# Attachment 1

Southern California Edison Calculation M-DSC-356,
"Evaluation of Modified Pressurizer Heater Sleeves"

| Southern California Edison Company<br>**INTERIM CALCULATION CHANGE NOTICE (ICCN)/ CALCULATION CHANGE NOTICE (CCN) COVER PAGE**<br>SUMMARY CHANGE<br>☒ NO ☐ YES | CALC NO.<br>M-DSC-356 | ICCN NO./ PRELIM. CCN NO.<br>N-3 | PAGE<br>1 | TOTAL NO. OF PAGES<br>15 |
|---|---|---|---|---|
| | BASE CALC. REV.<br>1 | UNIT<br>2 & 3 | CCN CONVERSION: CCN NO. CCN-<br>4 | CALC. REV.<br>1 |
| | CALCULATION SUBJECT: Evaluation of Modified Pressurizer Heater Sleeves | | | |
| CALCULATION CROSS-INDEX<br>☒ New/Updated Index Included<br>☐ Existing Index is Complete | ENGINEERING SYSTEM NUMBER/PRIMARY STATION SYSTEM DESIGNATOR<br>1201 / BBB | | | Q-CLASS<br>1 |
| Site Programs/Procedure Impact?<br>☒ NO ☐ YES, AR No. _____ | CONTROLLED PROGRAM OR DATABASE ACCORDING TO SO123-XXIV-5.1<br>☐ PROGRAM ☐ DATABASE | PROGRAM/DATABASE NAME(S)<br>☐ ALSO, LISTED BELOW<br>_____ | | VERSION/RELEASE NO.(S)<br>_____ |
| 10CFR50.59/72.48 Review:<br>AR No. 031100614-39 | | | | |

**1.** BRIEF DESCRIPTION OF ICCN/CCN:

The purpose of this CCN is evaluate the acceptability of the fillet weld connection between the Pressurizer heater sleeve and heater sheath using a maximum diametral gap of 0.060". The maximum gap tolerance of 0.060" is necessary to resolve the insertion difficulty encountered subsequent to the implementation of a half-nozzle repair of the Pressurizer sleeve. The diametral gap tolerance used in the original construction was 0.045" maximum.

Update Cross-Index
Update Table of Contents
Add Attachment III to the calculation

This evaluation is applicable to both Units 2 & 3.


INITIATING DOCUMENT (ECP, OTHER) AR 031100614-3 Rev. --

**2.** OTHER AFFECTED DOCUMENTS (CHECK AS APPLICABLE FOR CCN ONLY):

☐ YES ☒ NO OTHER AFFECTED DOCUMENTS EXIST AND ARE IDENTIFIED ON ATTACHED FORM 26-503.

**3.** APPROVED BY:

JUN GAOR / J. Gaor 5/24/05
ORIGINATOR (Print name/sign/date)
Approval requires PQS T3EN64 Qualification Verified: J-G. Initial

DISCIPLINE/ESC: DEO
FLS (Signature/date) 6/2/05
Approval requires PQS T3EN64 Qualification Verified: DLY Initial

Nabil M. El-Akily / N. El-Akily / 05/24/05
IRE (Print name/sign/date)
Approval requires PQS T3EN64 Qualification Verified: nme Initial

**4.** CONVERSION TO CCN DATE 6-9-05
SCE CDM-SONGS

SCE 26-122-1 REV. 8 4/05 [REFERENCE: SO123-XXIV-7.15]

Site File Copy

# CALCULATION CROSS-INDEX

ICCN NO./ N-3
PRELIM. CCN NO.



CCN CONVERSION:
CCN NO. CCN-- 4

Calculation No. M-DSC-356 Sheet ____ of ____

| 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 | |
| RLY 5/28/08 | C-E Report No. CENC-1420, Addendum 2 to the Analyticla Report for SONGS No. 2 Pressurizer | 0 | | | | |
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APTECH ENGINEERING SERVICES, INC.

