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Ref: 10CFR50.90

CPSES-200202358
Log # TXX-02107
File # 236

July 23, 2002

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

SUBJECT: COMANCHE PEAK STEAM ELECTRIC STATION (CPSES)
DOCKET NOS. 50-445 AND 50-446
REQUEST FOR ADDITIONAL INFORMATION REGARDING LICENSE AMENDMENT REQUEST (LAR) 01-012
STEAM GENERATOR TUBE REPAIR USING LEAK TIGHT SLEEVES

REF: 1) TXU Energy Letter, logged TXX-01086, from Mr. C. Lance Terry to the NRC dated October 23, 2001

2) Westinghouse Letter WPT-16339 dated July 11, 2002

Gentlemen:

In Reference 1, TXU Generating Company LP (TXU Energy) submitted proposed changes to the Technical Specifications associated with steam generator (SG) repair using leak tight sleeves at CPSES Unit 1 (License Amendment Request LAR 01-012). After review of the proposed changes, the NRC staff requested additional information. The information requested, as we understand it, and TXU Energy's responses are provided in the attachments.

Additionally, Enclosure 1 to this letter declassifies the Westinghouse Letter No. CSE-01-023 (Enclosure 2) from a proprietary document to a non-proprietary document.

D029

This communication contains the following commitments regarding CPSES Units 1.

Commitment Number	Commitment
27267	TXU Energy will visually inspect 100 percent of the inside surface of the tubes that will be sleeved; until such time that control is demonstrated to assure cleaning efficiency, a sample program may be used. The weld preparation procedures are currently in revision. The commitment will be implemented prior to 1RF09.
27268	Prior to ultrasonic inspection of steam generator tubes, a visual (VT-1) inspection will be required by CPSES procedures for detection of incomplete welds, blow holes, and weld splatter geometric irregularities in the welds. This requirement will be implemented prior to 1RF09.
27269	Plus point probe will be used in the inservice inspection for the sleeved tubes. This requirement will be implemented prior to 1RF09.

The requested change in the Technical Specifications, as provided in Attachment 3, supplement LAR-01-012, Reference 1. The safety analysis for proposed changes of LAR 01-012 and the determination that the changes in LAR 01-012 do not involve a significant hazard consideration remain valid with the supplemental changes provided in this letter. If you have any questions please contact Obaid Bhatty at (254) 897-5839.

I state under penalty of perjury that the foregoing is true and correct.

Executed on July 23, 2002.

Sincerely,

TXU Generation Company LP

By: TXU Generation Management Company LLC,
Its General Partner

C. L. Terry
Senior Vice President and Principal Nuclear Officer

By: Roger D. Walker
Roger D. Walker
Regulatory Affairs Manager

OAB/oab

Attachments:

1. Requests for Additional Information and Responses
2. Hydraulic Equivalency Number of Tubes with TIG Welded Sleeves for Comanche Peak Steam Electric Station.
3. Markup of CPSES Technical Specifications Pages

Enclosures:

1. Westinghouse Letter logged WPT-16339, dated July 11, 2002
2. Westinghouse Letter logged CSE-01-023, dated March 12, 2001

c - E. W. Merschoff, Region IV
W. D. Johnson, Region IV
D. H. Jaffe, NRR
Resident Inspectors, CPSES

REQUEST FOR ADDITIONAL INFORMATION AND RESPONSES REGARDING STEAM GENERATOR TUBE REPAIR USING LEAK TIGHT SLEEVES LICENSE AMENDMENT REQUEST (LAR) 01-012

Question 1

Specify the maximum allowable number of the leak tight sleeves to be installed in each SG, and discuss the method used to determine the maximum number of the sleeves and its associated uncertainties. Also, show that the effects of proposed sleeving tube conditions are bounded by the transient and accident analysis of the record.

TXU Energy Response:

The maximum allowable number of the leak tight sleeves to be installed in each steam generator will be the equivalent number of sleeved tubes that will produce the same flow reduction as the allowable tube plugging margin. The equivalent number of sleeved tubes that will produce the same flow reduction as one plugged tube will be referred to as the hydraulic equivalency of sleeves (sleeve/plug ratio). Currently, the updated Final Safety Analysis Report (FSAR) Appendix 4A and FSAR Table 15.6-5 reflects the tube plugging percentage as 10 for Unit 1. The hydraulic equivalency numbers for each type of sleeve are identified in Table 3 of Attachment 2. Additionally, Attachment 2 and Westinghouse letter report CSE-01-023 address the effects of the proposed sleeving tube conditions with regard to transient and accident analysis for CPSES.

Question 2

Specify the number of the plugged SG tubes assumed in the LOCA and non-LOCA transient analysis of the record, and include these numbers in the updated FSAR if they are not presented in the current FSAR.

TXU Energy Response

As stated in response to Question 1, the CPSES updated FSAR specifies this information in Appendix 4A and FSAR Table 15.6-5

REQUEST FOR ADDITIONAL INFORMATION AND RESPONSES REGARDING STEAM GENERATOR TUBE REPAIR USING LEAK TIGHT SLEEVES LICENSE AMENDMENT REQUEST (LAR) 01-012 (CONTINUED)

Question 3

Specify the sleeve/plug ratio applicable to the leak tight sleeves proposed for use in CPSES Unit 1, and discuss the acceptability of the method and assumptions used to determine the sleeve/plug ratio.

TXU Energy Response

Attachment 2 to this letter addresses this question.

Question 4

Provide the results of hydraulic test data and their comparison with values predicted by the calculational method used to determine the sleeve/plug ratio and identify the associated uncertainties.

TXU Energy Response

Attachment 2 to this letter addresses this question.

Question 5

On the proposed technical specification page (page 5.0-17), the plugging limit for the leak tight sleeves was not specified. The licensee needs to specify the plugging limit for the leak tight sleeves in terms of percentage of the sleeve wall thickness similar to the plugging limit for the laser welded sleeves in TS 5.5.9.e.1.f of the existing plant technical specifications.

TXU Energy Response

The plugging limit for the leak tight sleeve is same as the laser welded sleeve i.e., 43 percent of the nominal sleeve wall thickness. Attachment 3 provides the updated pages to the CPSES

REQUEST FOR ADDITIONAL INFORMATION AND RESPONSES REGARDING STEAM GENERATOR TUBE REPAIR USING LEAK TIGHT SLEEVES LICENSE AMENDMENT REQUEST (LAR) 01-012 (CONTINUED)

Technical Specification. This update now addresses "repaired" tubes in TS 5.5.9.e.1.f, which is in concert with the definition of repaired tube in TS 5.5.9.e.1.n.

Question 6

It is not clear to the staff that the loading (pressure and temperature) conditions imposed on the steam generator tubes at Comanche Peak are bounded by the loading conditions used in the design and qualification of the leak tight sleeve as discussed in the Westinghouse report, CEN-630-P. In the NRC's letter to Nuclear Energy Institute (NEI) dated February 10, 2000, subject: Generic Safety Evaluation-Steam Generator Leak Tight Sleeves Designed by ASEA Brown Boveri-Combustion Engineering, the staff concludes in section 4 of its safety evaluation that licensees shall perform a bounding assessment prior to implementing the sleeve repair. In the October 23, 2001, submittal, the licensee referenced the Westinghouse letter report, CSE-01-023, which may contain the relevant information regarding the bounding analysis of the loading conditions; however, the information was not discussed in sufficient detail in the submittal. The licensee needs to either discuss the bounding analysis and submit the Westinghouse letter report, CSE-01-023, for staff review.

TXU Energy Response

Westinghouse letter report, CSE-01-023, Enclosure 2, is available for NRC review. Both Attachment 2 and the Westinghouse letter report, CSE-01-023, discuss the bounding analysis. Please note that Westinghouse declassified the CSE-01-023 via letter WPT -16339 (Enclosure 1).

Question 7

The licensee stated that it will follow the Westinghouse report CEN-630-P, Revision 2, with regard to the installation of the leak tight sleeve. On page 5-1 of CEN-630-P, the sleeve examination program calls for a visual inspection of the inside surface of the candidate tube to confirm adequate cleaning surface prior to welding the sleeve to the tube. It states that "...The extent of this inspection program is presently 100% of tubes to be sleeved. At such time that process control is demonstrated to assure cleaning efficiency, a sampling program may be

REQUEST FOR ADDITIONAL INFORMATION AND RESPONSES REGARDING STEAM GENERATOR TUBE REPAIR USING LEAK TIGHT SLEEVES LICENSE AMENDMENT REQUEST (LAR) 01-012 (CONTINUED)

used...". In the NRC's letter to NEI dated February 10, 2000, the staff recommends that this visual inspection be included in licensee's weld preparation procedure (i.e., visual inspection of each tube to be sleeved) until licensees determine in accordance with 10 CFR 50.59 and based on vendor's recommendations that there is sufficient field experience to support a statistically based sampling plan for visual inspection. The licensee needs to discuss its weld preparation procedure with regard to this visual inspection.

TXU Energy Response

TXU Energy will visually inspect 100 percent of the inside surface of the tubes that will be sleeved until such time that process control is demonstrated to assure cleaning efficiency. After process control is demonstrated, a sampling program may be used. The weld preparation procedures are currently in revision. TXU Energy will ensure that it captures this commitment in the CPSES Commitment Tracking Program for implementation prior to start of the outage.

Question 8

On page 5-1 of CEN-630-P, it is stated that prior to the ultrasonic inspection, an optional visual (VT-1) inspection of the weld may be performed but is not required. The VT-1 inspection, as defined in ASME Section XI, is suitable for detection of incomplete welds, blow holes, and weld splatter geometric irregularities in the weld. In the NRC's letter dated February 10, 2000, the staff requires licensees to perform the visual (VT-1) inspection as an interim measure until licensees determine in accordance with 10 CFR 50.59 and based on vendor's recommendations that eddy current and ultrasonic inspections are sufficient to confirm an adequate weld. The licensee needs to discuss its position with regard to the VT-1 inspection.

TXU Energy Response

TXU Energy will assure that VT-1 inspection is specified in CPSES procedures for conditions specified in NRC staff's area of concern during the upcoming outage (1FRO9). However, TXU Energy may revise this position after this outage in accordance with 10 CFR 50.59 and based on

REQUEST FOR ADDITIONAL INFORMATION AND RESPONSES REGARDING STEAM GENERATOR TUBE REPAIR USING LEAK TIGHT SLEEVES LICENSE AMENDMENT REQUEST (LAR) 01-012 (CONTINUED)

vendor's recommendations that eddy current and ultrasonic inspections are sufficient to confirm an adequate weld.

