557	1991	15195	-973	0	0	15195	2240	-1806	17001
	179	0.073	-556	975	11230	-1485	0	0	11230	1880	-1461	12690
	180	0.145	698	1570	9530	-1956	0	0	9530	3138	-870	10399
	181	0.218	1495	3214	8728	-2205	0	0	8728	4722	-12	8740
PL	-		63	1757	10928	-1699	0	0	10928	2808	-988	11916
PB	178		-1627	-696	3083	638	0	0	3083	-372	-1951	5034
	181		1627	696	-3083	-638	0	0	1951	372	-3083	5034
PL+PB	178		-1564	1061	14010	-1061	0	0	14010	1436	-1939	15950
	181		1690	2453	7845	-2337	0	0	7845	4439	-296	8141
3	162	0.000	616	-13709	19950	-595	0	0	19950	640	-13733	33683
	167	0.106	749	-5248	17012	-2886	0	0	17012	1912	-6411	23423
	172	0.213	1731	920	13972	-3478	0	0	13972	4827	-2177	16149
	177	0.319	2184	3322	10872	-2871	0	0	10872	5680	-174	11047
	315	0.373	2305	2691	9293	-2452	0	0	9293	4958	38	9255
PL	-		2183	-1861	14914	-2770	0	0	14914	3591	-3269	18183
PB	162		-1285	-8378	5273	864	0	0	5273	-1181	-8482	13755
	315		1285	8378	-5273	-864	0	0	8482	1181	-5273	13755
PL+PB	162		898	-10240	20187	-1906	0	0	20187	1216	-10557	30744
	315		3468	6517	9641	-3634	0	0	9641	8934	1052	8590
4	158	0.000	360	-12433	17729	1499	0	0	17729	533	-12607	30335
	163	0.106	3460	-7130	17922	-1271	0	0	17922	3611	-7281	25203
	168	0.213	3562	625	16330	-3660	0	0	16330	6037	-1850	18180
	173	0.319	3886	3115	13176	-3355	0	0	13176	6878	124	13053
	312	0.379	4419	2997	11515	-3208	0	0	11515	6994	422	11094
	314	0.430	6559	2827	11006	-3127	0	0	11006	8334	1052	9954
PL	-		5002	-1403	15860	-1796	0	0	15860	5471	-1872	17733
PB	158		-2576	-8404	3443	2056	0	0	3443	-1924	-9057	12500
	314		2576	8404	-3443	-2056	0	0	9057	1924	-3443	12500
PL+PB	158		2426	-9808	19303	261	0	0	19303	2431	-9813	29117
	314		7578	7001	12417	-3852	0	0	12417	11152	3427	8991

Calculation No.: AES-C-3213-1	Made by: RLC	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: MTC	Date: 8 May 06	Project No.: AES 97103213-1Q
	Revision No.: 3	Document Control No.: I-2	Sheet No.: C-1 of C-6

Appendix C

WELD PAD GEOMETRY RECONCILIATION

Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: [signature]	Date: 8 May 06	Project No.: AES 97103213-1Q
	Revision No.: 3	Document Control No.: I-2	Sheet No.: C-2 of C-6

C.1 PURPOSE AND SUMMARY

The purpose of this Appendix is to reconcile the design of a polygon shaped weld pad with six sides to the design analysis calculation performed for a circular weld pad. The half nozzle weld repair utilizing a circular weld pad was explicitly evaluated to ASME Section III design. This repair geometry is shown in Figure C-1 (Ref. C1). As an alternative design,the six sided polgon shaped weld pad geometry is shown in Figure C-2 (Ref. C2). Reference to the word "calculation" will mean the finite element analysis and results presented in the main body of ths document.

The use of a noncircular weld pad in the repair of the bottom head level nozzle penetration will be covered under this calculation provided that the following conditions are satisfied:

1) The nozzle diameter and wall thickness are the same as defined in this calculation.
2) The ligament length (i.e., the distance from the nozzle outside surface to the top-side edge of the weld pad is not less than 5/8 inch.
3) The pad thickness is at least 7/16 inch but not exceeding not 11/16 inch.
4) The J-groove depth for the pad weld is at least 3/16 inch
5) All other dimensions, construction materials, and manner of fabrication are the same as defined in the calculation.

The technical basis and justification of this reconciliation are discussed below.

C.2 GEOMETRY RECONCILIATION

A comparative evaluation of the pad dimensions of the circular shape and the six-sided polygon is given in the table below.

Table C-1 Comparison of Pad Dimensions

Penetration	Pad Shape	Ligament Length	Thickness	J-Groove Depth
Level	Circular	1 3/8"	7/16"	3/16"
	6-sided Polyon	1 3/8"	7/16"	3/16"
Heater Sleeve	Circular	5/8"	19/32"	3/16"
	Square	5/8"	21/32"	3/16"

Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: [signature]	Date: 8 Mar 06	Project No.: AES 97103213-1Q
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The important dimensions that define the P_M, P_L, P_B stresses in the J-groove weld are the pad size (ligament length), thickness, and weld size (prep depth). All these dimensions are the same for the Level nozzle repair involving either the circular pad or six-sided polygon.

Also listed in the above table are the analyzed pad dimensions for the heater sleeve repair modfication (Refs. C3 and C4). These geometries were individually analyzed to ASME Section III Code requirements by finite element. Although the pads ligaments were smaller than those for the Level nozzle penetration, and slightly different thicknesses overall, the calculated peak stress intensities and fatigue usage factors were not significantly different given the different pad shapes. Further discussion of the stresses is given next.

C.3 STRESS COMPARISONS

The calculated Code stresses for the two different pad geometries for the heater sleeve repair were not significantly different between the circular and square shapes. This is shown in the table below from Refs. C3 and C4:

Table C-2 Comparison of Code Stress Ratios* for Heater Sleeve Repair

Condition	Stress Combination/Symbol	Circular Pad Shape	Square Pad Shape
Design	P_M	0.51	0.55
	P_L+P_B	0.80	0.82
Norma/Upset	$P_L+P_B+P_E+Q$	0.98	0.96
Emergency	P_M	0.38	0.42
	P_L+P_B	0.61	0.62
Test	P_M	0.52	0.52
	P_L+P_B	0.85	0.87
Fatigue Usage	U	0.0044	0.0042

* Ratio of stress intensity to Code Allowable stress intensity.

For the differences noted in the dimensions and given the two different shapes, the Code stresses are not significantly affected by pad shape. The above stress comparisons provides sufficient justification for applying the existing calculation to the six-sided polygon pad. A general statement of reconciliation for a general noncircular shape is formulated next.

Calculation No.: AES-C-3213-1	Made by: [initials]	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: MTC	Date: 8 Mar 06	Project No.: AES 97103213-1Q
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C.4 RECONCILIATION FINDINGS AND DISCUSSION

The following is a technical discussion of the findings and judgements formulated from this evaluation of pad geometries:

1) The key pad dimensions affecting the local stresses in the PZR Level nozzle attachment repair weld are the ligament length, pad thickness, and J-groove preparation size. For the detailed analysis performed for the heater sleeve repair, the ligament length can be as small as 5/8 inch without causing a significant stress deviation between the circular and square pad shapes. Ligament lengths greater than this value would be expected not to affect the local weld stress since the discontinuity created by the pad/shape configuration becomes more removed from the local weld region.

2) The pad thickness does not significantly affect the stress at the weld for the sizes analyzed. It would be expected that as the pad thickness increases, thermal stress may become elevated due to temperature gradients across the pad wall. For thicknesses between 7/16 and 11/16 inch, this effect is judged to be negligible, when compared to the bottom head wall thickness.

3) The local stress in the weld region will be sensitive to the size of the weld throat. All the evaluations performed used a 3/16 inch J-groove weld preparation. Therefore, this establishes the minimum weld size covered by this reconciliation.

C.4 REFERENCES

C1. "Pressurizer Primary Instrument Nozzle Geometry, 1/2 Nozzle Repair — Conceptual Design PZR Bottom Level Nozzle," (October 28, 1997) (ECD-6 in Project AES 97103213-1Q).

C2. "Pressurizer Instrumentation Nozzle Detail," Southern California Edison Change Notice, S023-919-30, (11/10/05) (ECD-2 in Project AES 05095929-1Q)

C3. Attachment II to SCE M-DSC-356, Rev. 2, "Evaluation of Modified Heater Sleeves with Circular Weld Pad – SONGS Units 2 and 3," Calculation AES-C-5212-4, Rev. 1, (10/27/05), (ICD-4 in Project AES 03105212-1Q).

C4. Attachment III to SCE M-DSC-356, Rev. 2, "Evaluation of Modified Heater Sleeves with Square Weld Pad – SONGS Units 2 and 3," Calculation AES-C-5212-5, Rev. 0, (10/27/05), (ICD-5 in Project AES 03105212-1Q).

Calculation No.: AES-C-3213-1	Made by: RL	Date: 12/08/05	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: MTC	Date: 8 Dec 2005	Project No.: AES 97103213-1Q
	Revision No.: 2	Document Control No.: I-2	Sheet No.: C-5 of C-6