CCN CONVERSION: CCN NO. 1

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|---|---|---|---|
| Calculation No.: AES-C-5212-1 SCE No. M-DSC-356, Rev. 1<br>Title: Evaluation of Modified Pressurizer Heater Sleeves - SONGS Units 2 and 3 | Made by: KCC | Date: 10/04/04 | Client: Southern California Edison |
| | Checked by: MTC | Date: 4 OCT 04 | Project No.: AES 03105212-1Q |
| | Revision No.: 1 | Document Control No.: 1-1 | Sheet No.: 6 of 1083 |

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| | J. Gaor | 05/23/05 | N. Elakily | 05/24/05 | | | | | | |
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**ATTACHMENT III - Evaluation of Fillet Weld at the Pressurizer Heater Sleeve/Heater Sheath Connection**

## 1. PURPOSE

The purpose of this calculation is to provide the basis for the acceptability of the fillet weld connection between the Pressurizer heater sleeve and heater sheath with a maximum diametral gap of 0.060". The maximum gap tolerance is necessary to resolve the heater insertion difficulty encountered subsequent to the implementation of a half-nozzle repair of the Pressurizer sleeve. Allowing a maximum diametral gap of 0.060" would decrease rework time and reduce total dose to the personnel due to the rework.
The maximum diametral gap of 0.045" between the heater sleeve and heater sheath was provided in the original ASME Code of Construction [6.1], which included ASME Code Case 1361-2 [6.2].

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## 2.0 SUMMARY OF RESULTS

The results of the evaluations, show that the use of larger diametral gap of 0.060" maximum in the fillet weld connection between the Pressurizer heater sleeve and heater sheath result in stresses and usage factor within the ASME Code Allowable limits. The results of the evaluation are presented in Section 8.0 and a summary of the stress results in the fillet weld connection is provided below.

The most critical Primary Stress Intensity calculated at the fillet weld connection:

$Pm = 7.442 \text{ ksi} < 9.78 \text{ ksi (0.6Sm)}$
$P_L + Pb = 18.722 < 24.45 \text{ ksi (1.5 Sm)}$

The maximum range of Primary plus Secondary Stress Intensity calculated at the fillet weld connection:

$P_L + Pb + Q = 42.38 \text{ ksi} < 48.9 \text{ ksi (3.0Sm)}$

The controlling fatigue stresses and Cumulative Usage Factor at the fillet weld connection for a design life of 40-year life:

$U = 0.40 < 1.0$

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## 3.0 ASSUMPTIONS

None required.

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## 4.0 DESIGN INPUT

A. Original Pressurizer Sleeve:
Outside Diameter, OD = 1.66" + 0.0 /- 0.002 [6.3]
Inside Diameter, ID = 1.273" + 0.010 / -0.0 [6.3]
Sleeve Material: SB 167 Alloy 600 [6.3]
Heater Sheath Material: Type 316 Stainless Steel [6.4]
Heater Sheath OD = 1.245" +/- 0.007" [6.4]

Table 4.1 – Properties of Alloy 600 [6.1]

| Property | Temperature, $^{o}$F | | | | | | |
|---|---|---|---|---|---|---|---|
| | 100 | 200 | 300 | 400 | 500 | 600 | 700 |
| E x $10^{6}$ psi | 31.5 | 30.9 | 30.5 | 30.0 | 29.6 | 29.2 | 28.6 |
| $\alpha$, $10^{-6}$ in/in/$^{o}$F | 7.20 | 7.40 | 7.56 | 7.70 | 7.80 | 7.90 | 8.00 |
| Sm, ksi | 23.3 | 23.3 | 23.3 | 23.3 | 23.3 | 23.3 | 23.3 |

E = modulus of elasticity, $\alpha$ = mean coefficient of thermal expansion, Sm = Design Stress Intensity Value

B. Replacement Pressurizer Sleeve:
OD = 1.66" nom. ( to be fitted to pressurizer hole penetration ) [6.5]
ID = 1.298" + 0.0 / -0.005 [6.5]
Sleeve Material: SB 166 Alloy 690 [6.5]
Heater Sheath OD = 1.245" +/- 0.007" [6.4]

Table 4.2 – Properties of Alloy 690 [6.6]

| Property | Temperature, $^{o}$F | | | | | | |
|---|---|---|---|---|---|---|---|
| | 100 | 200 | 300 | 400 | 500 | 600 | 700 |
| E x $10^{6}$ psi | 30.12 | 29.5 | 29.1 | 28.8 | 28.3 | 28.1 | 27.6 |
| $\alpha$, $10^{-6}$ in/in/$^{o}$F | 7.8 | 7.8 | 7.9 | 8.0 | 8.1 | 8.2 | 8.3 |
| Sm, ksi | 23.3 | 23.3 | 23.3 | 23.3 | 23.3 | 23.3 | 23.3 |

Note: The original ASME Code did not list Alloy 690 but was later specified in ASME Code Case 474. For Alloy 690, the values above are from the ASME Code 1998 Edition, 2000 Addenda [6.6], which were previously specified in Code Case 474-2 (code case was annulled and Alloy 690 was included in the ASME Code 1999 Addenda).