Question 9

It is not clear to the staff whether the proposed leak tight sleeve repair method is applicable to both units or unit 1 only. If the proposed leak tight sleeve repair method is proposed for both units, the licensee needs to modify the following Comanche Peak technical specification sections because the existing requirements for laser welded sleeves in the technical specifications that are relevant to the leak tight sleeves are applicable to unit 1 only. (1) Table 5.5-3 in the existing Comanche Peak technical specifications provides the inspection scope for repaired tubes (i.e., sleeved tubes) for unit 1 only. (2) TS 5.5.9.e.1.h, Tube Inspection, needs to be modified. (3) TS 5.5.9.e.1.e, Defect, needs to be modified. (4) TS 5.6.10.b.1 needs to be modified.

TXU Energy Response

Currently, TXU Energy is proposing the leak tight sleeve repair methodology for CPSES Unit 1 only. As stated in response to Question 5 refer to Attachment 3 the phrase "laser welded" is being removed and replaced with "repaired" and the phrase "nominal wall" is being replaced with "nominal sleeve wall".

Question 10

Confirm that the plus point probe will be used in the inservice inspection for the sleeved tubes.

TXU Energy Response

TXU Energy confirms that the plus point probe will be used in the inservice inspection for the sleeved tubes.

Hydraulic Equivalency Number of Tubes with TIG Welded Sleeves for Comanche Peak Steam Electric Station

1. Introduction

TXU Energy has proposed to install TIG welded sleeves (also referred to as leak tight sleeves) to repair Steam Generator (SG) tubes with degradation and return them to service at Comanche Peak Steam Electric Station (CPSES) Unit 1. TXU Energy believes that the degradation of the SG tubes may appear at the expansion transition zone at the top of the tube sheet or at the tube support plate elevations. For the purpose of this evaluation it is assumed that tube sleeve will introduce additional hydraulic resistance to reactor coolant flow, and hence reduce its flow rate. Moreover, tube plugging also increases flow resistance and thus results in decreased flow rate. To maintain plant operation within the licensed condition (plugging limit), it is important to recognize the equivalent number of sleeved tubes that will produce the same flow reduction as one plugged tube. Therefore, this ratio is referred to as the hydraulic equivalency of sleeves.

There are two types of sleeve that are being considered at CPSES. A description of these sleeves together with un-sleeved tube will be used for calculating pressure loss and thus hydraulic equivalency number. Consistent with Westinghouse drawings of these two types of sleeve, Figures 1 through 3 provide dimensions that are used for the calculation. Figure 1 illustrates the "Expansion Transition Zone Sleeve" (ETZ sleeve) and its location; the ETZ-Sleeve is 17.5 inches long. (The dimensions shown in the figures are not to scale). Figure 2 depicts the "Tube Support Sleeve" (TS Sleeve). The TS-sleeve is 9 inches long. Figure 3 shows the dimensions of the un-sleeved tube for CPSES Unit 1.

In response to the NRC staff's questions the hydraulic equivalency number will be calculated for the normal power operating conditions of CPSES Unit 1.

2. Methodology of Calculation

The calculation herein derives the expression for the number of tubes with sleeves, which may lead to the same effect as a plugged tube on flow reduction. The ratio of the number of tubes with sleeves to a plugged tube is the hydraulic equivalency. Flow reduction due to sleeves or plugs occurs due to the additional flow resistance of the sleeve or plug when compared to tubes without any sleeves or plugs. Therefore, the derivation of the equivalency number will involve pressure drop calculations. The pressure drop will consist of both friction loss and form loss, and the calculation will be based on full load operation.

For flow through the tube bundle, pressure drop can be expressed as follows.

$$\Delta p_o = K_o W_o^2 / \left(2 g_c \rho N_o^2 A_o^2\right) \qquad (1)$$

Where

Δp_o = pressure drop through the whole length of tube
K_o = total loss coefficient
W_o = flow rate per steam generator
g_c = unit conversion constant
ρ = water density
N_o = number of tubes per steam generator without plugging
A_o = flow area per tube without sleeve

Note that subscript "o" indicates that a tube bundle without any sleeves or plugs.

A similar expression can be written for a tube bundle without and with sleeves as follows.

$$\Delta p_u = K_u W_u^2 / \left(2 g_c \rho N_u^2 A_o^2\right) \qquad (2)$$

$$\Delta p_s = K_s W_s^2 / \left(2 g_c \rho N_s^2 A_o^2\right) \qquad (3)$$

The subscript "u" above indicates "unsleeved", and "s" "sleeved."

Additionally,

$$N_o = N_u + N_s \qquad (4)$$

Because of the way Equation (3) is articulated the total loss coefficient has to be expressed in terms of the inside diameter of a tube without the sleeve. Note that the flow rate for the tube bundle with some tubes being sleeved is expressed as follows.

$$W_{su} = W_u + W_s \qquad (5)$$

A similar expression for the tube bundle with some tubes being plugged can be written as follows.

$$\Delta p_p = K_p W_p^2 / \left(2 g_c \rho N_{up}^2 A_o^2\right) \qquad (6)$$

The subscript "p" above indicates the parameter for the case with some tubes being plugged.

Additionally,

$$N_o = N_{up} + N_p \tag{7}$$

Where N_p is the number of tubes being plugged.

Under the assumption of equality of pressure drops among the un-sleeved, sleeved and plugged tube, the above equations result in the following expression.

$$N_s / N_p = 1/\left(1 - \sqrt{K_u / K_s}\right) \tag{8}$$

Equation (8) is the defined hydraulic equivalency number. This is precisely the expression used in the Westinghouse "SLEEVE Code".

The key in determining the hydraulic equivalency number is thus in the calculation of loss coefficients. Both friction and form losses are calculated as required. As shown in Figures 1 to 3, the form loss consists of sudden contraction and expansion as well as gradual contraction and expansion. These form loss coefficients are calculated by standard correlations.

Equation (8) can be written in terms of flow rate through a single tube as follows.

$$N_s / N_p = 1/\left(1 - w_s / w_u\right) \tag{9}$$

Since flow rate w and loss coefficient K are unknown, iteration is required to get the solution. One simple way is to first calculate loss coefficient with equal flow rate between w_s and w_u, then Equation (8) will yield N_s/N_p that can be fed into Equation (9) to determine w_s / w_u. The new value of w_s and w_u will lead to new K_s and K_u, and thus N_s/N_p. The process will be repeated until a convergent solution is found.

The above methodology is the same as the Westinghouse "SLEEVE Code"[1]. The following are loss coefficients used for the different regions of the tube and sleeve.

2.1 Sudden Contraction

Tube inlet $K = 0.23$

for tube end flush with cladding surface.

Comanche Peak Unit 1 has the tube ends flush with cladding.

---

1 This SLEEVE Code has been reviewed by the NRC staff during the review of the Laser Welded Sleeve submittal

2.2 Sudden Contraction within Tube or Sleeve

$$K = 0.5\left[1-\left(\frac{D_{small}}{D_{large}}\right)^2\right]$$

For gradual contraction, the above equation will be multiplied by a factor that is a function of contraction angle. For current sleeve, the multiplier ranges from 0.37 to 0.66.

2.2.1 Sudden Expansion within Tube or Sleeve

$$K = \left[1-\left(\frac{D_{small}}{D_{large}}\right)^2\right]^2$$

For gradual expansion, the above equation will be multiplied by a factor that is a function of expansion angle. For current sleeve, the multiplier ranges from 0.37 to 0.66.

2.2.2 Tube Exit

Tube outlet $K = 0.53$

2.2.3 Friction Loss

$$K = 4f(L/D)$$

Where f is the friction factor, L is the length of the individual section in question, and D is the diameter of the individual section in question. There are many sections for the tube and the tube with sleeve. The friction factor is given by the following equation that is applicable to both tube and sleeve:

$$f = 0.014 + 0.125\,\mathrm{Re}^{-0.32}$$

Where Re is the Reynolds number.

All loss coefficients are adjusted so that they are referenced to the flow area defined by the inside diameter of the tube without expansion.

3. Results of Calculation

Relevant conditions for hydraulic equivalency calculation are given in Table 1 for both units. Those conditions include the geometry and designed thermal hydraulic conditions. Actual operation conditions can differ from those shown in the table. However, the hydraulic equivalency would not be affected.

Table 1 Conditions of thermal-hydraulics and geometry

Parameter	Unit 1
Reactor coolant flow, lbm/hr	35.5 x 10^6
Average coolant inlet temperature, T_{avg}, °F	589.1
Reactor coolant pressure, p_c, psia	2250
Coolant viscosity, lbm/ft-sec	0.0000585
Number of U-tubes, N_o	4578
Diameter of channel head, inch	125.12
Thickness of tube sheet, inch	21.18
Tube ID, D_i, inch	0.664
Average tube length, L, ft	57.4

Calculations were made for three installations of two types of sleeves, as shown in Figures 1 to 3. Results of loss coefficients for all three installations are listed in Table 2.

Table 2 Loss coefficient of un-sleeved and sleeved tube

Case	Total loss coefficient
Tube without sleeve	12.9662
Tube with ETZ-Sleeve	13.7710
Tube with TS-Sleeve	13.4614
Tube with ETZ-Sleeve plus TS-Sleeve	14.1795

As expected, the ETZ-Sleeve has a higher loss coefficient than the TS-Sleeve. The main cause is not the length, but the contraction loss at the inlet of the sleeve and the lower expansion/rolled loss is much higher for the ETZ-Sleeve. For the same inlet and lower expansion zone, the TS-Sleeve has a larger ratio of diameters between upstream and downstream, and thus loss coefficients are smaller.

According to the loss coefficients shown in Table 2, hydraulic equivalency numbers are readily obtained and summarized in Table 3.

Table 3 Hydraulic Equivalency Number

Case	Hydraulic Equivalency Number
ETZ-Sleeve	34
TS-Sleeve	54
ETZ-Sleeve plus TS-Sleeve	23

Hydraulic equivalency number is not sensitive to the variation of the operating conditions. For example, an increase in the primary coolant flow from 35.5 x 10^6 lb_m/hr to 39.1 x 10^6 lb_m/hr (i.e., 10% increase) results in a decrease in the hydraulic equivalency number less than 1%.