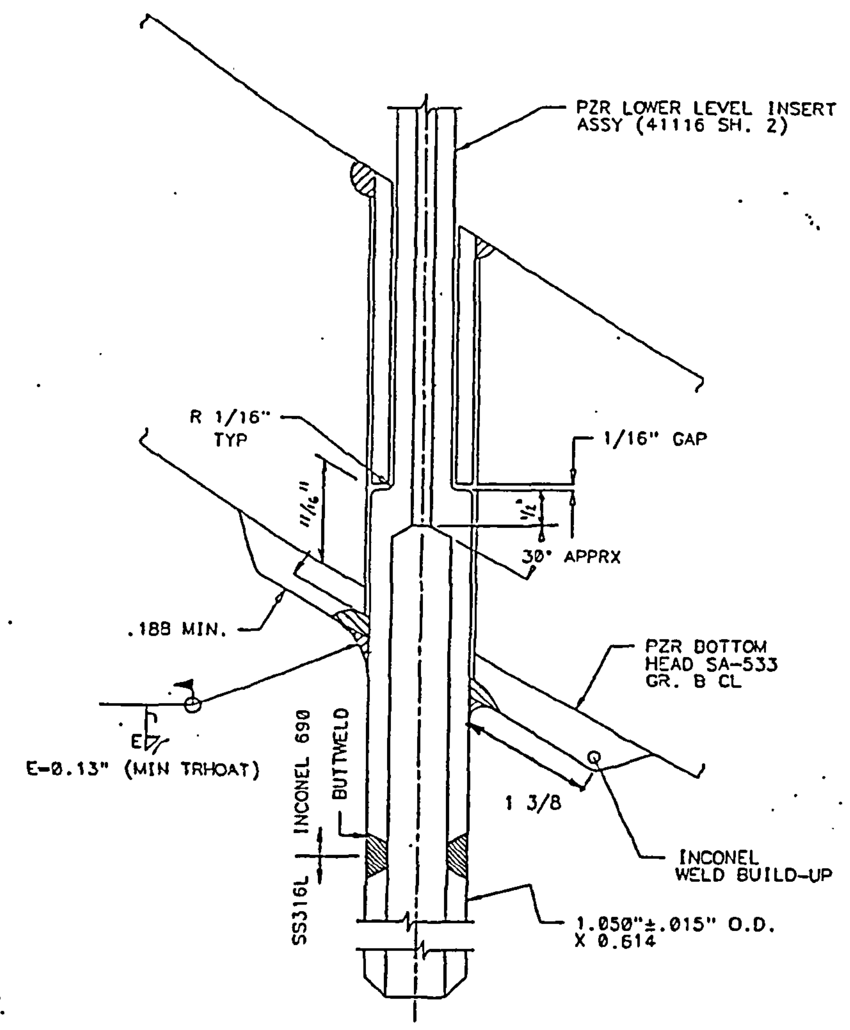

Figure C-1 – Weld Repair Geometry – Circular Shaped Pad

Calculation No.: AES-C-3213-1	Made by: RLC	Date: 12/08/05	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: MTC	Date: 8 DEC 2005	Project No.: AES 97103213-1Q
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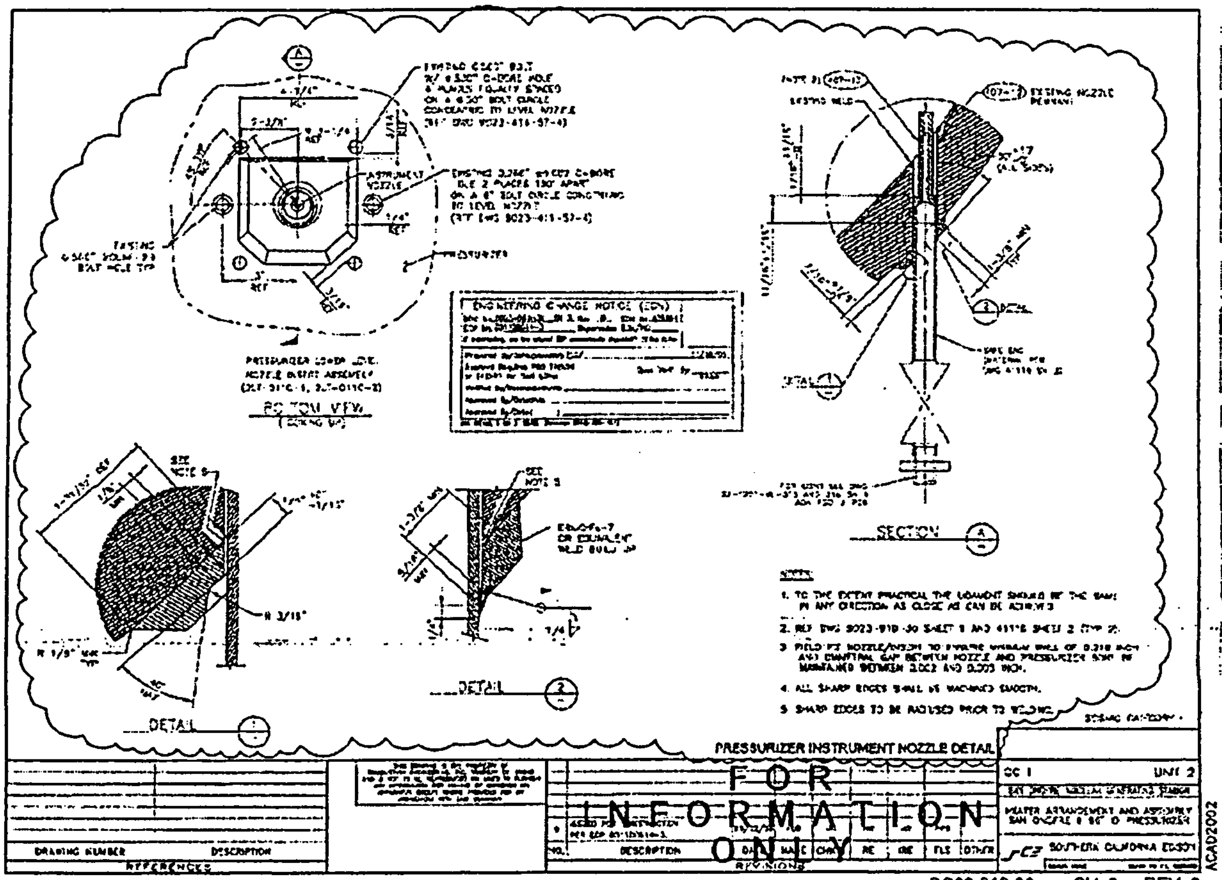

S023-919-30 SH 3 REV 0

Figure C-2 – Weld Repair Geometry – Six-Sided Polygon Shaped Pad

Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: MTC	Date: 8 Mar 06	Project No.: AES 97103213-1Q
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Appendix D

MODIFIED NOZZLE SLEEVE REPAIR RECONCILIATION

Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: [signature]	Date: 8 Mar 06	Project No.: AES 97103213-1Q
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D.1 INTRODUCTION

The purpose of this Appendix is to reconcile the design of modified repair geometry used in instrumentation level nozzle 2LT-0110-2 in Unit 2. The modified repair is shown in Figure D-1. The original bore hole in the bottom head was enlarged and a new Alloy 690 nozzle sleeve was employed. This new sleeve had a larger outside diameter and thicker wall to accommodate the new hole penetration in order to preserve the inside dimensions for the level instrument. The new sleeve geometry is shown in Figure D-2. The as-built dimension of the counter bore hole through the weld pad and into the base metal of the bottom head is illustrated in Figure D-3. These drawings were provided in Ref. D1. Reference to the words "original calculation" will mean the finite element analysis and results presented in the main body of this document.

This appendix also includes a description and results for an axisymmetric finite model that was developed to determine the effect of the modified geometry on stress intensities due to internal pressure. This is given in Section D.4. The stresses determined in the original calculation for thermal transients and mechanical loads were judged to be reasonable and appropriate to be used in this analytical reconciliation of the modified repair.

Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: [signature]	Date: 8 Mar 06	Project No.: AES 97103213-1Q
	Revision No.: 3	Document Control No.: I-2	Sheet No.: D-3 of D-34

D.2 SUMMARY

The modified repair design was reconciled to the original calculation by evaluating the effect of the new geometry (i.e., larger bore hole and sleeve) to the allowable stress calculations. Following the original calculation, a Code reevaluation per NB-3200 of ASME Section III was performed at the two limiting locations in the nozzle J-groove weld. The two locations are Sections 3 and 4 for the ID/OD nodal locations as shown in Figure 2-1. All calculated stresses meet the ASME Code stress limits in this reevaluation, as summarized below:

	Allowable Stress Ratio			
	Primary Stress		Primary + Secondary Stress	
	P_M	$P_L + P_b$	$P_L + P_b + Q$	Section
Design	0.42	0.50	---	3
Normal and Upset*	---	---	0.18	4
Faulted	0.17	0.21	---	3
Test	0.50	0.59	---	3

* Cooldown transient

The computed stress intensities and allowable stress limits are presented in Section D.4.

The fatigue analysis was performed in Section 8.6 of the original calculation. This evaluation demonstrates that the nozzle is exempt from detailed fatigue analysis requirements per the exemption rules of NB-3222.4(d). This result is consistent with the original design, which was also exempt from fatigue requirements (Ref. 4). There is no significant change in the modified design that would alter the original analysis. Therefore, no further evaluation for fatigue design (i.e., transient analyses and cyclic evaluation) is required.

Calculation No.: AES-C-3213-1	Made by:	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: MTC	Date: 8 Mar 06	Project No.: AES 97103213-1Q
	Revision No.: 3	Document Control No.: I-2	Sheet No.: D-4 of D-34

D.3 ASSUMPTIONS

The following assumptions are made:

1) The primary region for the assessment of Code stresses will be the two sections across the J-groove weld (Sections 2 and 3 in the original calculation). Section 3 was the limiting location for the original weld repair configuration. These two sections will be the subject of the reconciliation.

2) The dominant stresses in the J-groove weld are the result of pressure loading. This is based on the results of the original calculation. Therefore, the stresses for internal pressure were reevaluated in a finite element model consistent with the original calculation.

3) Thermal stresses from the original calculation are assumed to be representative of the modified geometry. This is justified since the thermal loads acting in the outer surface of the bottom head will not be significant for the design basis transients.

4) Fatigue exemption evaluation of the original calculation remains valid. This is justified since the overall peak stress, temperature differentials, and number of cycles are not significantly changed for the modified design.

Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 3/9/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: [signature]	Date: 8 Mar 06	Project No.: AES 97103213-1Q
	Revision No.: 3	Document Control No.: I-2	Sheet No.: D-5 of D-34

D.4 GEOMETRY AND ANALYSIS

A comparative evaluation of the nozzle and pad dimensions of the level nozzle repair is given in the table below.

Table D-1 Comparison of Nozzle/Pad Dimensions

Nozzle Design	Nozzle OD	Wall Thickness	Pad Thickness	J-Groove Depth
Original	1.050"	0.218"	7/16"	3/16"
Modified	1.411"	0.409"	1/2"	0.24"

The important dimensions that define the P_M, P_L, P_B stresses in the J-groove weld are the pad thickness, nozzle size, and weld size (prep depth). The modified repair sleeve geometry is nominally stronger than the original configuration based on J-groove weld size and nozzle R/t ratio.

To verify the modified design, an axisymmetric finite element model was developed by SCE (Ref. D2) in similar manner as was done for the original calculation. This model is shown in Figure D-4. The model includes the bottom head, the nozzle sleeve and J-groove weld. The major geometric features of the repair, namely, the pad, J-groove, fillet weld reinforcement, and sleeve were modeled in detail. Some modelling simplification was made in regions away from the region of interest (J-groove weld) since that will not affect the local stresses at the J-groove. The element detail local to the J-groove region is shown in Figure D-5.

The boundary conditions applied to the model for internal pressure is shown in Figure D-6. The model geometry and boundary condition inputs were checked herein as part of the stress reevaluation.

A contour plot of the stress intensities for a pressure of 2500 psia is given in Figure D-7.

Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: [signature]	Date: 8 May 06	Project No.: AES 97103213-1Q
	Revision No.: 3	Document Control No.: I-2	Sheet No.: D-6 of D-34

D.5 CODE STRESS EVALUATION

The design requirements of NB-3200 are used to assess the stress allowables and design acceptance for all load combinations considered in Section 4 of the original calculation. The results from the stress analysis are scaled according to Section 8.4.2 for the two nozzle sections under evaluation and compared with the Code allowable stress limits. The stress allowable limits are provided below from the original design code (Ref. 6):

	Primary Membrane		Membrane + Bending	Primary + Secondary
Plant Condition	P_M	P_L	$P_L + P_b$	$P_L + P_b + Q$
Design	$1.0S_m$	$1.5S_m$	$1.5S_m$	---
Normal and upset	---	---	---	$3.0\ S_m$
Faulted	$2.4S_m$	$3.6S_m$	$3.6S_m$	---
Test	$0.9S_y$	---	$1.35S_y$	---

where P_M is the general primary membrane stress intensity, P_L is the local primary membrane stress intensity (including discontinuities), P_b is the primary bending stress, and Q is secondary stress (thermal stresses). Peak stresses are excluded from static stress evaluations, but are considered in the fatigue evaluation. The same basic evaluation was followed as used in the original calculation.