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C. Heater Sheath Material: Type 316 Stainless Steel [6.4] . Note: Sheath material remains unchanged.

Table 4.1 – Properties of Type 316 Stainless Steel [6.1]

| Property | Temperature, $^{o}F$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | 100 | 200 | 300 | 400 | 500 | 600 | 700 |
| Ex $10^{6}$ psi | 28.2 | 27.7 | 27.1 | 26.6 | 26.1 | 25.4 | 24.8 |
| $\alpha$, $10^{-6}$ in/in/$^{o}F$ | 9.16 | 9.34 | 9.47 | 9.59 | 9.70 | 9.82 | 9.93 |
| Sm, ksi | 20.0 | 20.0 | 20.0 | 19.2 | 17.9 | 17.0 | 16.3 |

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## 5.0 METHOD OF EVALUATION

The fillet weld between the Pressurizer heater sleeve and the heater sheath will be evaluated using the same methodology as the original Combustion Engineering (CE) Stress Report [6.7]. The loads and weld cross sectional properties are modified by the ratio of the new diametral and the original diametral gap. The results of the evaluation will demonstrate compliance with the original ASME Code stress requirements for Class 1 components [6.1].

The original fillet weld connection between the Pressurizer heater sleeve and heater sheath was constructed in accordance with Code Case 1361-2 which required a maximum of 0.045" diametral gap between connecting parts. The 0.045" maximum diametral gap limits the deflection of the part inside the penetration thereby limiting the bending stresses that can be imposed on the fillet weld.

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## 6.0 REFERENCES

1. ASME BPVC Section III Code, Rules for Construction of Nuclear Power Plant Components, 1971 Edition, 1971 Summer Addenda.
2. ASME Code Case 1361-2, Socket Welds, Section III.
3. SO23-919-33 Rev. 2, Internal Details for SONGS Unit 2 Pressurizer
4. SO23-919-2-D58 Rev. 1, Heater Element Assembly
5. Drawing No. 41116 Sh. 2 Rev. 3, Primary System Instrument Nozzle Details
6. ASME BPVC Section III Code, Rules for Construction of Nuclear Power Plant Components, 1998 Edition through 2000 Addenda.
7. C-E Report No. CENC-1420, Addendum 2 to the Analytical Report for SONGS Unit. No. 2 Pressurizer

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## 7.0 NOMENCLATURE

Terms used are as defined in the body of the calculation.

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## 8.0 CALCULATIONS

The original C-E Analytical Report [6.1] evaluated the sleeve to sheath fillet weld for Primary Membrane (Pm), Primary + Secondary ($P_L$ + Pb + Q), Shear ($\tau$) and Fatigue Usage Factor. The new 3/16" fillet weld size has a throat which is reduced from that originally evaluated due to the increase in gap between the heater sleeve and heater sheath. The increase in gap also increases the stress due to the internal pressure.

See Figure 8-1 for the schematic configuration of the heatersleeve to heater sheath fillet weld connection.

The throat of the fillet weld evaluated in the original C-E Analytical Report was 0.1227". For the new configuration, the weld throat is calculated as follows:

throat size = ( 0.619 + 0.1875 – 0.649 ) X 0.707 = 0.111",
where: outside radius of heater sheath = 1.238 / 2 = 0.619" (min. radius)
inner radius of heater sleeve = 1.298 / 2 = 0.649" (max. radius)
fillet weld size = 0.1875".

The applied axial force due to internal pressure is 3.182 kips.