It has been known that there is excess conservatism in calculating hydraulic equivalency number by the standard correlations of loss coefficients of friction and contraction/expansion form losses, as concluded from full scale testing for similar sleeves. Figure 4 shows the ratios of the tested hydraulic equivalencies to the predicted ones. The ratios are greater than 2.0; this clearly demonstrates the existence of the excess conservatism by the methodology. It is expected that both ETZ-sleeve and TS-Sleeve would behave the same, and thus there would be excess conservatism for the hydraulic equivalency number shown in Table 3.

Figure 1 Dimensions of Transition Zone Sleeve (Sleeve is 17.5 inch long)

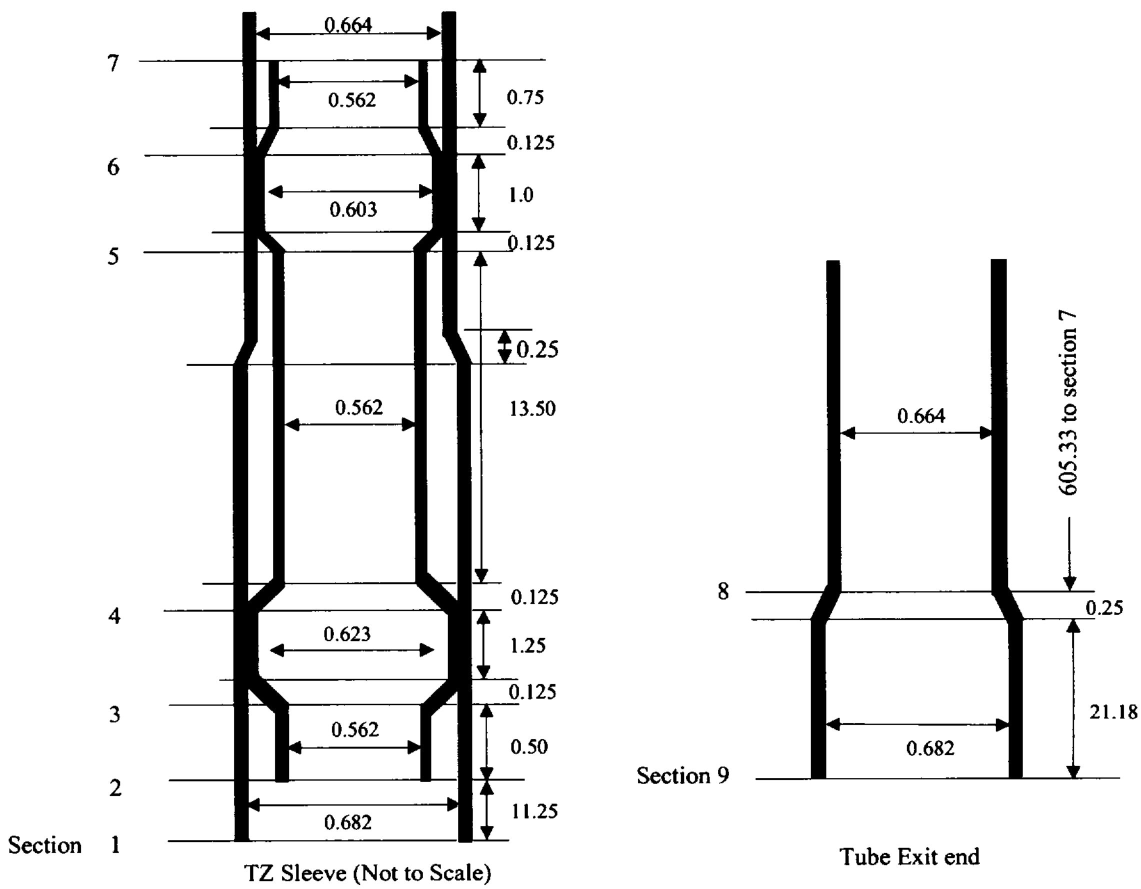
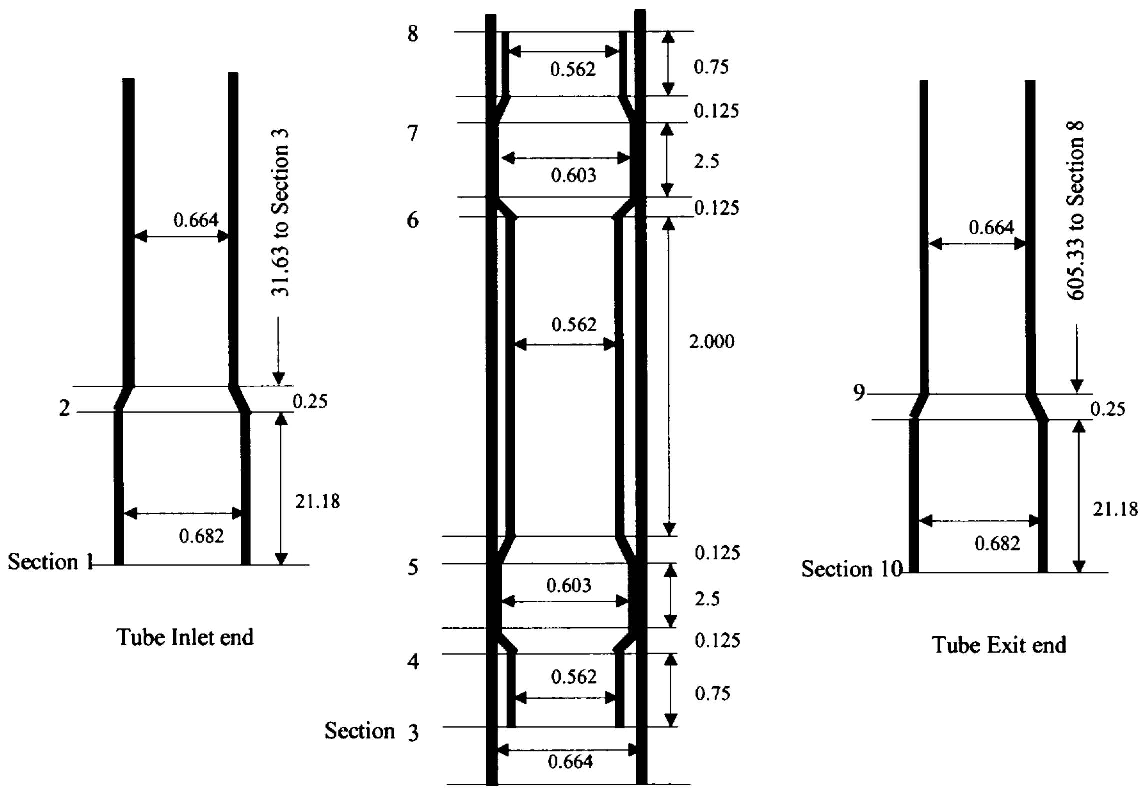


Figure 2 Dimensions of Tube Support Sleeve (Sleeve is 9 inch long)



TS Sleeve (Not to Scale)

Figure 3 Dimensions of Un-sleeved Tube

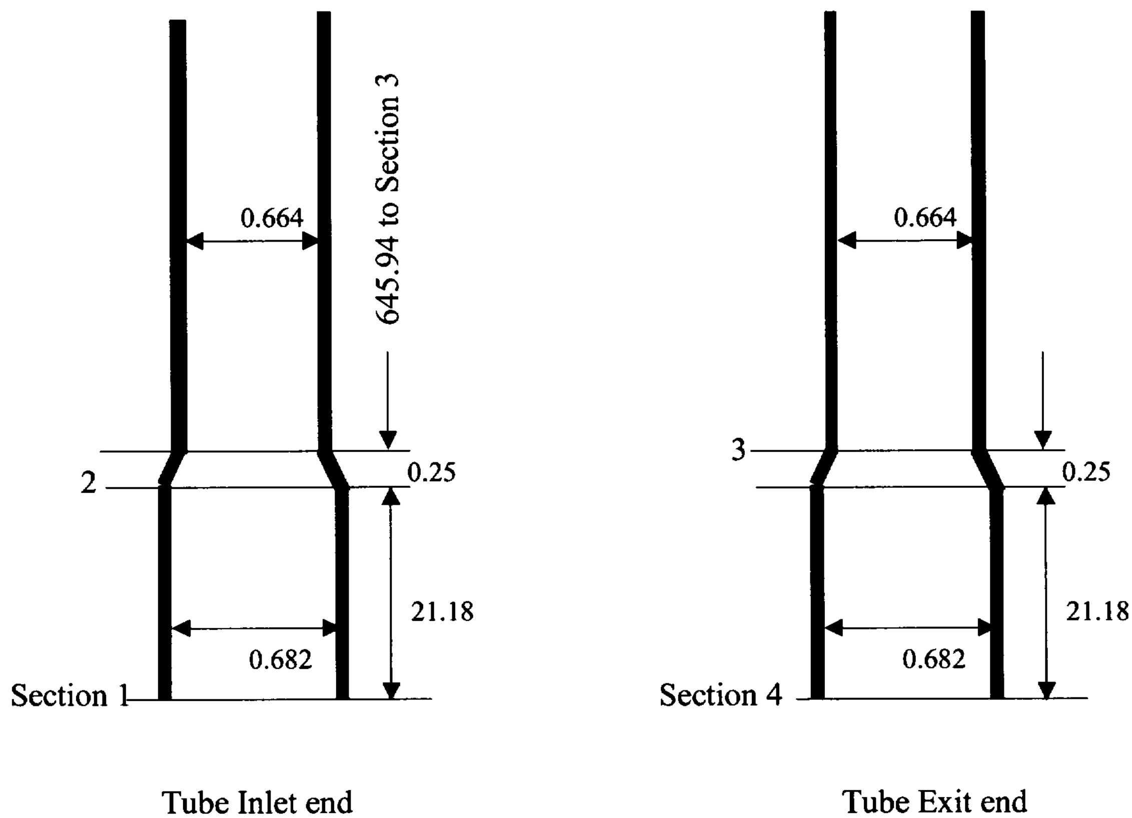
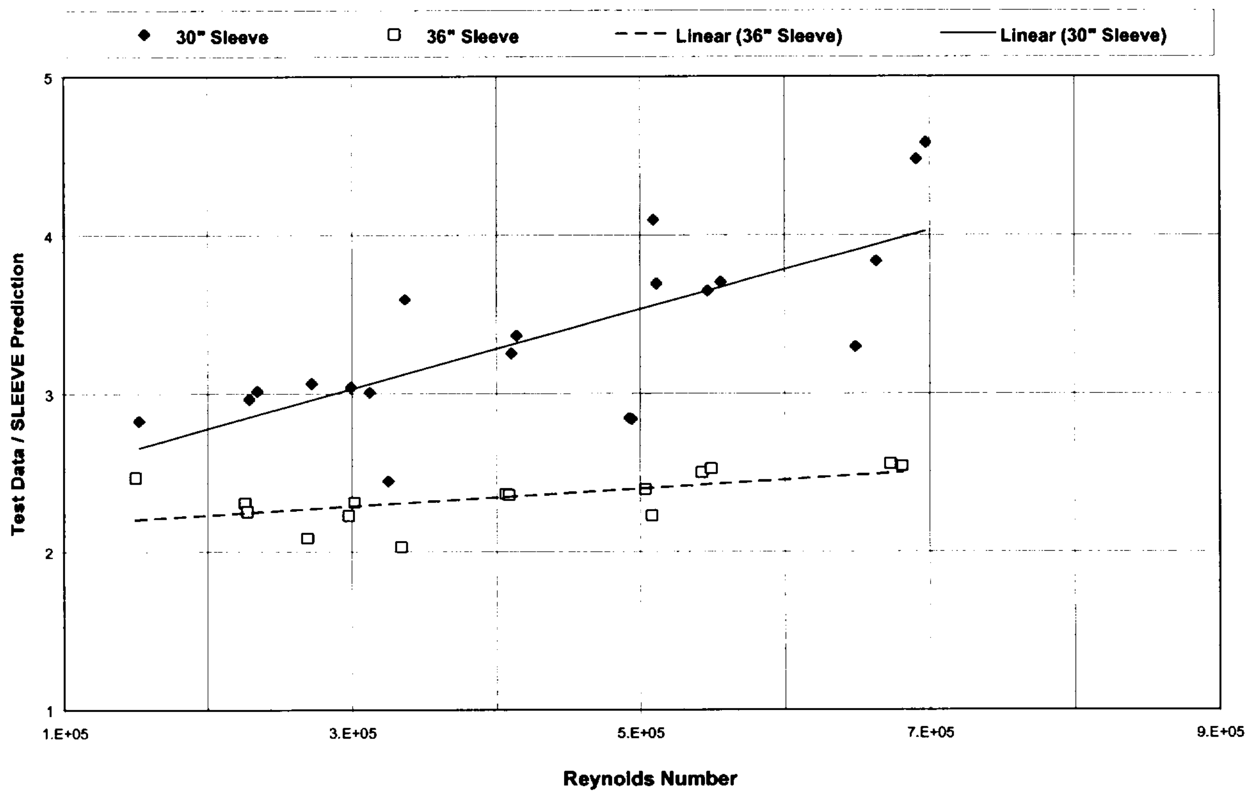