The same spreadsheet analysis is used to combine stresses with the appropriate scaling factors. The only change was that the pressure stress case for the modified sleeve design was used instead of the original nozzle. Superposition is used to combine individual component stresses and membrane and bending stresses. The comparisons of computed stress intensities with Code allowable stress limits are summarized below.

Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: [signature]	Date: 8 May 06	Project No.: AES 97103213-1Q
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1. For the design loading combinations:

Design Condition (P_D + DW + OBE)						
	Primary Stress Intensities (ksi)					
Nozzle Section	P_M	Allowable $1.0S_m$	Ratio	$P_L + P_b$	Allowable $1.5S_m$	Ratio
3	9.80	23.3	0.420	17.42	34.95	0.498
4	9.73	23.3	0.418	16.38	34.95	0.469

Note: Design condition stresses are higher than some normal/upset stresses because thermal stresses act to reduce pressure stresses in the nozzle attachment weld region.

2. For normal and upset loading combinations considering heatup/cooldown thermal conditions:

Normal and Upset Condition (P + DW + OBE + THER)			
	Primary + Secondary Stress Intensities (ksi)		
Nozzle Section	$P_L + P_b + Q$	Allowable $3.0S_m$	Ratio
3	10.56	69.9	0.151
4	12.61	69.9	0.180

Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 3/8/00	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: MTC	Date: 8 May 00	Project No.: AES 97103213-1Q
	Revision No.: 3	Document Control No.: I-2	Sheet No.: D-8 of D-34

3. For normal and upset loading combinations considering cooldown with thermal stratification transient:

Normal and Upset Condition (P + DW + OBE + THER)			
	Primary + Secondary Stress Intensities (ksi)		
Nozzle Section	$P_L + P_b + Q$	Allowable $3.0S_m$	Ratio
3	12.35	69.9	0.177
4	11.81	69.9	0.169

4. For normal and upset loading combinations considering plant load/unload and step change transients:

Normal and Upset Condition (P + DW + OBE + THER)			
	Primary + Secondary Stress Intensities (ksi)		
Nozzle Section	$P_L + P_b + Q$	Allowable $3.0S_m$	Ratio
3	10.21	69.9	0.146
4	12.22	69.9	0.174

Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: [signature]	Date: 9 May 06	Project No.: AES 97103213-1Q
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5. For normal and upset loading combinations considering reactor trip for loss of flow transient:

Normal and Upset Condition (P + DW + OBE + THER)			
	Primary + Secondary Stress Intensities (ksi)		
Nozzle Section	$P_L + P_b + Q$	Allowable $3.0S_m$	Ratio
3	10.01	69.9	0.143
4	11.83	69.9	0.169

6. For faulted load combination under design basis earthquake:

Faulted Condition (P_D + DW + DBE)						
	Primary Stress Intensities (ksi)					
Nozzle Section	P_M	Allowable $2.4S_m$	Ratio	$P_L + P_b$	Allowable $3.6S_m$	Ratio
3	9.68	55.92	0.173	17.23	83.88	0.205
4	9.60	55.92	0.172	16.15	83.88	0.193

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: MTC	Date: 8 Mar 06	Project No.: AES 97103213-1Q
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7. For test load combinations under hydrotest conditions:

Test Condition (P + DW)						
	Primary Stress Intensities (ksi)					
Nozzle Section	P_M	Allowable $0.9S_y$	Ratio	$P_L + P_b$	Allowable $1.35S_y$	Ratio
3	12.41	24.84	0.500	22.01	37.26	0.591
4	12.33	24.84	0.496	20.75	37.26	0.557

Note: For test conditions, S_y is conservatively assumed as 27.6 ksi (T=700°F).

Based on the above stress evaluations, all calculated stress intensities meet the ASME Code stress limits in this reevaluation.

D.6 REFERENCES

D1. Repair Drawings for Modified Sleeve, Southern California Edison, (March 4, 2006) (ECD-6)

D2. ANSYS Finite Element Model Input and Stress Output Files, Results transmitted electronically, Southern California Edison, (March 6, 2006) (ECD-7).

Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: MTC	Date: 8 Mar 06	Project No.: AES 97103213-1Q
	Revision No.: 3	Document Control No.: I-2	Sheet No.: D-11 of D-34

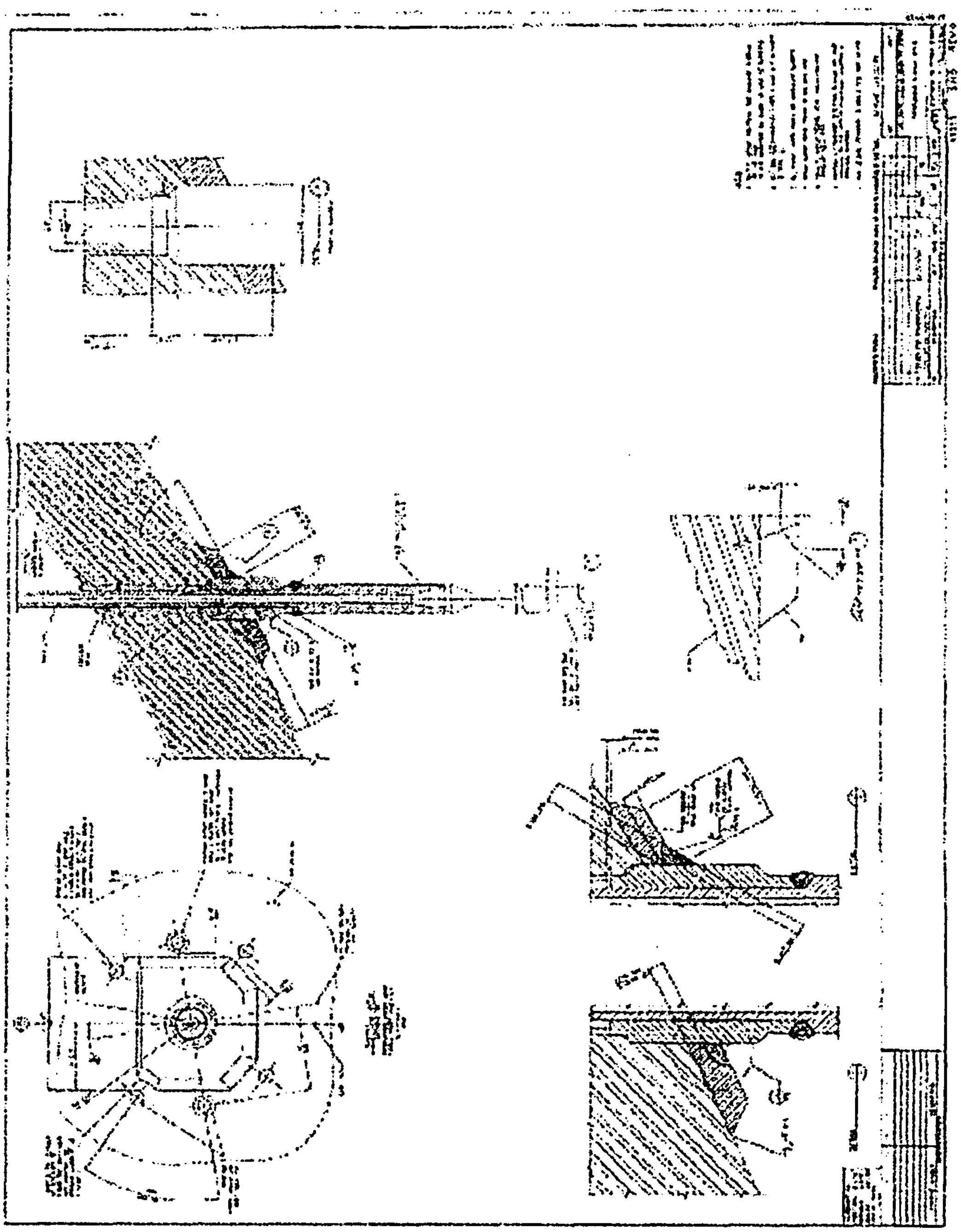


Figure D-1 – Modified Weld Repair Geometry

Calculation No.: AES-C-3213-1	Made by: PCL	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: MTC	Date: 8 Mar 06	Project No.: AES 97103213-1Q
	Revision No.: 3	Document Control No.: I-2	Sheet No.: D-12 of D-34