The new applied axial force due to internal pressure becomes,
$F = 3.14 \times (0.649)^2 \times 2500 = 3.306$ kips

For the Primary Stress Intensity evaluation , Pm, the new stress is calculated by multiplying the original Pm by the ratio of the increase in Force and by the decrease in the throat size of the fillet weld. The original Pm = 6.48 ksi, thus, the new Pm is,
Pm = 6.48 X (3.306 / 3.182) X (0.1227 / 0.111) = 7.442 ksi,
which is less than the allowable of 9.78 ksi ( 0.6 Sm for SS Type 316 at 700 °F)

Therefore, the Primary Stress Intensity criteria is satisfied.

Primary membrane + bending stresses ($P_L$ + Pb) were not explicitly calculated in the original C-E Analytical Report since there were no primary bending loads on the fillet weld due to the close tolerance between the sleeve and the sheath. For conservatism, the maximum bending loads calculated under seismic and pressure pulsation loadings will be included in this evaluation. The maximum bending stress per the original report is 11.28 ksi ,
($P_L$ + Pb) = 7.442 + 11.28 = 18.722 ksi < 24.45 ksi (1.5 Sm) for SS Type 316

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To calculate the new stress, conservatively, the throat factor will be squared to account for bending across the throat as opposed to pure shear,

$(P_L + Pb) = 18.722 \text{ X } (3.306/3.182) \text{ X } (0.1227 / 0.111)^2$

$= 23.77 \text{ ksi} < 24.45 \text{ ksi (1.5 Sm) for SS Type 316.}$

Therefore, the Primary membrane + bending stress intensity criteria is satisfied.

For the Primary + Secondary Stress Intensity evaluation, the maximum stress intensity calculated in the heater sleeve to sheath weld is 30.35 ksi as shown in the original C-E report.
The thermal stresses are directly proportional to the modulus of elasticity times the coefficient of thermal expansion of the material being welded. The comparison of E times $\alpha$ of the materials is shown below:

| Property | Temperature, $^{o}$F | | | | | | |
|---|---|---|---|---|---|---|---|
| | 100 | 200 | 300 | 400 | 500 | 600 | 700 |
| E $\alpha$ (Alloy 600) | 226.8 | 228.7 | 230.6 | 231.0 | 230.9 | 230.7 | 228.8 |
| E $\alpha$ (Alloy 690) | 235 | 230.1 | 229.9 | 230.4 | 229.2 | 230.4 | 229.1 |
| E $\alpha$ (SS Type 316) | 258.3 | 258.7 | 256.6 | 255.1 | 253.2 | 249.4 | 246.3 |

The increase in thermal stress is estimated by using the equation below assuming that the weld stress is proportional to the differential expansion between the heater sleeve and the heater sheath.

$\sigma / \sigma_o = [ (E_{ss} \alpha_{ss} - E_{690} \alpha_{690}) / (E_{ss} \alpha_{ss} - E_{600} \alpha_{600}) ]$

where: $\sigma$ = new stress, $\sigma_o$ = original stress

Substituting the values in the equation above, at different temperatures, the ratio of $\sigma / \sigma_o$ is tabulated below:

| | Temperature, $^{o}$F | | | | | | |
|---|---|---|---|---|---|---|---|
| Property | 100 | 200 | 300 | 400 | 500 | 600 | 700 |
| $\sigma / \sigma_o$ | 0.74 | 0.95 | 1.03 | 1.02 | 1.08 | 1.02 | 0.98 |

Based on the above, the increase in thermal stress when using Alloy 690 sleeve in lieu of the original Alloy 600 sleeve is less than 10%. For conservatism, the stress due to pressure plus thermal stress will be increased by 10%.

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The new Primary + Secondary Stress Intensity is,

$(P_L + Pb + Q) = 30.35 \times 1.10 \times (3.306/3.182) \times (0.1227 / 0.111)^2$

$= 42.38$ ksi $<$ 48.9 ksi (3.0 Sm)

Therefore, Primary + Secondary stress intensity criteria is satisfied.