Figure 4 Ratios of Hydraulic Equivalencies Based on the Test Data to SLEEVE Code Predictions



Attachment 3 to TXX-02107

Pages: 5.0-16
5.0-17a

5.5.9 Steam Generator (SG) Tube Surveillance Program (continued)

f) Plugging or Repair Limit means the imperfection depth at or beyond 83
which the tube shall be removed from service by plugging or (for
Unit 1 only) repaired by sleeving and is equal to 40% of the
nominal tube wall thickness. The plugging limit for ~~laser welded
repaired~~ sleeves is equal to 43% of the nominal sleeve wall
thickness. This definition does not apply to that portion of the Unit 71
1 tubing that meets the definition of an F* tube. This definition does 70
not apply to tube support plate intersections for which the voltage-
based plugging criteria are being applied. Refer to 5.5.9e.1m) for the
repair limit applicable to these intersections; 71

g) Unserviceable describes the condition of a tube if it leaks or contains
a defect large enough to affect its structural integrity in the event of
an Operating Basis Earthquake, a loss-of-coolant accident, or a steam
line or feedwater line break as specified in Specification 5.5.9d.3,
above; 71

h) Tube Inspection means an inspection of the steam generator tube
from the tube end (hot leg side) completely around the U-bend to the
top support of the cold leg. For a tube repaired by sleeving (for
Unit 1 only) the tube inspection shall include the sleeved 83
portion of the tube;

i) Preservice Inspection means an inspection of the full length of each
tube in each steam generator performed by eddy current techniques
prior to service to establish a baseline condition of the tubing. This
inspection shall be performed prior to initial POWER OPERATION
using the equipment and techniques expected to be used during
subsequent inservice inspections; 71

j) F* Distance (Unit 1 only) is the distance of the hardroll expanded 71
portion of a tube which provides a sufficient length of non-degraded
tube expansion to resist pullout of the tube from the tubesheet. The
F* distance is equal to 1.13 inches, plus an allowance for eddy
current measurement uncertainty, and is measured down from the top
of the tubesheet, or the bottom of the roll transition, whichever is
lower in elevation;

k) F* Tube (Unit 1 only) is that portion of the tubing in the area of the
tubesheet region below the F* distance with a) degradation below the
F* distance equal to or greater than 40%, b) which has no indication
of degradation within the F* distance, and c) that remains inservice;

(continued)

5.5.9 Steam Generator (SG) Tube Surveillance Program (continued)

2. The steam generator shall be determined OPERABLE after completing the corresponding actions (plug all tubes exceeding the plugging limit and all tubes containing through-wall cracks) required by Table 5.5-2 and Table 5.5-3.

(continued)

Westinghouse

Westinghouse Electric Company
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WPT-16339

Attention: O. Bhatty

July 11, 2002
No Response Required

TXU ENERGY
COMANCHE PEAK STEAM ELECTRIC STATION
UNITS 1 and 2
Declassification of Proprietary Information in Westinghouse Letter No. CSE-01-023

Dear Mr. Terry:

Westinghouse has been informed that TXU Energy would like to include Westinghouse letter number CSE-01-023, "Effect of Comanche Peak 1 and 2 (D4 and D5) Steam Generator Parameters on the Generic TIG Welded Sleeves with 85/15/Flow Split" in a submittal to the NRC staff. This information was provided to the utility under the heading "Westinghouse Proprietary" in March of 2001.

It is the policy of Westinghouse to prevent the unauthorized disclosure of proprietary information to persons or organizations outside of Westinghouse. Westinghouse has re-reviewed the information provided within Westinghouse letter number CSE-01-023. This document describes the effect of the Comanche Peak 1 and 2 steam generator operating parameters on the structural adequacy of the TIG welded sleeve. It has been determined that the information is non-proprietary in nature and that it may be distributed both internal and external to Westinghouse. Therefore, the information is declassified as Westinghouse Non-Proprietary Class 3 and is available for unlimited distribution and it can be submitted to the NRC staff without the completion of an affidavit.

This letter is provided in lieu of removing the "Westinghouse Proprietary" heading from Pages 2 through 11 and Page 1-1 of 1-7 of the subject document.

Please contact Mr. Gary Whiteman at 412-374-5175 or me if you have any questions or comments.

Very truly yours,

WESTINGHOUSE ELECTRIC COMPANY

J. S. Wyble, Manager
Comanche Peak Project

/mah

24 Total Pages

VL-01-000541

Westinghouse Electric Company
Nuclear Services

APPROVED
S.M. Swilley
4/15/01

This status is subject to vendor compliance with all contract requirements, drawings, and specifications

1201 Riverfront Parkway
Chattanooga, TN 37402
USA

To: D. G. Stepnick

cc: E. P. Kurdziel
D. P. Siska

March 12, 2001
Southeast Nuclear Service Center

SUBJECT: **EFFECT OF COMANCHE PEAK 1 AND 2 (D4 & D5) STEAM GENERATOR PARAMETERS ON THE GENERIC TIG WELDED SLEEVES WITH 85/15 FLOW SPLIT**

REFERENCES:

(1) Westinghouse Steam Generator Information Report, NSD-RMW-90-070, SG-90-02-026, Revision 6, February 1990.
(2) CENP Report No. CEN-630-P, Revision 02, "Repair of ¾" O.D. Steam Generator Tubes Using Leak Tight Sleeves", June 1997.
(3) ASME Boiler and Pressure Vessel Code, Section II, Materials, Part D – Properties, 1992 Edition.
(4) CENP Letter Report No. CSE-00-130, "Effect of Comanche Peak 1 and 2 (D4 & D5) Steam Generator Parameters on the Generic TIG Welded Sleeves", December 20, 2000.
(5) E-mail Note from Steve Swilley to David Stepnick on "Sleeving", February 16, 2001 (Copy in Attachment 3).

INTRODUCTION

This letter report is an update to the one in Reference 4 where the feedwater flow split was revised to the actual value of 0.15 (Reference 5) vs the assumed value of 0.2 in Reference 4. A detailed review of the Reference 2 licensing report was performed to determine the effect of the Comanche Peak 1 and 2 (D4 & D5) steam generator parameters on the generic TIG-welded sleeves. The first 7 sections of this licensing report address installation technique, testing that was performed on the sleeves and acceptance criteria for sleeve design. Other than where these sections reference Section 8, none are affected by the Comanche Peak 1 and 2 steam generator parameters. Section 9 addresses the testing performed to ensure a proper weld is obtained while Section 10 addresses the operational effect of sleeving. Neither of these sections is affected by the Comanche Peak parameters. Thus, only the structural evaluation of the sleeve presented in Section 8 of the licensing report is affected by the Comanche Peak parameters. The remainder of this letter report addresses the specific areas within Section 8 and describes the effect of the Comanche Peak parameters on the structural adequacy of the TIG-welded sleeve.

[redacted]

Section 8.1 Design Sizing and Primary Stress

Design sizing is affected only by the design tubesheet differential pressure, sleeve geometry and material properties. Since these factors are unaffected by the Comanche Peak parameters, there are no changes to the design sizing. Primary stress is affected by the same parameters as the design sizing and is therefore unaffected by the Comanche Peak parameters. The assumed ΔP across the sleeve during accident conditions (2850 psi and -1198 psi for Feedwater Line Break and LOCA, respectively) are also unaffected by the Comanche Peak parameters. Thus, the primary stress in the sleeve for these conditions is also unaffected.