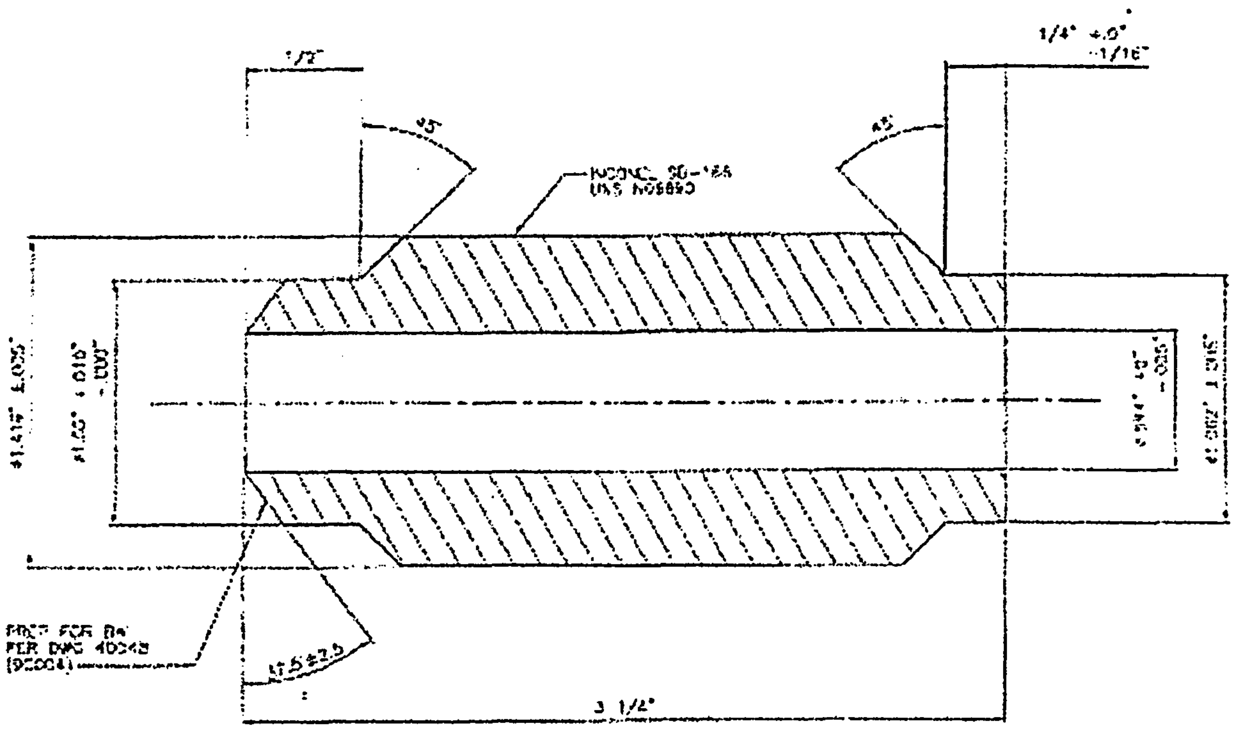
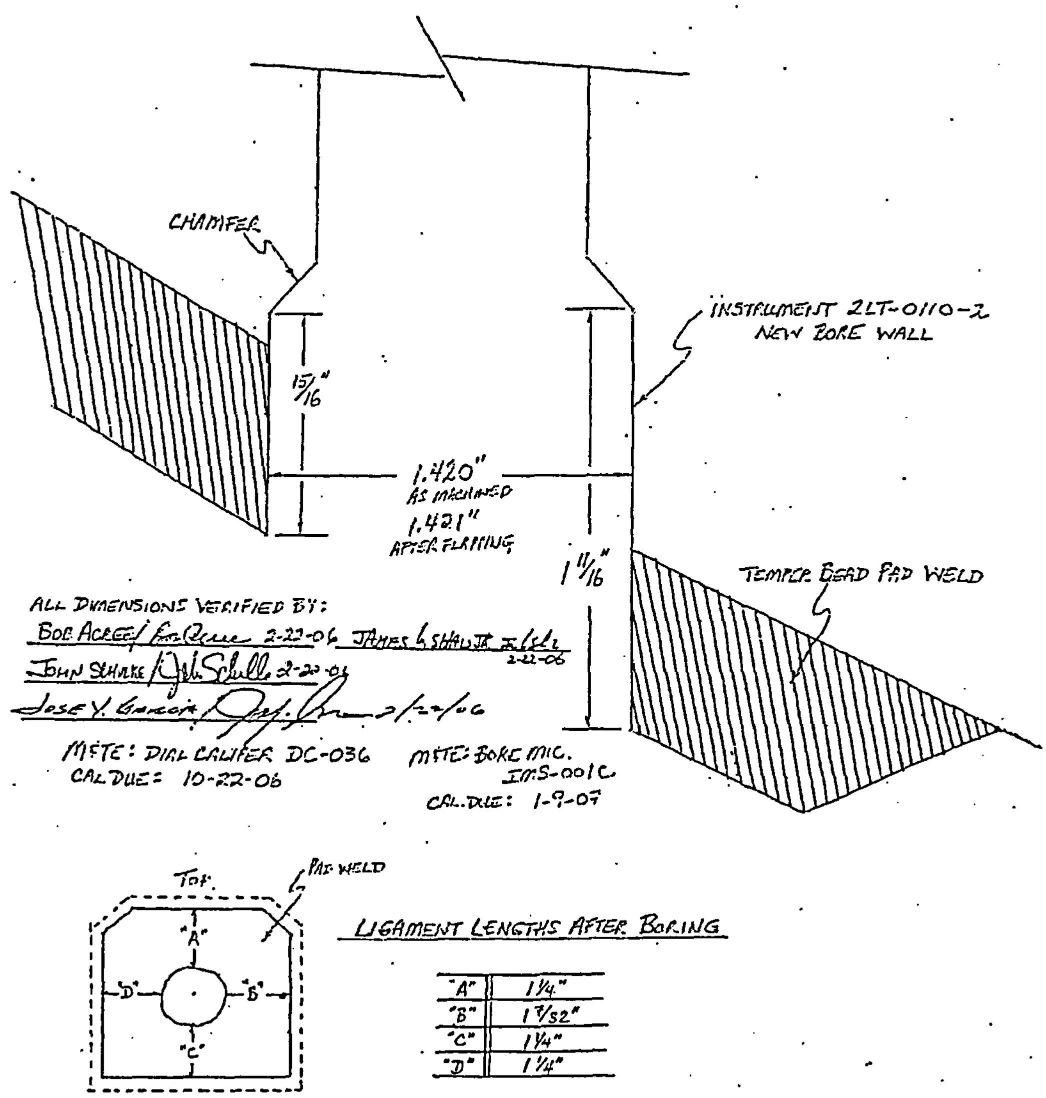


Figure D-2 – Modified Nozzle Sleeve

Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: MTC	Date: 8 Mar 06	Project No.: AES 97103213-1Q
	Revision No.: 3	Document Control No.: I-2	Sheet No.: D-13 of D-34



"A"	1 1/4"
"B"	1 7/32"
"C"	1 1/4"
"D"	1 1/4"

Figure D-3 – As-Built Bore Hole Dimensions

Calculation No.: AES-C-3213-1	Made by: RLC	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: MTC	Date: 8 Mar 06	Project No.: AES 97103213-1Q
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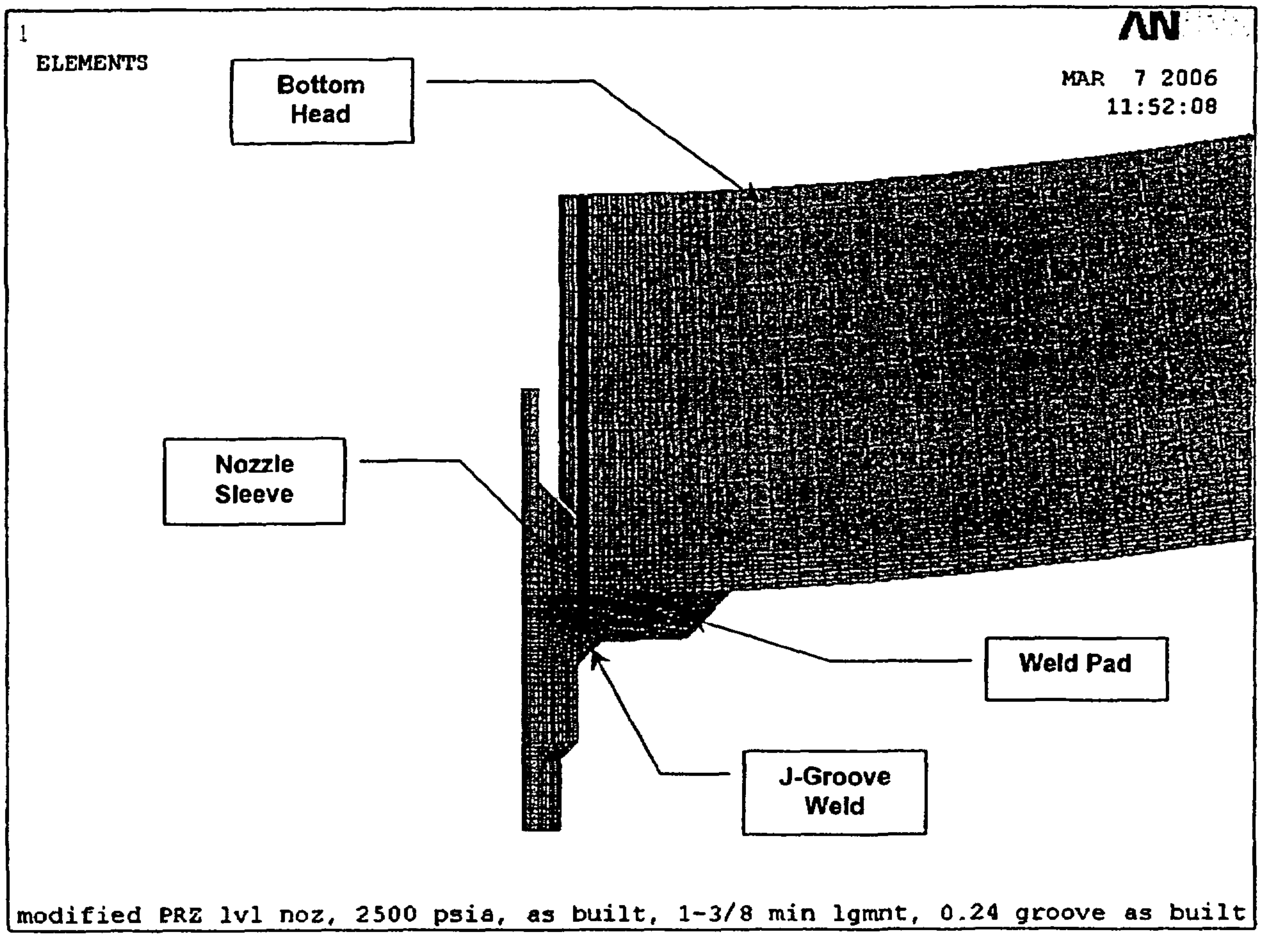

Figure D-4 – Finite Element Model

Calculation No.: AES-C-3213-1	Made by: RCC	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: MTC	Date: 8 Mar 06	Project No.: AES 97103213-1Q
	Revision No.: 3	Document Control No.: I-2	Sheet No.: D-15 of D-34