For the Primary + Secondary + Peak Stress Intensity evaluation, the maximum stress intensity calculated in the heater sleeve to sheath weld is 141.75 ksi using a conservative stress concentration factor of 5.0 as shown in the original C-E report. (Note: the minimum stress concentration factor for fillet welds to be used for fatigue analysis as given in Code Case 1361-2 is 4.0).
Using the above ratio for the $(P_L + Pb + Q)$, with a pressure increase factor for the trip transient of (2.55 / 2.50), the new Primary + Secondary + Peak Stress Intensity is,

$(P_L + Pb + Q + F) = 141.75 \times (2.55 / 2.50) \times 1.10 \times (3.306/3.182) \times (0.1227 / 0.111)^2$

$= 201.91$ ksi

The allowable number of cycles for alternating stress of 101 ksi is approximately 1750 cycles. For 700 cycles, considering a 40 year design life, the cumulative usage factor may be bounded by (700 / 1750), or 0.40, which is less than the allowable usage factor of 1.0.

ATTACHMENT III
E&TS DEPARTMENT

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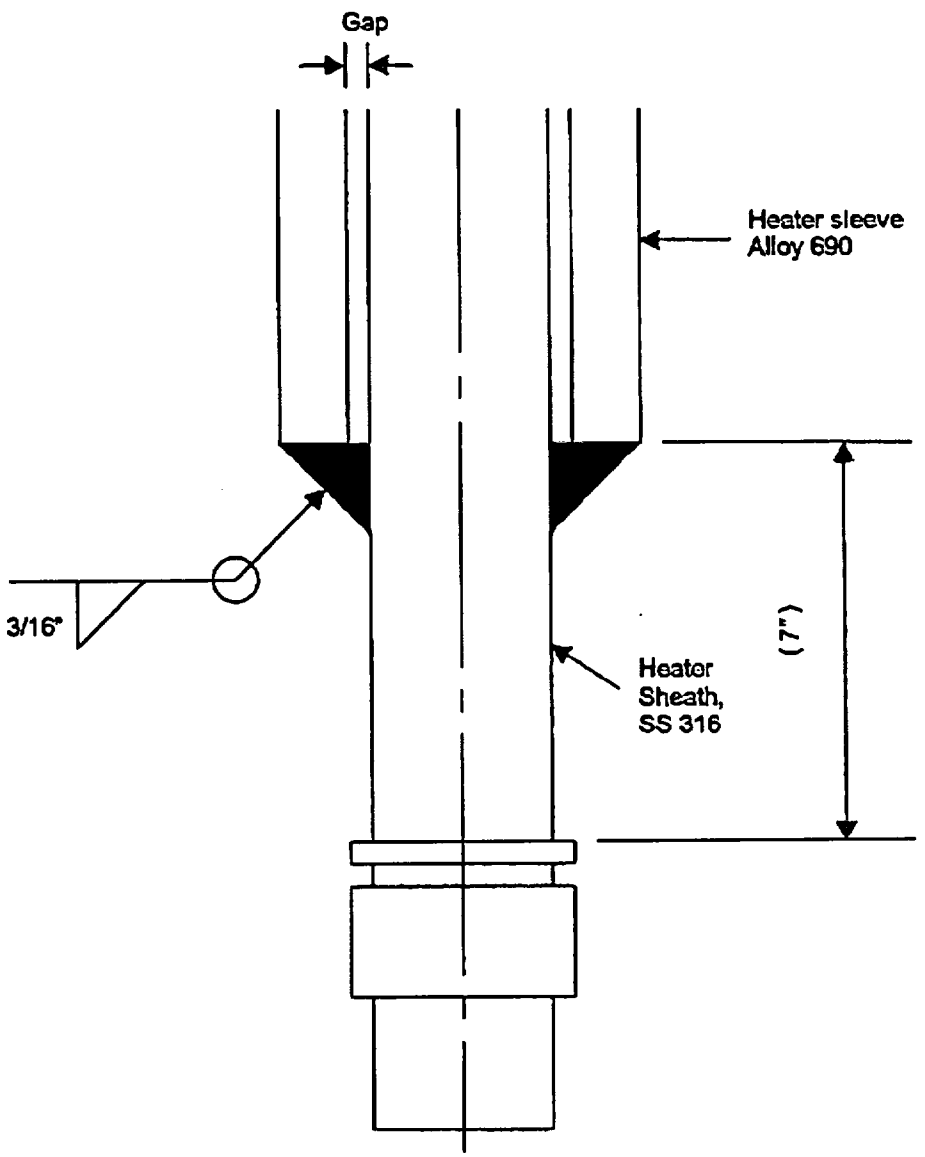
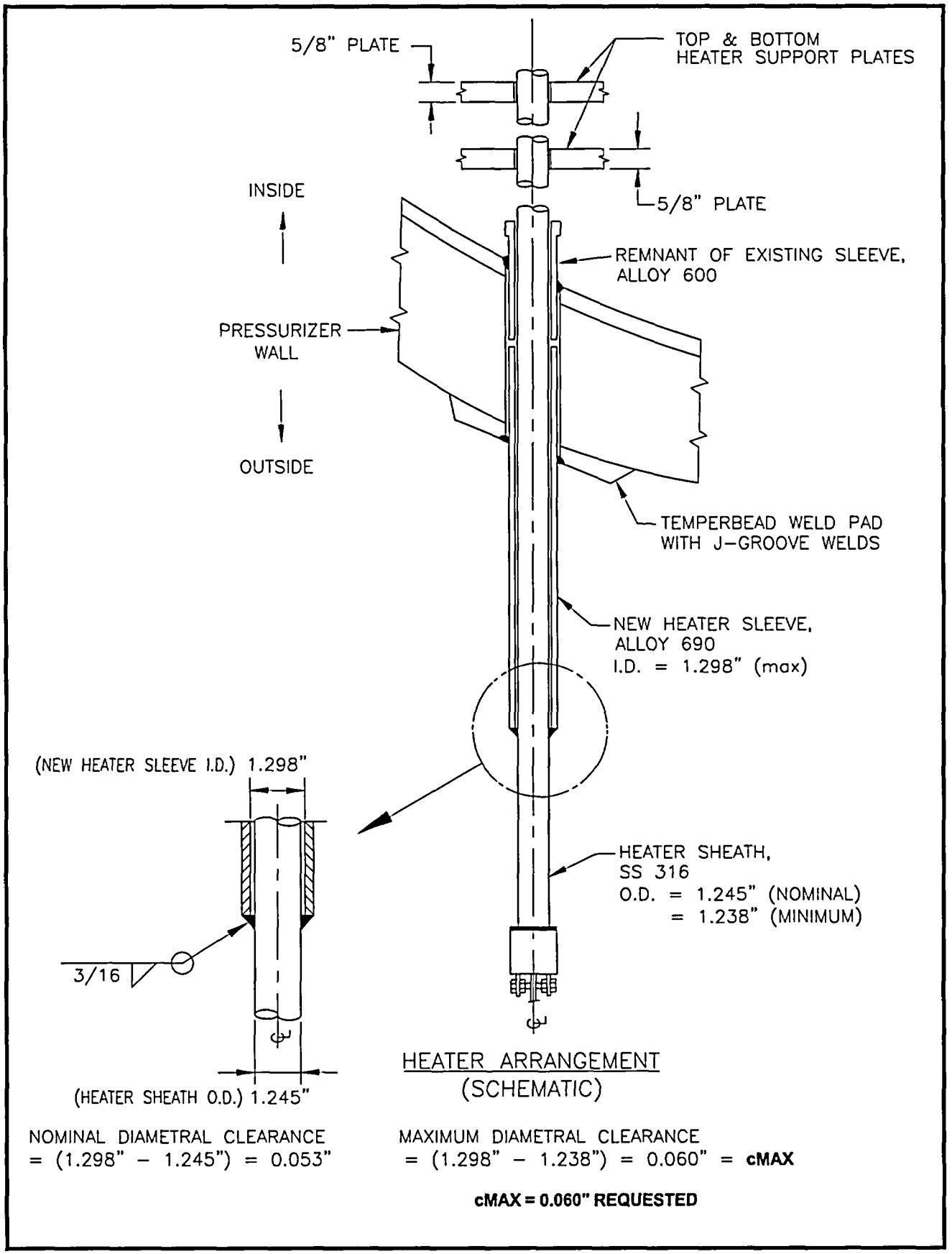



Figure 8.1 Schematic of the heater sleeve to heater sheath fillet weld connection

# Attachment 2

Figure

"Typical Heater Arrangement"




HEATER ARRANGEMENT
(SCHEMATIC)

NOMINAL DIAMETRAL CLEARANCE
= (1.298" – 1.245") = 0.053"

MAXIMUM DIAMETRAL CLEARANCE
= (1.298" – 1.238") = 0.060" = **cMAX**

**cMAX = 0.060" REQUESTED**