Section 8.2 Loadings on the Sleeve

The upper tube weld pullout load and the lower sleeve rolled section push-out load are dependent on the sleeve geometry and the ΔP that occurs during accident conditions. None of these parameters are affected by the Comanche Peak conditions. Hence, the safety factors calculated in this section of Reference 1 remain valid. The discussion in Section 8.2 of Reference 1 on weld fatigue will be discussed in section 8.6.

Section 8.3 Regulatory Guide 1.121 Allowable Degradation

This section of the report shows that the 3 x Normal Operating (NOP) ΔP criterion is limiting with respect to allowable degradation. Since the accident condition ΔP will not change and the NOP ΔP is less for the Comanche Peak Units than what was reported in Reference 2, the allowable sleeve degradation will remain at 50.7% or greater for the Comanche Peak plants. Therefore, the allowable degradation remains above the plugging criterion of 40% and is therefore acceptable.

Section 8.4 Determination of Maximum Axial Load

The maximum axial loads in the sleeve result from thermal expansion during normal full power operation when the sleeved tube is not locked into the first support plate. Both Comanche Peak 1 and 2 (D4 & D5) steam generators were investigated to determine the most realistic and most conservative set of parameters.

In almost all cases, sleeves are installed in the interior of the tube bundle where the secondary flow is low and there is a buildup of sludge. For these cases, the feedwater and recirculation flow entering the tube bundle are heated to saturation conditions before they contact the tube/sleeve assembly. Thus, the axial load is based on the parameters provided in Reference 1 (Thot = 618.8 °F and Tsec = 545.3 °F (D4) and 545.0 °F (D5)). For those cases where a sleeve is installed in a tube at the periphery of the tube bundle, the secondary fluid has not yet reached saturation conditions. The secondary temperature, T_{sec}, near the tubesheet on the hot leg side of the tube bundle periphery is calculated as follows for the 100% steady state condition.

[redacted]

Section 8.4 Determination of Maximum Axial Load (Continued)

The downcomer enthalpy, h_{DC}, is:

h_{DC} = [(DC Flow – 0.15 x Steam Flow) x h_f + 0.15 x Steam Flow x h_{fw}] / DC Flow

where:

DC Flow = (CR-1) x Steam flow + 0.15 x Steam Flow
CR = 2.4 (D4 Unit) and 3.2 (D5 Unit) (Reference 1)
Steam flow = 3.79 x 10^6 lb / hr (D4 and D5 Units, Reference 1)
0.15 = Feedwater Flow Split (Actual Value per Reference 5)
h_f = 542.55 BTU / lb for 1000 psia (D4 and D5 Units, Reference 1)
h_{fw} = 419.03 BTU / lb for 440 °F, feedwater temperature (D4 and D5 Units, Reference 1)

Substituting:

h_{DC} = 530.60 BTU / lb for D4 Unit and 534.67 BTU / lb for D5 Unit or
T_{sec} = 535.18 °F for D4 Unit and 538.41 °F for D5 Unit.

The **maximum axial load** on the sleeve for the **Comanche Peak 1 (D4) steam generator** occurs at the tube bundle periphery and is **830 lb.** The **maximum axial load** on the sleeve for the **Comanche Peak 2 (D5) steam generator** occurs at the tube bundle periphery and is **811 lb.** Both of these axial loads are less than those maximum values of 927 lb. (Westinghouse) and 999 lb. (CENP) as noted in Table 8-2 of Reference 2. Besides normal operation, 15% steady state, 0% steady state (hot standby), and feedwater cycling conditions are also used in the axial load evaluations. Thus, all of the stresses that are calculated in Reference 2 bound the worst case sleeve installation for the Comanche Peak 1 and 2 Units.

Section 8.5 Sleeved Tube Vibration Considerations

Vibrational considerations for the sleeve/tube assembly are based primarily on testing and are not affected by the Comanche Peak conditions. The seismic evaluations are dependent on sleeve and tube bundle geometry as well as defined seismic loads. Since these parameters will not change for the Comanche Peak conditions, all values calculated in this section of Reference 2 remain valid.

[redacted]

Section 8.6 Fatigue Evaluation

Reference 2 provides a detailed fatigue evaluation for the worst case of all CE-designed sleeves installed in 0.75-inch Alloy 600 tubing. This evaluation addresses Westinghouse designed steam generators (including Comanche Peak 1 & 2) as well as CE-designed steam generators that are licensed to install these sleeves. A summary of this fatigue evaluation is provided below.

A Finite Element Model (FEM) with the ANSYS Computer Code was used to calculate stresses and determine the fatigue usage factor. Figure 1 depicts the FEM of the upper tube weld for both CE and Westinghouse designed steam generators with Alloy 600 tubes. A tube thickness of .043 inches is conservatively used in the analysis.

The lower end of the tube was assumed to be locked near the secondary side surface of the tubesheet. From the previous analysis, it was found that the sleeve develops higher compressive loadings if the tube is free to slide through the first support. Therefore, sliding at the tube-to-support interface was conservatively assumed. The FEM consists of 2-D isoparametric elements with an axisymmetric option.

Axial loads are then applied to the bottom of the sleeve FEM. The CE operating and transient conditions are used because they result in the maximum temperature differences and maximum axial loads. The transients were selected on the basis of the worst case combinations. The stresses resulting from the axial load cases are combined with the 100% steady state pressure case stresses. These combined stresses are added to the thermal case stresses resulting from the radial thermal expansion for the transients considered.

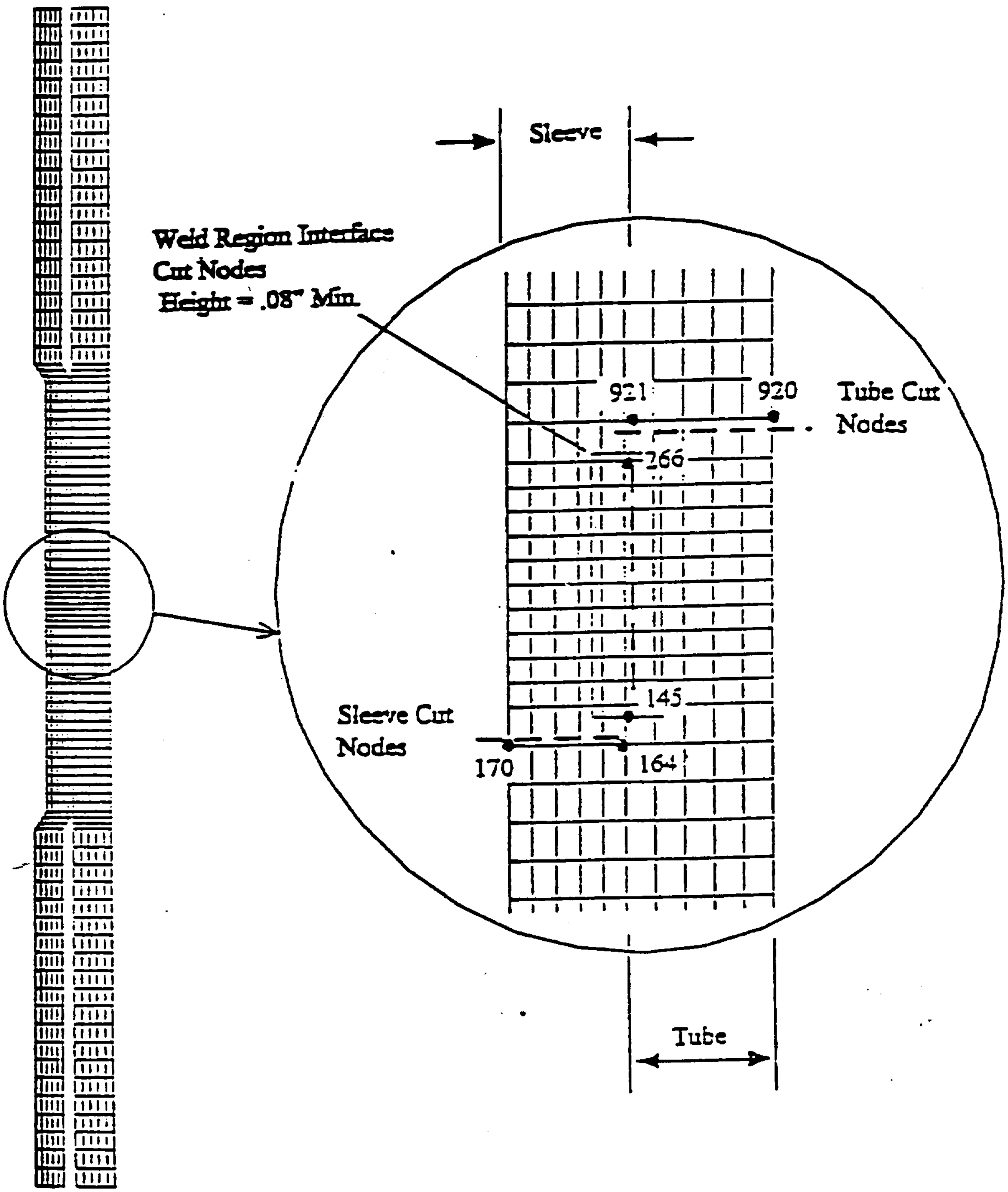
A stress concentration factor of 4 is conservatively applied to the linearized membrane plus bending stresses for the axial, radial and shear stress components. The concentration factor is applied at the sleeve outside surface located below the weld, the top and bottom of the weld, and to the inside surface of the tube location above the weld.

The results of this structural analysis are summarized in the tables on pages 6 through 10. They consist of the nodal stresses at the critical section, the range of stress evaluation and the fatigue usage factor. These results show that, even assuming the higher axial loads and more restrictive transient conditions than occurs for the Comanche Peak 1 and 2 Units: the usage factor is equal to 0.017, which is significantly less than the ASME Code allowable value of 1.0.