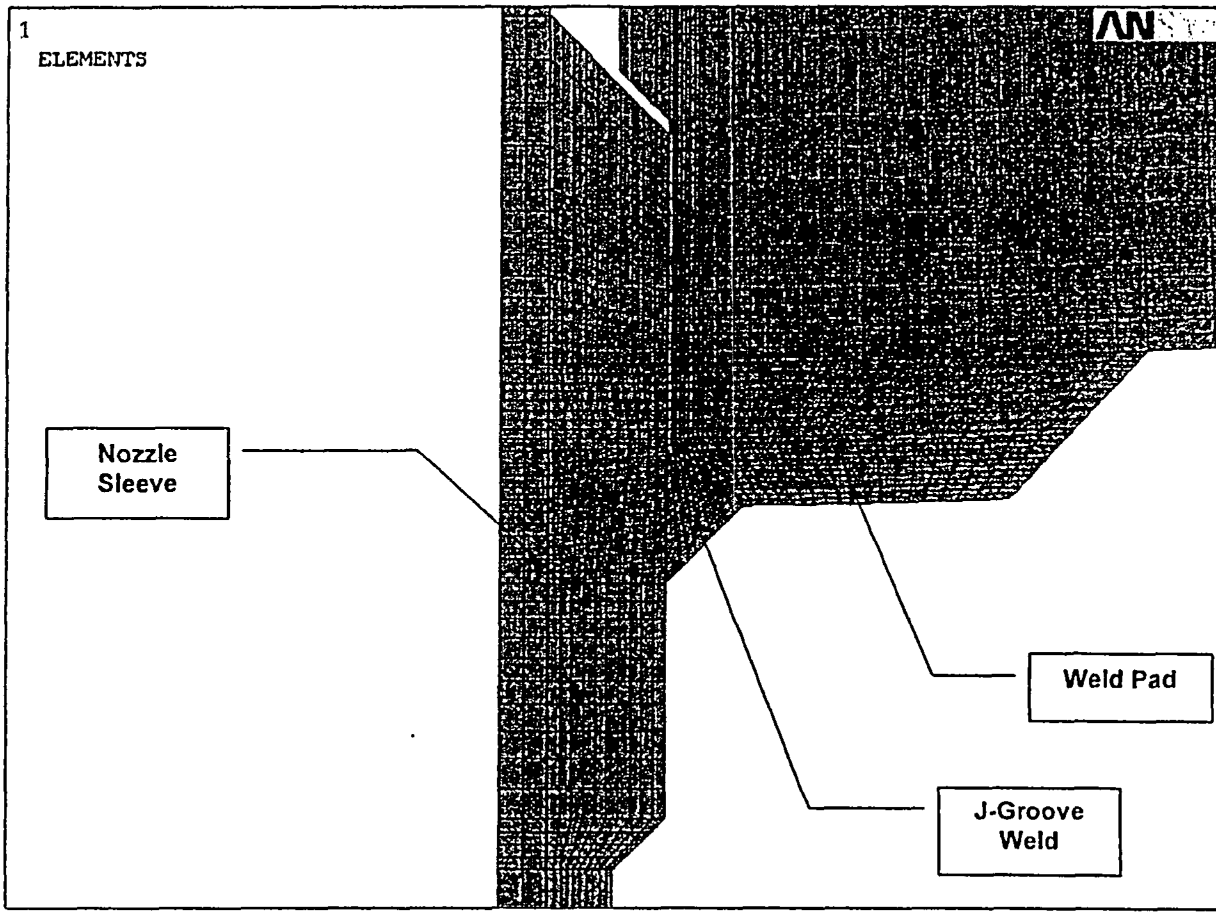

Figure D-5 – Finite Element Model – J-Groove Region

Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: [signature]	Date: 8 Mar 06	Project No.: AES 97103213-1Q
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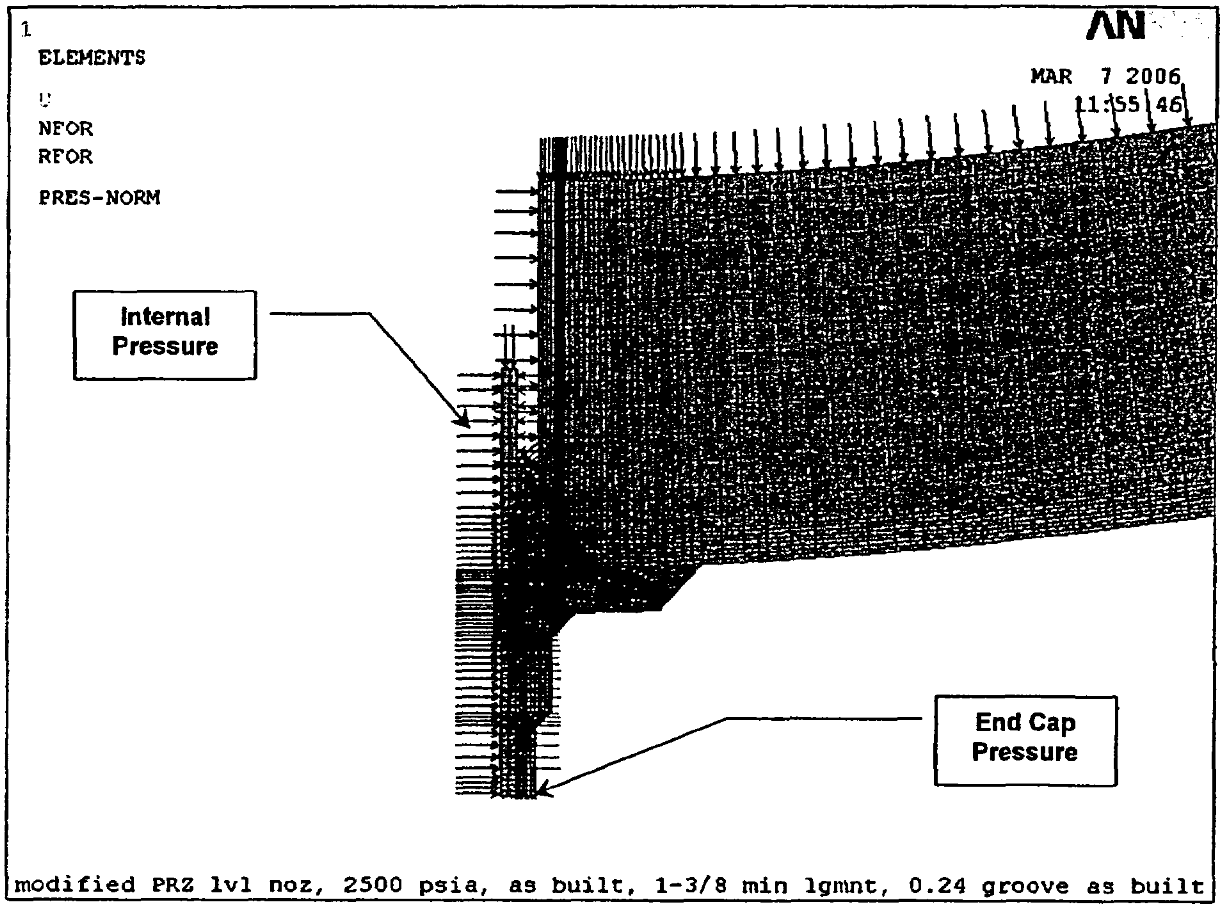

Figure D-6 – Pressure Boundary Conditions (P = 2500 psia)

Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 3/18/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: MTC	Date: 8 Mar 06	Project No.: AES 97103213-1Q
	Revision No.: 3	Document Control No.: I-2	Sheet No.: D-17 of D-34

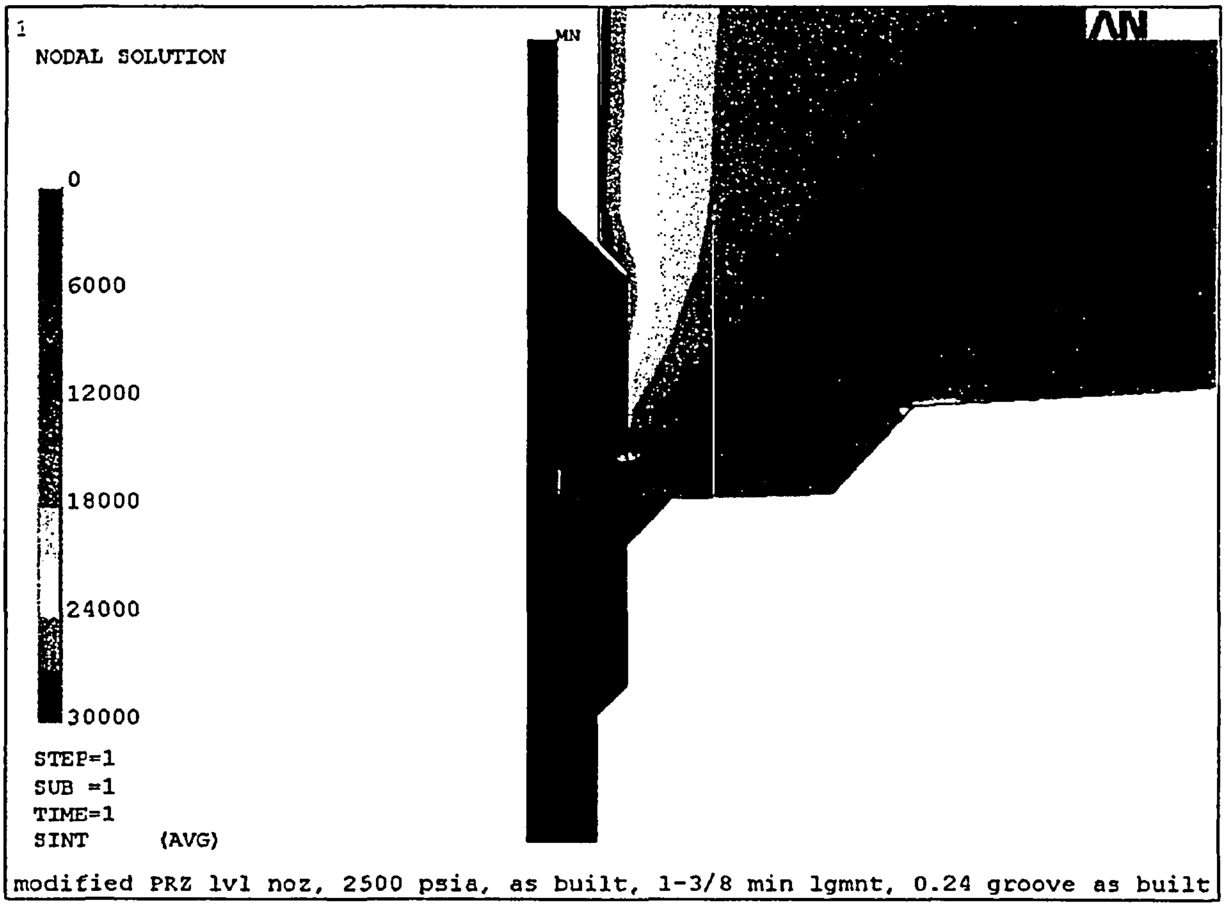

Figure D-7 – Stress Intensities for Design Pressure

Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 5/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: [signature]	Date: 9 May 06	Project No.: AES 97103213-1Q
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D.7 APPENDIX – ANSYS INPUT

The ANSYS model input listing for the pressure case for the modified nozzle sleeve is given below:

```
/batch
/prep7
/title,modified PRZ lvl noz, 2500 psia, as built, 1-3/8 min lgmnt, 0.24 groove as
built
!   file name: ln10
!
et,1,plane42,,,1
!
!    asme 1989 code
!    material 1 - vessel cladding & sleeve
!
mptemp,1,70,100,200,300,400,500
mptemp,7,600,700
!
!    material 1 - heater sleeve SB-167
!
a1=8.6
b1=0.154
a2=8.7
b2=0.154
a3=9.1
b3=0.156
a4=9.6
b4=0.160
a5=10.1
b5=0.165
a6=10.6
b6=0.1716
a7=11.1
b7=0.174
a8=11.6
b8=0.179
d1=a1/(1728.0*b1)
d2=a2/(1728.0*b2)
d3=a3/(1728.0*b3)
d4=a4/(1728.0*b4)
d5=a5/(1728.0*b5)
d6=a6/(1728.0*b6)
d7=a7/(1728.0*b7)
d8=a8/(1728.0*b8)
```

Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: MTC	Date: 8 Mar 06	Project No.: AES 97103213-1Q
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```
!
e1=31.0e6
e2=30.8e6
e3=30.2e6
e4=29.9e6
e5=29.5e6
e6=29.0e6
e7=28.7e6
e8=28.2e6
!
al1=0.
al2=6.90e-6
al3=7.20e-6
al4=7.40e-6
al5=7.57e-6
al6=7.70e-6
al7=7.82e-6
al8=7.94e-6
!
mpdata,c,1,1,1.0,1.0,1.0;1.0,1.0,1.0
mpdata,c,1,7,1.0,1.0
mpdata,kxx,1,1,a1/12.,a2/12.,a3/12.,a4/12.,a5/12.,a6/12.
mpdata,kxx,1,7,a7/12.0,a8/12.0
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mpdata,ex,1,1,e1,e2,e3,e4,e5,e6
mpdata,ex,1,7,e7,e8
mpdata,nuxy,1,1,0.3,0.3,0.3,0.3,0.3,0.3
mpdata,nuxy,1,7,0.3,0.3
mpdata,alpx,1,1,al1,al2,al3,al4,al5,al6
mpdata,alpx,1,7,al7,al8
!
!
!    material 2 - prz lower head SA-533 Grade B Class 1
!
mptemp,1,70,100,200,300,400,500
mptemp,7,600,700
a1=22.3
b1=0.429
a2=22.6
b2=0.427
a3=23.4
b3=0.420
a4=23.8
b4=0.408
a5=23.8
b5=0.389
a6=23.5
```

Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: [signature]	Date: 8 Mar 06	Project No.: AES 97103213-1Q
	Revision No.: 3	Document Control No.: I-2	Sheet No.: D-20 of D-34

```
b6=0.366
a7=23.0
b7=0.342
a8=22.3
b8=0.319
d1=a1/(1728.0*b1)
d2=a2/(1728.0*b2)
d3=a3/(1728.0*b3)
d4=a4/(1728.0*b4)
d5=a5/(1728.0*b5)
d6=a6/(1728.0*b6)
d7=a7/(1728.0*b7)
d8=a8/(1728.0*b8)
!
e1=29.5e6
e2=29.3e6
e3=28.8e6
e4=28.3e6
e5=27.7e6
e6=27.3e6
e7=26.7e6
e8=25.5e6
!
al1=0.
al2=7.06e-6
al3=7.25e-6
al4=7.43e-6
al5=7.58e-6
al6=7.70e-6
al7=7.83e-6
al8=7.94e-6
!
mpdata,c,2,1,1.0,1.0,1.0,1.0,1.0,1.0
mpdata,c,2,7,1.0,1.0
mpdata,kxx,2,1,a1/12.,a2/12.,a3/12.,a4/12.,a5/12.,a6/12.
mpdata,kxx,2,7,a7/12.0,a8/12.0
mpdata,dens,2,1,d1,d2,d3,d4,d5,d6
mpdata,dens,2,7,d7,d8
mpdata,ex,2,1,e1,e2,e3,e4,e5,e6
mpdata,ex,2,7,e7,e8
mpdata,nuxy,2,1,0.3,0.3,0.3,0.3,0.3,0.3
mpdata,nuxy,2,7,0.3,0.3
mpdata,alpx,2,1,al1,al2,al3,al4,al5,al6
mpdata,alpx,2,7,al7,al8
!
!
!    material 3 - type 316 stainless steel
!
```

Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: [signature]	Date: 8 Mar 06	Project No.: AES 97103213-1Q
	Revision No.: 3	Document Control No.: I-2	Sheet No.: D-21 of D-34

```
a1=7.7
b1=0.134
a2=7.9
b2=0.136
a3=8.4
b3=0.141
a4=9.0
b4=0.145
a5=9.5
b5=0.151
a6=10.0
b6=0.156
a7=10.5
b7=0.162
a8=11.0
b8=0.167
d1=a1/(1728.0*b1)
d2=a2/(1728.0*b2)
d3=a3/(1728.0*b3)
d4=a4/(1728.0*b4)
d5=a5/(1728.0*b5)
d6=a6/(1728.0*b6)
d7=a7/(1728.0*b7)
d8=a8/(1728.0*b8)
!
e1=28.3e6
e2=28.1e6
e3=27.6e6
e4=27.0e6
e5=26.5e6
e6=25.8e6
e7=25.3e6
e8=24.8e6
!
al1=0.
al2=8.54e-6
al3=8.76e-6
al4=8.97e-6
al5=9.21e-6
al6=9.42e-6
al7=9.60e-6
al8=9.76e-6
!
mpdata,c,3,1,1.0,1.0,1.0,1.0,1.0,1.0
mpdata,c,3,7,1.0,1.0
mpdata,kxx,3,1,a1/12.,a2/12.,a3/12.,a4/12.,a5/12.,a6/12.
mpdata,kxx,3,7,a7/12.0,a8/12.0
mpdata,dens,3,1,d1,d2,d3,d4,d5,d6
```

Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: [signature]	Date: 8 Mar 06	Project No.: AES 97103213-1Q
	Revision No.: 3	Document Control No.: I-2	Sheet No.: D-22 of D-34

```
mpdata,dens,3,7,d7,d8
mpdata,ex,3,1,e1,e2,e3,e4,e5,e6
mpdata,ex,3,7,e7,e8
mpdata,nuxy,3,1,0.3,0.3,0.3,0.3,0.3,0.3
mpdata,nuxy,3,7,0.3,0.3
mpdata,alpx,3,1,al1,al2,al3,al4,al5,al6
mpdata,alpx,3,7,al7,al8
!
!
pi=4.0*atan(1.0)
eps=0.01
!
pr1=2500.0                    ! design pressure, psia
!
!-------------------- coordinate systems -----------------------
k,100,,
k,101,,-1.0,,
k,102,1.0,-1.0,,
cskp,11,1,100,101,102
csys,0
!
!-------------------- lower head dimensions --    ----------------
rin=48.0                      ! radius to cladding
tcld=7.0/16.0                 ! cladding thickness
rcld=rin+tcld                 ! radius to base metal
tbas=3.0+7.0/8.0              ! thickness of the base metal
rout=rcld+tbas                ! outside radius
rl1=7.5                       ! model boundary
!
!
!-------------------- nozzle dimensions ------------------
rnsi=0.25/2.0                ! inside radius
rnso=0.584/2.0               ! outside radius
rpip=1.05/2.0                ! 0.75 pipe outside radius
hnz1=1.0                     ! nozzle length outside weld area into base metal
hnz2=1.0                     ! nozzle length outside weld area below pad
!
! ----------------- sleeve and hole dimensions --------------------
pt2=0.24                     ! groove depth
rh1=1.072/2.0                ! hole original radius
rh2=1.421/2.0                ! enlarged hole
hs1=1.0+5.0/16.0-pt2         ! height of sleeve inside base metal
clr1=5.0/1000.0              ! clearance between nozzle and sleeve
clr2=5.0/1000.0              ! clearance between nozzle and hole
rsli=rnso+clr1               ! sleeve inside radius
rslo=rh2-clr2                ! sleeve outside radius
tslv=rslo-rsli               ! sleeve wall thickness
hs2=1.6                      ! sleeve height below base metal
```

Calculation No.: AES-C-3213-1	Made by: Ale	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: MTC	Date: 8 Mar 06	Project No.: AES 97103213-1Q
	Revision No.: 3	Document Control No.: I-2	Sheet No.: D-23 of D-34

```
hwl=2.55                    ! butt weld below base metal
!
!
pr2=pr1*rnsi*rnsi/(rpip*rpip-rnsi*rnsi)  ! cap pressure
!
!
!--------------------- pad size --------------------------------
gran=30.0                   ! groove side angle
delt=0.0725                 ! pad thickness adjustment
pt1=3.0/16.0                ! pad between head and weld
pthk=pt2+pt1+delt           ! actual thickness
plig=1.0+3.0/8.0            ! ligament length
rpdi=rout+pt1+delt          ! pad radius to groove
rpdo=rout+pthk              ! pad outside radius
!
!
!--------------------- weld size --------------------------------
thrt=0.19                   ! minimum throat
gr1=1.0/8.0                 ! groove width
wl3=0.269                   ! fillet weld leg
!
!
ang1=asin(rpip/rpdo)+plig/rpdo    ! pad edge
ang2=asin(rslo/rpdi)+gr1/rpdi     ! j groove corner
ang3=asin(rslo/rpdo)+wl3/rpdo     !
ang4=ang1+pthk/rout               !
!
!--------------------- keypoints --------------------------------
!
!
y42=sqrt(rpdi*rpdi-rslo*rslo)   ! j groove weld
k,42,rslo,-y42,
k,58,rnsi,-y42,
k,59,rnso,-y42,
k,41,rsli,-y42,
k,29,rh2,-y42,
!
y36=y42-hs1
k,36,rslo,-y36                    ! K 36
y35=y36-tslv
k,35,rsli,-y35,
k,52,rnsi,-y35,
k,53,rnso,-y35,
k,50,rnsi,-y35+hnzl,
k,51,rnso,-y35+hnzl,
!
y14=y36-sin(pi/4.0)/16.0
r14=sqrt(y14*y14+rh2*rh2)
```

Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: [signature]	Date: 8 Mar 06	Project No.: AES 97103213-1Q
	Revision No.: 3	Document Control No.: I-2	Sheet No.: D-24 of D-34