[redacted]

Figure 1

Node and Stress Cut Identification for Finite Element Model



[redacted]

STRESS RESULTS AT THE 100% STEADY STATE TRANSIENT

SLEEVE, SECTION BELOW WELD (KSI)				
LOCATION	σ_{Radial}	σ_{Axial}	σ_{Hoop}	τ_{Shear}
INSIDE, Node 170	-2.33	-6.59	-6.94	-.88
OUTSIDE, Node 164	-1.72	-17.31	-9.32	-.88
MEMBRANE	-2.47	-12.05	-8.13	-.88

WELD (KSI)				
LOCATION	σ_{Radial}	σ_{Axial}	σ_{Hoop}	τ_{Shear}
BOTTOM, Node 145	-2.13	-5.61	-6.43	2.18
TOP, Node 266	-3.67	-7.89	-5.26	2.18
MEMBRANE	-2.90	-8.43	-5.86	2.18

TUBE, SECTION ABOVE WELD (KSI)				
LOCATION	σ_{Radial}	σ_{Axial}	σ_{Hoop}	τ_{Shear}
INSIDE, Node 921	-3.23	-2.63	11.68	-.79
OUTSIDE, Node 920	-.94	11.12	14.12	-.79
MEMBRANE	-2.24	4.39	12.91	-.79

[redacted]

STRESS RESULTS AT THE 15% STEADY STATE TRANSIENT

SLEEVE, SECTION BELOW WELD (KSI)				
LOCATION	σ_{Radial}	σ_{Axial}	σ_{Hoop}	τ_{Shear}
INSIDE, Node 170	-2.19	-4.15	-3.36	-.23
OUTSIDE, Node 164	-1.48	-4.25	-2.98	-.23
MEMBRANE	-1.89	-4.20	-3.17	-.23

WELD (KSI)				
LOCATION	σ_{Radial}	σ_{Axial}	σ_{Hoop}	τ_{Shear}
BOTTOM, Node 145	-2.54	-4.75	-4.26	.43
TOP, Node 266	-2.85	-5.20	-4.12	.43
MEMBRANE	-2.69	-6.30	-4.20	.43

TUBE, SECTION ABOVE WELD (KSI)				
LOCATION	σ_{Radial}	σ_{Axial}	σ_{Hoop}	τ_{Shear}
INSIDE, Node 921	-2.68	1.63	10.72	-.35
OUTSIDE, Node 920	-.87	7.04	10.89	-.35
MEMBRANE	-1.75	4.39	10.80	-.35

[redacted]

STRESS RESULTS AT THE 0% STEADY STATE TRANSIENT

SLEEVE, SECTION BELOW WELD (KSI)				
LOCATION	σ_{Radial}	σ_{Axial}	σ_{Hoop}	τ_{Shear}
INSIDE, Node 170	-2.20	-2.01	1.49	-.20
OUTSIDE, Node 164	-1.04	-1.22	1.68	-.20
MEMBRANE	-1.70	-1.61	1.59	-.20

WELD (KSI)				
LOCATION	σ_{Radial}	σ_{Axial}	σ_{Hoop}	τ_{Shear}
BOTTOM, Node 145	-2.27	.08	.99	-.15
TOP, Node 266	-2.18	.23	.79	-.15
MEMBRANE	-2.23	-1.57	.88	-.15

TUBE, SECTION ABOVE WELD (KSI)				
LOCATION	σ_{Radial}	σ_{Axial}	σ_{Hoop}	τ_{Shear}
INSIDE, Node 921	-1.93	3.96	8.57	-.22
OUTSIDE, Node 920	-.80	4.79	7.62	-.22
MEMBRANE	-1.16	4.39	8.10	-.22

[redacted]

STRESS RESULTS AT THE FEEDWATER CYCLING TRANSIENT

SLEEVE, SECTION BELOW WELD (KSI)				
LOCATION	σ_{Radial}	σ_{Axial}	σ_{Hoop}	τ_{Shear}
INSIDE, Node 170	-2.20	.07	6.02	-.09
OUTSIDE, Node 164	-.63	2.79	6.34	-.09
MEMBRANE	-1.48	1.46	6.18	-.09

WELD (KSI)				
LOCATION	σ_{Radial}	σ_{Axial}	σ_{Hoop}	τ_{Shear}
BOTTOM, Node 145	-2.10	4.31	5.69	-.83
TOP, Node 266	-1.54	5.18	5.09	-.83
MEMBRANE	-1.82	2.69	5.39	-.83

TUBE, SECTION ABOVE WELD (KSI)				
LOCATION	σ_{Radial}	σ_{Axial}	σ_{Hoop}	τ_{Shear}
INSIDE, Node 921	-1.23	6.43	6.64	-.06
OUTSIDE, Node 920	-.73	2.43	4.47	-.06
MEMBRANE	-.58	4.39	5.56	-.06

[redacted]

STRESS INTENSITY RANGE AT THE WORST LOCATION

SLEEVE, SECTION BELOW WELD - *OUTSIDE SURFACE*						
	PRINCIPAL STRESSES			STRESS INTENSITIES		
CONDITION	S1	S2	S3	S1-S3	S2-S3	S1-S2
100% STEADY STATE	-9.23	-17.41	-1.72	-7.51	-15.69	8.18
15% STEADY STATE	-2.94	-4.29	-1.48	-1.46	-2.82	1.35
0% STEADY STATE	1.69	-1.23	-1.04	2.73	-.20	2.92
FEEDWATER CYCLING	6.35	2.79	-.63	6.97	3.41	3.51
		RANGE		14.48	19.10	8.81

Max. SI Range = 19.10 < 3 S_m = 80 ksi

FATIGUE EVALUATION AT THE WORST LOCATION

A stress concentration factor of 4 is applied to the axial, radial and shear stress.

SLEEVE, SECTION BELOW WELD - *OUTSIDE SURFACE*						
	PRINCIPAL STRESSES			STRESS INTENSITIES		
CONDITION	S1	S2	S3	S1-S3	S2-S3	S1-S2
100% STEADY STATE	-9.12	-69.45	-6.87	-2.25	-62.58	60.34
15% STEADY STATE	-2.92	-17.07	-5.9	2.99	-11.16	14.15
0% STEADY STATE	1.77	-4.98	-4.14	5.91	-.83	6.74
FEEDWATER CYCLING	11.19	6.32	-2.5	13.69	8.82	4.87

OUTSIDE SURFACE - S2 - S3 (SLEEVE, SECTION BELOW WELD)						
CONDITIONS	S_{max}	S_{min}	S_{alt}	N_{allow}	N_{req}	U
FW CYC -100% SS	8.82	-62.58	35.70	207048	2000	.0097
AMBIENT -100% SS	0.00	-62.58	31.29	471610	500	.0011
0% SS - 100% SS	-.83	-62.58	30.88	512441	3180	.0062
					Total U =	**.0170**

By inspection of the previous tables it can be seen that the usage factors for the other locations will be less than .017.

[redacted]

Based on these evaluations, it is concluded that TIG-welded sleeves, as qualified by the report in Reference 2, are acceptable for use in the Comanche Peak 1 and 2 steam generators.

Prepared by,

B. A. Bell

VERIFICATION STATUS: COMPLETE

The Safety-Related design information contained in this document has been verified to be correct by means of Design Review using Checklist in QP-3.10 of QPM-101.

Name J. G. THAKKAR Signature ________ Date 3/12/2001
Independent Reviewer

APPROVED BY: ________ D.P. SISKA DATE 3-13-2001

Attachment 1: Mathcad 8.0 Files
Attachment 2: Other Design Document Checklist (For Q. A. Records only)
Attachment 3: References

[redacted]

ATTACHMENT 1

MATHCAD 8.0 FILES

"CP3_SLV01.mcd" TIG-Welded Sleeve in Comanche Peak 1 (D4) Tube

"CP4_SLV01.mcd" TIG-Welded Sleeve in Comanche Peak 2 (D5) Tube

Comanche Peak 1 (Westinghouse D4) Plant 26.0" TIG-Welded Sleeve "CP3_SLV01.MCD" page 1

==

Data:
====

Tube w/T fluid prim = 618.8 °F & Tfluid sec = 535.18 °F.
Center of Lower Joint to Center of Last Upper Joint, & Sleeve Ro = 0.3125 in.
TUBE BUNDLE PERIPHERY and 0.043 inch tube wall thickness!!

$i := 0..4$ Sleeve and Tube Geometry and Orientation Dimensions are from References 1 & 2 (figure 8-3).

Outer Radius (in.) Inner Radius (in.) Length (in.)

$$Ro := \begin{bmatrix} .3125 \\ .375 \\ 0 \\ .375 \\ 0 \end{bmatrix} \quad Ri := \begin{bmatrix} .281 \\ .332 \\ 0 \\ .332 \\ 0 \end{bmatrix} \quad L := \begin{bmatrix} 24.125 \\ 14.32 \\ 9.805 \\ 21.93 \\ 36.25 \end{bmatrix}$$

1. Sleeve
2. Lower Tube (Sleeved)
3. Tube in Tubesheet (Sleeved)
4. Upper Tube (unsleeved to support)
5. Surrounding Tubes for D4 S.G.

$Tpri := 618.8$ (max. value for West. Plant in Reference 1)

$Tsec := 535.18$ (derived min. value for West. Plant in Reference 5) $Tnt := \dfrac{2 \cdot Tpri + Tsec}{3}$ $Tnt = 590.93$

From Reference 3, values for modulus of elasticity, Ea, (psi) and coefficient of thermal expansion, αm, (in./in./°F):

$$Ea := \begin{bmatrix} 28.006 \\ 28.894 \\ 0 \\ 28.727 \\ 0 \end{bmatrix} \cdot 10^6 \quad \text{and} \quad \alpha m := \begin{bmatrix} 8.1750 \\ 7.7492 \\ 7.4576 \\ 7.8109 \\ 7.8109 \end{bmatrix} \cdot 10^{-6} \quad \text{for} \quad Ta := \begin{bmatrix} Tpri \\ Tsec \\ Tpri \\ Tnt \\ Tnt \end{bmatrix}$$

Inconel 690
Inconel 600
SA-508, Cl. 2
Inconel 600
Inconel 600

Cross-sectional area of the respective body, in^2.

$$Area_i := \pi \cdot \left[\left(Ro_i\right)^2 - \left(Ri_i\right)^2 \right]$$

Spring constant for the respective body, lb./in.

$$K_i := \frac{Area_i \cdot Ea_i}{L_i}$$

Material Property Matrices (Reference 3):

E :=

T	E_{600}	E_{690}
-100	31.9	31.2
70	31	30.3
200	30.2	29.5
300	29.9	29.1
400	29.5	28.8
500	29	28.3
600	28.7	28.1
700	28.2	27.6

α :=

T	α_{600}	α_{690}	α_{cs}
70	6.76	7.73	6.41
100	6.9	7.76	6.50
150	7.07	7.80	6.57
200	7.2	7.85	6.67
250	7.31	7.89	6.77
300	7.4	7.93	6.87
350	7.5	7.98	6.98
400	7.57	8.02	7.07
450	7.64	8.06	7.15
500	7.7	8.09	7.25
550	7.77	8.13	7.34
600	7.82	8.16	7.42
650	7.88	8.20	7.52

Comanche Peak 1 (Westinghouse D4) Plant 26.0" TIG-Welded Sleeve. TUBE NOT LOCKED IN SUPPORT PLATE page 2

Setup Linear Interpolation Function for Material Properties

$E_{600}(T) := 10^3 \cdot \text{linterp}(E^{<0>}, E^{<1>}, T)$ $\alpha_{600}(T) := 10^{-6} \cdot \text{linterp}(\alpha^{<0>}, \alpha^{<1>}, T)$ Alloy 800

$E_{690}(T) := 10^3 \cdot \text{linterp}(E^{<0>}, E^{<2>}, T)$ $\alpha_{690}(T) := 10^{-6} \cdot \text{linterp}(\alpha^{<0>}, \alpha^{<2>}, T)$ Inconel 600

$\alpha_{508}(T) := 10^{-6} \cdot \text{linterp}(\alpha^{<0>}, \alpha^{<3>}, T)$ SA-508, Cl. 2

$$Ta = \begin{bmatrix} 618.8 \\ 535.2 \\ 618.8 \\ 590.9 \\ 590.9 \end{bmatrix} \quad E := \begin{bmatrix} E_{690}(Ta_0) \\ E_{600}(Ta_1) \\ 0 \\ E_{600}(Ta_3) \\ 0 \end{bmatrix} \cdot 10^3 \quad E = \begin{bmatrix} 2.801 \cdot 10^7 \\ 2.889 \cdot 10^7 \\ 0 \\ 2.873 \cdot 10^7 \\ 0 \end{bmatrix} \quad \alpha m := \begin{bmatrix} \alpha_{690}(Ta_0) \\ \alpha_{600}(Ta_1) \\ \alpha_{508}(Ta_2) \\ \alpha_{600}(Ta_3) \\ \alpha_{600}(Ta_4) \end{bmatrix}$$

Alloy 800
Inconel 600
SA-508, Cl. 2
Inconel 600
Inconel 600

TABLE 1 PROPERTIES

	$Ro_i =$	$Ri_i =$	$L_i =$	$Area_i =$	$Ta_i =$	$E_i \cdot 10^{-6} =$	$K_i \cdot 10^{-3} =$	$\alpha m_i \cdot 10^6 =$
1. Sleeve	0.3125	0.281	24.125	0.0587	618.8	28.006	68.1812	8.175
2. Lower Tube (Sleeved)	0.375	0.332	14.32	0.0955	535.18	28.8945	192.7092	7.7493
3. Tube in Tubesheet (Sleeved)	0	0	9.805	0	618.8	0	0	7.4576
4. Upper Tube (unsleeved to support)	0.375	0.332	21.93	0.0955	590.9267	28.7272	125.1092	7.8109
5. Surrounding Tubes	0	0	36.25	0	590.9267	0	0	7.8109

$i := 0..4$

Transients — Primary Temp. (°F) — Secondary Temp. (°F)

$$tra := \begin{bmatrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{bmatrix} \quad Tpri := \begin{bmatrix} 618.8 \\ 567 \\ 557 \\ 618.8 \\ 533 \end{bmatrix} \quad Tsec := \begin{bmatrix} 535.18 \\ 549 \\ 557 \\ 535.18 \\ 557 \end{bmatrix}$$

100% Power
15% S.S.
0% S.S.
Reactor Trip
Feedwater Cycling

The deflection or deformation of an axially loaded member due to temperature differences, d, is defined for bodies 1, 2, and 3 in Figure 8-4 of Reference 2 as follows:

$\delta 1 := L_0 \cdot \alpha m_0 \cdot (Tpri - 70)$ $\quad \delta 2 := L_1 \cdot \alpha m_1 \cdot (Tsec - 70)$ $\quad \delta 3 := L_2 \cdot \alpha m_2 \cdot (Tpri - 70)$

$\delta forced := \delta 2 + \delta 3 - \delta 1$ for the unlocked tube case

$Kt := \dfrac{K_0 \cdot K_1}{K_0 + K_1}$ (Springs in series) $F1 := \delta forced \cdot Kt$ **Sleeve load for the unlocked tube case**

$\Delta 1 := \dfrac{F1}{K_0}$ deflection of an axially loaded sleeve (body 1) in compression or tension

$Kt = 5.036 \cdot 10^4$

$\delta 6 := \delta 1 + \Delta 1$ net elongation of composite member 6 in Figure 8-5 of Reference 2

TABLE 2 UNLOCKED TUBE

$tra_i =$		$Tpri_i =$	$Tsec_i =$	$\delta 1_i =$	$\delta 2_i =$	$\delta 3_i =$	$\delta forced_i =$	$F1_i =$	$\Delta 1_i =$	$\delta 6_i =$
1	100% Power	618.8	535.18	0.1082	0.0516	0.0401	-0.0165	-830.2785	-0.0122	0.0961
2	15% S.S.	567	549	0.098	0.0532	0.0363	-0.0085	-429.289	-0.0063	0.0917
3	0% S.S.	557	557	0.096	0.054	0.0356	-0.0064	-322.0786	-0.0047	0.0913
4	Reactor Trip	618.8	535.18	0.1082	0.0516	0.0401	-0.0165	-830.2785	-0.0122	0.0961
5	FW Cycling	533	557	0.0913	0.054	0.0339	-0.0034	-172.077	-0.0025	0.0888

$K6 := K_0 + K_1$ (Springs in parallel)

$K6 = 2.61 \cdot 10^5$

$Tt := \frac{2 \cdot Tpri + Tsec}{3}$ temperatures of bodies 4 and 5

The deflection or deformation of an axially loaded member due to temperature differences, d, is defined for bodies 4 and 5 in Figure 8-5 of Reference 2 as follows:

$\delta 4 := \left(L_3 \cdot \alpha m_3\right) \cdot (Tt - 70)$ $\delta 5 := \left(L_4 \cdot \alpha m_4\right) \cdot (Tt - 70)$

$K3K6 := \frac{K_3 \cdot K6}{K_3 + K6}$ (Springs in series) $K3K6 = 8.456 \cdot 10^4$

$\delta forced := \delta 5 + \delta 3 - \delta 4 - \delta 6$ for the case with the tube locked in the first support

$F6 := K3K6 \cdot \delta forced$ Force on composite member 6 in Figure 8-5 of Reference 2

$\Delta 6 := \frac{F6}{K6}$ additional deflection of composite member 6 due to being locked in the support

$B\Delta := \Delta 1 + \Delta 6$ (addition of body 1 deflection, D1, and composite member 6 deflection, D6)

$F\_sleeve := B\Delta \cdot K_0$ **Sleeve load for the locked tube case**

TABLE 3 LOCKED TUBE

$tra_i =$		$Tpri_i =$	$Tsec_i =$	$Tt_i =$	$\delta 5_i =$	$\delta 4_i =$	$\delta forced_i =$
1	100% Power	618.8	535.18	590.9267	0.1475	0.0892	0.0023
2	15% S.S.	567	549	561	0.139	0.0841	-0.0005
3	0% S.S.	557	557	557	0.1379	0.0834	-0.0012
4	Reactor Trip	618.8	535.18	590.9267	0.1475	0.0892	0.0023
5	Feedwater Cycling	533	557	541	0.1334	0.0807	-0.0023

$tra_i =$		$F6_i =$	$\Delta 6_i =$	$B\Delta_i =$	$F\_sleeve_i =$
1	100% Power	197.6813	0.0008	-0.0114	-778.6164
2	15% S.S.	-39.0983	-0.0001	-0.0064	-439.507
3	0% S.S.	-104.9557	-0.0004	-0.0051	-349.5078
4	Reactor Trip	197.6813	0.0008	-0.0114	-778.6164
5	Feedwater Cycling	-190.4666	-0.0007	-0.0033	-221.8536

Data:

Tube w/T fluid prim = 618.8 °F & Tfluid sec = 538.41 °F.
Center of Lower Joint to Center of Last Upper Joint, & Sleeve Ro = 0.3125 in.
TUBE BUNDLE PERIPHERY and 0.043 inch tube wall thickness!!

$i := 0..4$ Sleeve and Tube Geometry and Orientation Dimensions are from References 1 & 2 (Figure 8-3).

Outer Radius (in.) Inner Radius (in.) Length (in.)

$$Ro := \begin{bmatrix} .3125 \\ .375 \\ 0 \\ .375 \\ 0 \end{bmatrix} \quad Ri := \begin{bmatrix} .281 \\ .332 \\ 0 \\ .332 \\ 0 \end{bmatrix} \quad L := \begin{bmatrix} 24.125 \\ 14.32 \\ 9.805 \\ 21.93 \\ 36.25 \end{bmatrix}$$

1. Sleeve
2. Lower Tube (Sleeved)
3. Tube in Tubesheet (Sleeved)
4. Upper Tube (unsleeved to support)
5. Surrounding Tubes for D5 S.G.