```
k,14,rh2,-y14,
y13=y14-(rh2-rh1)
k,13,rh1,-y13,
!
x30=rpdi*sin(ang2)
y30=rpdi*cos(ang2)
k,30,x30,-y30,                          ! K 30
y3=sqrt(rin*rin-x30*x30)
y9=sqrt(rcld*rcld-x30*x30)
y25=sqrt(rout*rout-x30*x30)
k,3,x30,-y3,
k,9,x30,-y9,
k,25,x30,-y25,
!
y32=sqrt(rpdo*rpdo-rslo*rslo)+wl3
k,32,rslo,-y32,                         ! K 32
k,60,rnsi,-y32,
k,61,rnso,-y32,
k,43,rsli,-y32,
!
y24=sqrt(rout*rout-rh2*rh2)
y45=y24+hs2                             ! nozzle lower end
y47=y45+(rslo-rpip)
!
y72=y24+hw1
y49=y72-0.25
k,69,rnsi,-y72,
k,70,rnso,-y72,
k,71,rsli,-y72,
k,72,rpip,-y72,
!
k,62,rnsi,-y45,
k,63,rnso,-y45,
k,44,rsli,-y45,
k,45,rslo,-y45
!
k,64,rnsi,-y47,
k,65,rnso,-y47,
k,46,rsli,-y47,
k,47,rpip,-y47,
!
k,66,rnsi,-y49,
k,67,rnso,-y49,
k,48,rsli,-y49,
k,49,rpip,-y49,
!
x33=rpdo*sin(ang3)
y33=rpdo*cos(ang3)
```

Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: [signature]	Date: 8 Mar 06	Project No.: AES 97103213-1Q
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```
k,33,x33,-y33,                          ! K 33
!
rt1=0.2
x68=rslo+rt1*(x33-rslo)
y68=y32+rt1*(y33-y32)
k,68,x68,-y68                           ! K 68
!
x34=rpdo*sin(ang1)
y34=rpdo*cos(ang1)
k,34,x34,-y34,                          ! K 34
!
x26=rout*sin(ang4)
y26=rout*cos(ang4)
k,26,x26,-y26,
!
x31=x26+(pt1+delt)*(x34-x26)/pthk
y31=y26+(pt1+delt)*(y34-y26)/pthk
k,31,x31,-y31,
!
y2=sqrt(rin*rin-rh2*rh2)
y8=sqrt(rcld*rcld-rh2*rh2)
k,24,rh2,-y24                           ! K 24
k,56,rnsi,-y24,
k,57,rnso,-y24,
k,39,rsli,-y24,
k,40,rslo,-y24,
k,2,rh2,-y2,
k,8,rh2,-y8,
!
y37=0.5*(y24+y35)
y38=0.5*(y24+y36)
k,37,rsli,-y37,
k,38,rslo,-y38,
k,54,rnsi,-y37,
k,55,rnso,-y37,
!
r19=sqrt(rh2*rh2+y38*y38)
k,19,rh2,-y38,
!
y1=sqrt(rin*rin-rh1*rh1)
y7=sqrt(rcld*rcld-rh1*rh1)
k,1,rh1,-y1,
k,7,rh1,-y7,
!
!
y15=sqrt(r14*r14-x30*x30)
k,15,x30,-y15,
y20=sqrt(r19*r19-x30*x30)
```

Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: [signature]	Date: 8 May 06	Project No.: AES 97103213-1Q
	Revision No.: 3	Document Control No.: I-2	Sheet No.: D-26 of D-34

```
k,20,x30,-y20,
!
si4=sin(ang4)
co4=cos(ang4)
x4=rin*si4
y4=rin*co4
x10=rcld*si4
y10=rcld*co4
x16=r14*si4
y16=r14*co4
x21=r19*si4
y21=r19*co4
!
k,4,x4,-y4,
k,10,x10,-y10,
k,16,x16,-y16,
k,21,x21,-y21,
!
ang5=10.0*pi/180.0
si5=sin(ang5)
co5=cos(ang5)
x5=rin*si5
y5=rin*co5
x11=rcld*si5
y11=rcld*co5
x17=r14*si5
y17=r14*co5
x22=r19*si5
y22=r19*co5
x27=rout*si5
y27=rout*co5
!
k,5,x5,-y5
k,11,x11,-y11
k,17,x17,-y17
k,22,x22,-y22
k,27,x27,-y27
!
k,6,rin,,
k,12,rcld,,
k,18,r14,,
k,23,r19,,
k,28,rout,,
!
!
! ---------------- lines ----------------------------
1,50,51              ! L 1          nozzle
*rep,9,2,2           ! L 1 - 9
```

Calculation No.: AES-C-3213-1	Made by: RLC	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: MTC	Date: 8 Mar 06	Project No.: AES 97103213-1Q
	Revision No.: 3	Document Control No.: I-2	Sheet No.: D-27 of D-34

```
1,50,52               ! L 10
*rep,8,2,2            ! L 10 - 17
1,51,53               ! L 18
*rep,8,2,2            ! L 18 - 25
!
1,35,36               ! L 26          sleeve
*rep,4,2,2            ! L 26 - 29
1,43,32               ! L 30
1,44,45               ! L 31
*rep,3,2,2            ! L 31 - 33
!
1,35,37               ! L 34         sleeve sides
*rep,4,2,2            ! L 34 - 37
1,43,44               ! L 38
1,44,46               ! L 39
1,46,48               ! L 40
1,36,38               ! L 41
*rep,3,2,2            ! L 41 - 43
1,42,32               ! L 44
1,32,45               ! L 45
1,45,47               ! L 46
1,47,49               ! L 47
!
1,42,29               ! L 48
1,32,68               ! L 49
!
csys,11
1,1,2                 ! L 50
*rep,3,6,6            ! L 50 - 52
csys,0
1,1,7                 ! L 53
1,7,13                ! L 54
1,2,8                 ! L 55
1,8,14                ! L 56
1,14,19               ! L 57
*rep,3,5,5            ! L 57 - 59
1,29,68               ! L 60
!
csys,11
1,2,3                 ! L 61
*rep,3,6,6            ! L 61 - 63
1,19,20               ! L 64
*rep,3,5,5            ! L 64 - 66
csys,0
1,68,33               ! L 67
!
1,3,9                 ! L 68
1,9,15                ! L 69
```

Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 3/9/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: [signature]	Date: 8 Mar 06	Project No.: AES 97103213-1Q
	Revision No.: 3	Document Control No.: I-2	Sheet No.: D-28 of D-34

```
1,15,20             ! L 70
*rep,3,5,5          ! L 70 - 72
1,30,33             ! L 73
!
csys,11
1,3,4               ! L 74
*rep,3,6,6          ! L 74 - 76
1,20,21             ! L 77
*rep,3,5,5          ! L 77 - 79
1,33,34             ! L 80
!
csys,0
1,4,10              ! L 81
1,10,16             ! L 82
1,16,21             ! L 83
1,21,26             ! L 84
!
csys,11
1,4,5               ! L 85
*rep,3,6,6          ! L 85 - 87
1,21,22             ! L 88
1,26,27             ! L 89
!
csys,0
1,5,11              ! L 90
1,11,17             ! L 91
1,17,22             ! L 92
1,22,27             ! L 93
!
csys,11
1,5,6               ! L 94
*rep,3,6,6          ! L 94 - 96
1,22,23             ! L 97
1,27,28             ! L 98
!
csys,0
1,6,12              ! L 99
1,12,18             ! L 100
1,18,23             ! L 101
1,23,28             ! L 102
!
1,26,31             ! L 103
1,31,34             ! L 104
!
1,66,69             ! L 105
1,67,70             ! L 106
1,48,71             ! L 107
1,49,72             ! L 108
```

Calculation No.: AES-C-3213-1	Made by: RLC	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: MTC	Date: 9 Mar 06	Project No.: AES 97103213-1Q
	Revision No.: 3	Document Control No.: I-2	Sheet No.: D-29 of D-34

```
1,67,48             ! L 109
1,69,70             ! L 110
*rep,3,1,1          ! L 110 - 112
!
!
! --------------------- line division ---------------
lsel,,,,1,9       ! nozzle
lsel,a,,,110
lesi,all,,,2
!
nn0=10
lsel,,,,26,28
lsel,a,,,30,33
lsel,a,,,112
lesi,all,,,nn0
lsel,,,,29
lesi,all,,,nn0,0.5
!
lsel,,,,50,52
lesi,all,,,4
!
lsel,,,,61,67     ! sleeve and weld
lesi,all,,,8
!
nn1=20
lsel,,,,74,78
lsel,a,,,80
lesi,all,,,nn1,2.0
lsel,,,,79
lesi,all,,,nn1,3.0
!
lsel,,,,85,89
lesi,all,,,20,2.0
!
lsel,,,,94,98
lesi,all,,,80,2.5
!
lsel,,,,105,108
lesi,all,,,4
!
lsel,,,,17,25,8
lsel,a,,,40,47,7
lesi,all,,,4
!
lsel,,,,16,24,8
lsel,a,,,33,46,13
lesi,all,,,4
!
```

Calculation No.: AES-C-3213-1	Made by: RLL	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: MTC	Date: 8 May 06	Project No.: AES 97103213-1Q
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```
lsel,,,,15,23,8
lsel,a,,,38,45,7
lesi,all,,,10,2.0
!
nn2=12
lsel,,,,14,22,8
lsel,a,,,37
lsel,a,,,73
lsel,a,,,104
lesi,all,,,nn2
lsel,,,,44,60,16
lesi,all,,,nn2,2.0
!
lsel,,,,13,21,8
lsel,a,,,36,43,7
lsel,a,,,59,72,13
lsel,a,,,103
lesi,all,,,8
!
lsel,,,,53,55,2
lsel,a,,,68,81,13
lsel,a,,,90,99,9
lesi,all,,,2
!
lsel,,,,54,56,2
lsel,a,,,69,82,13
lsel,a,,,91,100,9
lesi,all,,,10
!
lsel,,,,11,19,8
lsel,a,,,34,41,7
lsel,a,,,57,70,13
lsel,a,,,83,92,9
lsel,a,,,101
lesi,all,,,4
!
lsel,,,,12,20,8
lsel,a,,,35,42,7
lsel,a,,,58,71,13
lsel,a,,,84,93,9
lsel,a,,,102
lesi,all,,,8
!
lsel,,,,10,18,8
lesi,all,,,6
!
alls
!
```

Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: [signature]	Date: 8 Mar 06	Project No.: AES 97103213-1Q
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```
! -------------------- areas -----------------------
a,50,51,53,52       ! A 1  nozzle
*rep,8,2,2,2,2      ! A 1 - 9
a,66,67,70,69       ! A 10
a,67,48,71,70       ! A 11
a,48,49,72,71       ! A 12
!
a,35,36,38,37       ! A 13 sleeve
*rep,3,2,2,2,2      ! A 13 - 15
a,41,42,32,43       ! A 16
a,43,32,45,44       ! A 17
a,44,45,47,46       ! A 18
a,46,47,49,48       ! A 19
!
a,42,29,68,32       ! A 20 vessl head
a,24,25,30,29       ! A 21
a,29,30,33,68       ! A 22
a,25,26,31,30       ! A 23
a,30,31,34,33       ! A 24
!
a,1,2,8,7           ! A 25
*rep,5,1,1,1,1      ! A 25 - 29
a,7,8,14,13         ! A 30
*rep,5,1,1,1,1      ! A 30 - 34
a,14,15,20,19       ! A 35
*rep,4,1,1,1,1      ! A 35 - 38
a,19,20,25,24       ! A 39
*rep,4,1,1,1,1      ! A 39 - 42
!
! --------------------  meshing  ------------------
esiz,1.0
mshk,1
type,1
!
asel,,,,1,11
mat,3
ames,all
!
asel,,,,12,23
mat,1
ames,all
!
asel,,,,29,41
mat,2
ames,all
!
asel,,,,24,28
mat,1
```

Calculation No.: AES-C-3213-1	Made by: RLL	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: MTC	Date: 8 Mar 06	Project No.: AES 97103213-1Q
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```
ames,all
!
alls
!
!
! ------------------ internal pressure ---------------
lsel,,,,1          ! nozzle
lsel,a,,,10,17
lsel,a,,,105
lsel,a,,,18,25
lsel,a,,,109
!
lsel,a,,,34,40     ! sleeve
lsel,a,,,26
lsel,a,,,41,43
lsel,a,,,48
lsel,a,,,50
lsel,a,,,52,54
lsel,a,,,57,59
lsel,a,,,61,74,13
lsel,a,,,85,94,9
nsll,,1
sf,all,pres,prl
!
alls
!
lsel,,,,110,112
nsll,,1
sf,all,pres,-pr2
!
alls
!
! ------------------- displacement b.c. --------------
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nsll,,1
d,all,uy,0.
!
alls
!
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nlis,382,390,8
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nlis,390,897,507
nlis,493,895,402
nlis,712,716,4
nlis,184,189,5
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Calculation No.: AES-C-3213-1	Made by: RLL	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: MTC	Date: 8 Mar 06	Project No.: AES 97103213-1Q
	Revision No.: 3	Document Control No.: I-2	Sheet No.: D-33 of D-34

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*abbr,conv0,/psf,conv,0
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*abbr,v2,/vie,,-.5,.3,-1
*abbr,vx,/vie,,1,,
*abbr,vy,/vie,,,1,
*abbr,vz,/vie,,,,1
!
wsort,all
!
save
! /sho,x11
! /men,on
fini
/solu
solve
fini
/post1
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ppath,2,470
prsect,,
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Calculation No.: AES-C-3213-1	Made by: [signature]	Date: 3/8/06	Client: SCE
Title: Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation — SONGS, Units 2 and 3	Checked by: MTC	Date: 8 Mar 06	Project No.: AES 97103213-1Q
	Revision No.: 3	Document Control No.: I-2	Sheet No.: D-34 of D-34

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prsect,,
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/exit
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E&TS DEPARTMENT

CALCULATION SHEET

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	CCN CONVERSION: CCN NO. CCN - 2

Project or ECP SONGS 2 & 3 Calc No. M-DSC-354

Subject Pressurizer Bottom Head Instrumentation Level Nozzle Evaluation Sheet E-1 of E-5

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
	Jun Gaor	4/17/06	N. Elakily	4/24/06						

APPENDIX E

Unit 3 Bottom Head Half-Nozzle Design Reconciliation

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
	Jun Gaor	4/17/06	N. Elakily	4/24/06						

E.1 PURPOSE

The purpose of this appendix is to reconcile the design of the modified half-nozzle in Unit 3 with the half-nozzle design in the base calculation.

The modified half-nozzle is shown in Figure E-1. The half-nozzle design covered in the base calculation (including Apendix D), is shown in Figure E-2. The differences between the modified half-nozzle and the original half-nozzle design are provided below.

1. The original design is a one-piece design, with the pressurizer level insert and half-nozzle combined as one piece (ref. Dwg. 41011 Sh. 5 Rev. 0). This is shown in Fig. E-2 (a).
   In Fig, E-2 (b), a two-piece design was implemented to accommodate a larger hole penetration as a result of machining error. The original pressurizer level insert and a new half-nozzle with a larger OD and thicker wall were used (ref. Dwg. 41011 Sh. 6 Rev. 0).

2. The modified half-nozzle covered in this appendix as shown in Figure E-1, is similar to the two-piece half nozzle in Fig. E-2 (b) but with a standard size nozzle.

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
	Jun Gaor	4/17/06	N. Elakily	4/24/06						

E.2 SUMMARY

The modified half-nozzle design was reconciled to the base calculation by evaluating the effect of the geometry to the critical stresses.

The critical stresses in the half-nozzle design are the stresses in the J-Groove weld as based on the results in the base calculation.

The geometry of the modified nozzle is compared with that of the original nozzle design as shown in Table E-1 below.

Table E-1 Comparison of Nozzle/Pad Dimensions

Nozzle Design	Nozzle OD	Nom. Wall Thickness	Pad Thickness	J-Groove Depth	Fillet Weld throat size
Original Fig. 2(a)	1.050" nom. (2LT-0110-1)	0.218	7/16" min (design) ½" +1/8/-0 (actual)	0.188 min. (design) 0.24" min. (actual)	0.13" min. (design) 0.19" min. (actual)
Modified Fig. E-1	1.131"nom (3LT-0110-1) 1.083" nom (3LT-0110-2)	0.268 0.244	½" +1/8/-0 ½" +1/8/-0	0.24" min. 0.24" min.	0.19" min. 0.19" min.

The above comparison shows that the modified design Fig. E-1, is stronger than the original design Fig. 2 (a), based on the pad, J-groove/fillet weld sizes and nozzle R/t ratio.

The above evaluation demonstrates that the modified design satisfies the ASME Code stress limits and no further detailed analysis need be performed. The differences in the design are not significant and will not invalidate the results of the original analysis.

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
	Jun Gaor	4/17/06	N. Elakily	4/24/06						

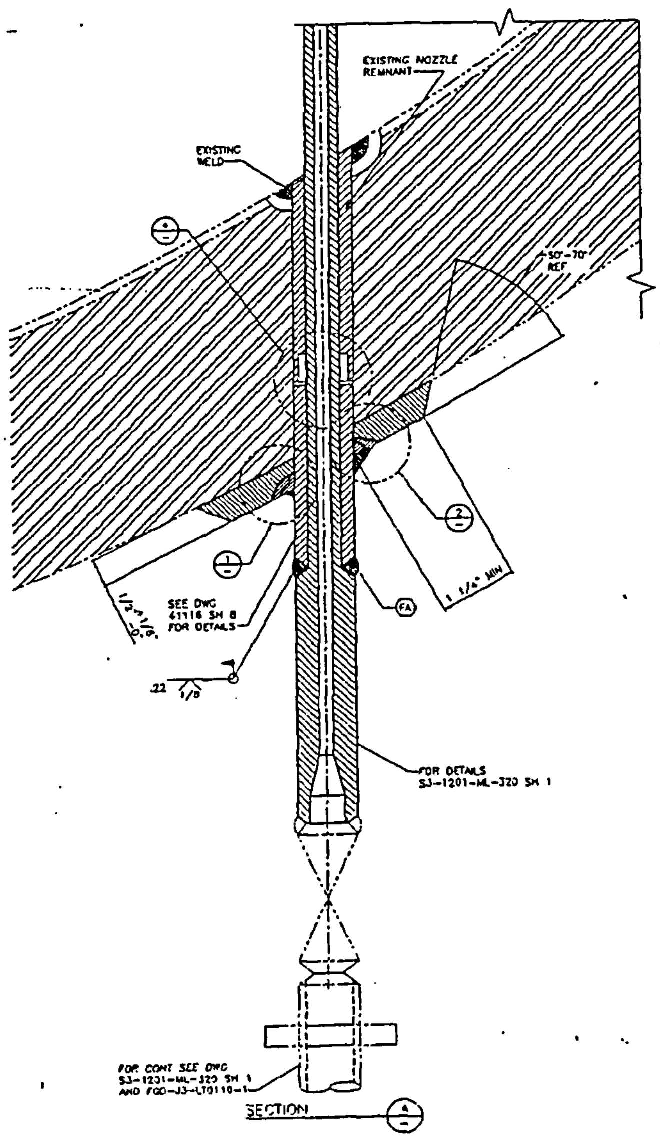
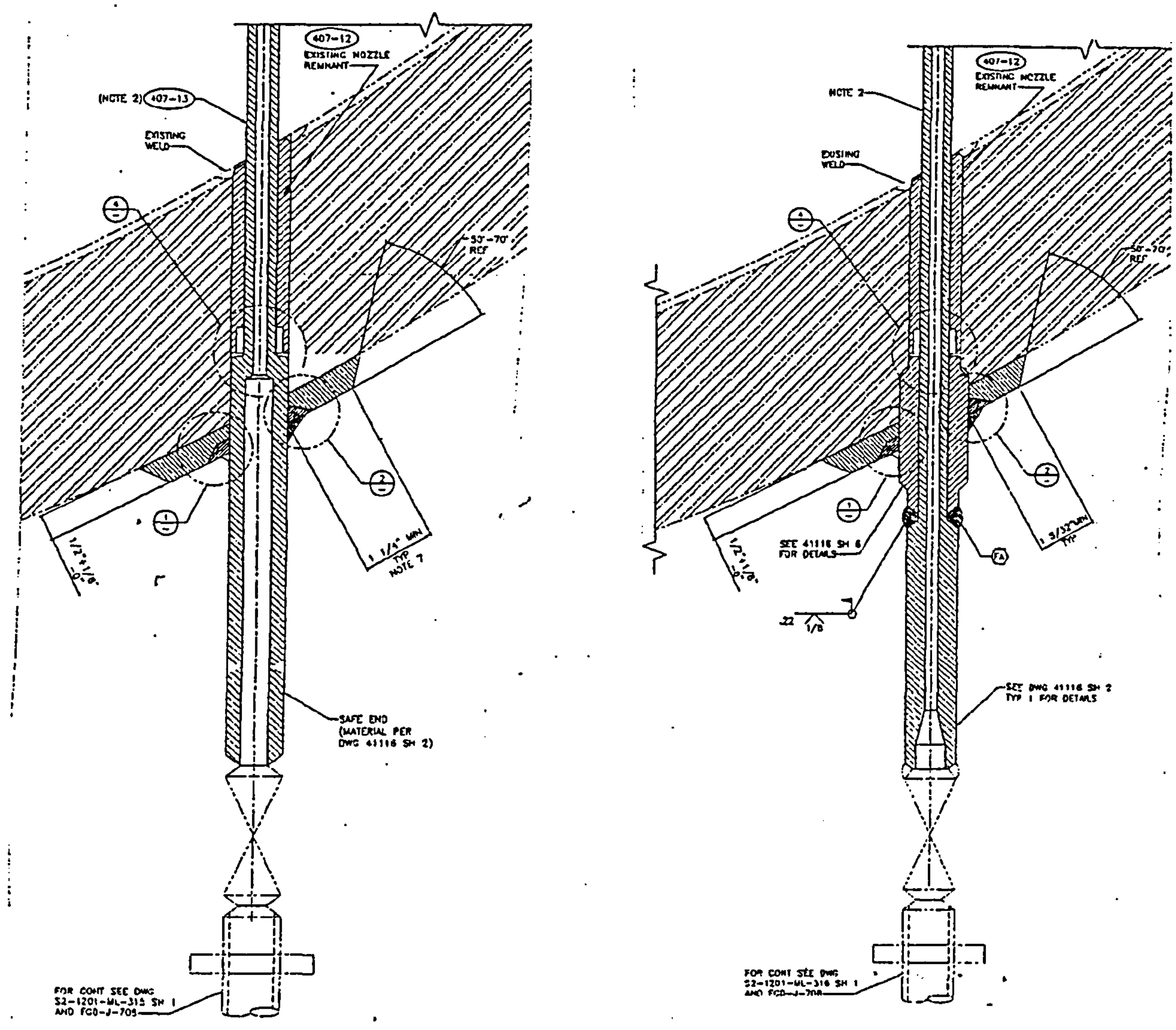


Figure E-1 Modified Half-Nozzle

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE	REV INDICATOR
	Jun Gaor	4/17/06	N. Elaklly	4/24/06						



(a) One-piece design (b) Two-piece design

Figure E-2