$Tpri := 618.8$ (max. value for West. Plant in Reference 1)

$Tsec := 538.41$ (derived min. value for West. Plant in Reference 5) $Tnt := \frac{2 \cdot Tpri + Tsec}{3}$ $Tnt = 592$

From Reference 3, values for modulus of elasticity, Ea, (psi) and coefficient of thermal expansion, αm, (in./in./°F):

$$Ea := \begin{bmatrix} 28.006 \\ 28.885 \\ 0 \\ 28.724 \\ 0 \end{bmatrix} \cdot 10^{6} \quad \text{and} \quad \alpha m := \begin{bmatrix} 8.1750 \\ 7.7538 \\ 7.4576 \\ 7.812 \\ 7.812 \end{bmatrix} \cdot 10^{-6} \quad \text{for} \quad Ta := \begin{bmatrix} Tpri \\ Tsec \\ Tpri \\ Tnt \\ Tnt \end{bmatrix}$$

Inconel 690
Inconel 600
SA-508, Cl. 2
Inconel 600
Inconel 600

Cross-sectional area of the respective body, in^2.

$$Area_i := \pi \cdot \left[(Ro_i)^2 - (Ri_i)^2 \right]$$

Spring constant for the respective body, lb./in.

$$K_i := \frac{Area_i \cdot Ea_i}{L_i}$$

Material Property Matrices (Reference 3):

E :=

T	E_{600}	E_{690}
-100	31.9	31.2
70	31	30.3
200	30.2	29.5
300	29.9	29.1
400	29.5	28.8
500	29	28.3
600	28.7	28.1
700	28.2	27.6

α :=

T	α_{600}	α_{690}	α_{cs}
70	6.76	7.73	6.41
100	6.9	7.76	6.50
150	7.07	7.80	6.57
200	7.2	7.85	6.67
250	7.31	7.89	6.77
300	7.4	7.93	6.87
350	7.5	7.98	6.98
400	7.57	8.02	7.07
450	7.64	8.06	7.15
500	7.7	8.09	7.25
550	7.77	8.13	7.34
600	7.82	8.16	7.42
650	7.88	8.20	7.52

Comanche Peak 2 (Westinghouse D5 Plant 26.0" TIG-Welded Sleeve, TUBE NOT LOCKED IN SUPPORT PLATE page 2
==

Setup Linear Interpolation Function for Material Properties

$E_{600}(T) := 10^3 \cdot \text{linterp}(E^{<0>}, E^{<1>}, T)$ $\alpha_{600}(T) := 10^{-6} \cdot \text{linterp}(\alpha^{<0>}, \alpha^{<1>}, T)$ Alloy 800

$E_{690}(T) := 10^3 \cdot \text{linterp}(E^{<0>}, E^{<2>}, T)$ $\alpha_{690}(T) := 10^{-6} \cdot \text{linterp}(\alpha^{<0>}, \alpha^{<2>}, T)$ Inconel 600

$\alpha_{508}(T) := 10^{-6} \cdot \text{linterp}(\alpha^{<0>}, \alpha^{<3>}, T)$ SA-508, Cl. 2

$$Ta = \begin{bmatrix} 618.8 \\ 538.4 \\ 618.8 \\ 592 \\ 592 \end{bmatrix} \quad \begin{matrix}\text{Alloy 800} \\ \text{Inconel 600} \\ \text{SA-508, Cl. 2} \\ \text{Inconel 600} \\ \text{Inconel 600}\end{matrix} \quad E := \begin{bmatrix} E_{690}(Ta_0) \\ E_{600}(Ta_1) \\ 0 \\ E_{600}(Ta_3) \\ 0 \end{bmatrix} \cdot 10^3 \quad E = \begin{bmatrix} 2.801 \cdot 10^7 \\ 2.888 \cdot 10^7 \\ 0 \\ 2.872 \cdot 10^7 \\ 0 \end{bmatrix} \quad \alpha m := \begin{bmatrix} \alpha_{690}(Ta_0) \\ \alpha_{600}(Ta_1) \\ \alpha_{508}(Ta_2) \\ \alpha_{600}(Ta_3) \\ \alpha_{600}(Ta_4) \end{bmatrix}$$

TABLE 1 PROPERTIES

	$Ro_i =$	$Ri_i =$	$L_i =$	$Area_i =$	$Ta_i =$	$E_i \cdot 10^{-6} =$	$K_i \cdot 10^{-3} =$	$\alpha m_i \cdot 10^6 =$
1. Sleeve	0.3125	0.281	24.125	0.0587	618.8	28.006	68.1812	8.175
2. Lower Tube (Sleeved)	0.375	0.332	14.32	0.0955	538.41	28.8848	192.6491	7.7538
3. Tube in Tubesheet (Sleeved)	0	0	9.805	0	618.8	0	0	7.4576
4. Upper Tube (unsleeved to support)	0.375	0.332	21.93	0.0955	592.0033	28.724	125.0962	7.812
5. Surrounding Tubes	0	0	36.25	0	592.0033	0	0	7.812

$i := 0..4$

Transients — Primary Temp. (°F) — Secondary Temp. (°F)

$$tra := \begin{bmatrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{bmatrix} \quad \begin{matrix}\text{100\% Power} \\ \text{15\% S.S.} \\ \text{0\% S.S.} \\ \text{Reactor Trip} \\ \text{Feedwater Cycling}\end{matrix} \quad Tpri := \begin{bmatrix} 618.8 \\ 567 \\ 557 \\ 618.8 \\ 533 \end{bmatrix} \quad Tsec := \begin{bmatrix} 538.41 \\ 549 \\ 557 \\ 538.41 \\ 557 \end{bmatrix}$$

The deflection or deformation of an axially loaded member due to temperature differences, d, is defined for bodies 1, 2, and 3 in Figure 8-4 of Reference 2 as follows:

$\delta 1 := L_0 \cdot \alpha m_0 \cdot (Tpri - 70)$ $\delta 2 := L_1 \cdot \alpha m_1 \cdot (Tsec - 70)$ $\delta 3 := L_2 \cdot \alpha m_2 \cdot (Tpri - 70)$

$\delta forced := \delta 2 + \delta 3 - \delta 1$ for the unlocked tube case

$Kt := \dfrac{K_0 \cdot K_1}{K_0 + K_1}$ (Springs in series) $F1 := \delta forced \cdot Kt$ **Sleeve load for the unlocked tube case**

$\Delta 1 := \dfrac{F1}{K_0}$ deflection of an axially loaded sleeve (body 1) in compression or tension

$Kt = 5.036 \cdot 10^4$

$\delta 6 := \delta 1 + \Delta 1$ net elongation of composite member 6 in Figure 8-5 of Reference 2

TABLE 2 UNLOCKED TUBE

$tra_i =$		$Tpri_i =$	$Tsec_i =$	$\delta 1_i =$	$\delta 2_i =$	$\delta 3_i =$	$\delta forced_i =$	$F1_i =$	$\Delta 1_i =$	$\delta 6_i =$
1	100% Power	618.8	538.41	0.1082	0.052	0.0401	-0.0161	-810.6334	-0.0119	0.0963
2	15% S.S.	567	549	0.098	0.0532	0.0363	-0.0085	-427.692	-0.0063	0.0917
3	0% S.S.	557	557	0.096	0.0541	0.0356	-0.0064	-320.4643	-0.0047	0.0913
4	Reactor Trip	618.8	538.41	0.1082	0.052	0.0401	-0.0161	-810.6334	-0.0119	0.0963
5	FW Cycling	533	557	0.0913	0.0541	0.0339	-0.0034	-170.4749	-0.0025	0.0888

$K6 := K_0 + K_1$ (Springs in parallel)

$K6 = 2.61 \cdot 10^5$

$Tt := \frac{2 \cdot Tpri + Tsec}{3}$ temperatures of bodies 4 and 5

The deflection or deformation of an axially loaded member due to temperature differences, d, is defined for bodies 4 and 5 in Figure 8-5 of Reference 2 as follows:

$\delta 4 := \left(L_3 \cdot \alpha m_3\right) \cdot (Tt - 70)$ $\delta 5 := \left(L_4 \cdot \alpha m_4\right) \cdot (Tt - 70)$

$K3K6 := \frac{K_3 \cdot K6}{K_3 + K6}$ (Springs in series) $K3K6 = 8.455 \cdot 10^4$

$\delta forced := \delta 5 + \delta 3 - \delta 4 - \delta 6$ for the case with the tube locked in the first support

$F6 := K3K6 \cdot \delta forced$ Force on composite member 6 in Figure 8-5 of Reference 2

$\Delta 6 := \frac{F6}{K6}$ additional deflection of composite member 6 due to being locked in the support

$B\Delta := \Delta 1 + \Delta 6$ (addition of body 1 deflection, D1, and composite member 6 deflection, D6)

$F\_sleeve := B\Delta \cdot K_0$ **Sleeve load for the locked tube case**

TABLE 3 LOCKED TUBE

tra_i =		$Tpri_i$ =	$Tsec_i$ =	Tt_i =	$\delta 5_i$ =	$\delta 4_i$ =	$\delta forced_i$ =
1	100% Power	618.8	538.41	592.0033	0.1478	0.0894	0.0022
2	15% S.S.	567	549	561	0.139	0.0841	-0.0005
3	0% S.S.	557	557	557	0.1379	0.0834	-0.0013
4	Reactor Trip	618.8	538.41	592.0033	0.1478	0.0894	0.0022
5	Feedwater Cycling	533	557	541	0.1334	0.0807	-0.0023

tra_i =		$F6_i$ =	$\Delta 6_i$ =	$B\Delta_i$ =	F_sleeve_i =
1	100% Power	184.1542	0.0007	-0.0112	-762.4953
2	15% S.S.	-40.4329	-0.0002	-0.0064	-438.2612
3	0% S.S.	-106.3074	-0.0004	-0.0051	-348.2531
4	Reactor Trip	184.1542	0.0007	-0.0112	-762.4953
5	Feedwater Cycling	-191.8117	-0.0007	-0.0032	-220.6146

[redacted]

ATTACHMENT 2

Other Design Document Checklist (3 pages)

(Copies in Q.A. Records)

[redacted]

Other Design Document Checklist

Instructions: The Independent Reviewer is to complete this checklist for each Other Design Document. This Checklist is to be made part of the Quality Record package, although it need not be made a part of or distributed with the document itself. The second section of this checklist lists potential topics which could be relevant for a particular "Other Design Document". If they are applicable, then the relevant section of the Design Analysis Verification Checklist shall be completed and attached to this checklist. (Sections of the Design Analysis Verification Checklist which are not used may be left blank.)

Section 1: To be completed for all "Other Design Documents"	Yes	N/A
Overall Assessment		
1. Are the results/conclusions correct and appropriate for their intended use?	☑	
2. Are all limitations on the results/conclusions documented?	☑	
Documentation Requirements		
1. Is the documentation legible, reproducible and in a form suitable for filing and retrieving as a Quality Record?	☑	
2. Is the document identified by title, document number and date?	☑	
3. For a complete or page change revision, is there a revision history page?	☐	☑
4. Are all pages identified with the document number including revision number?	☑	☐
5. Do all pages have a unique page number?	☑	☐
6. Does the content clearly identify, as applicable:		
a. objective.	☑	☐
b. design inputs (in accordance with QP 3.2).	☑	☐
c. conclusions.	☑	☐
7. Is the verification status of the document indicated?	☑	
8. If an Independent Reviewer is the supervisor or Project Manager, has authorization as an Independent Reviewer been documented?	☐	☑
Assumptions / Contingencies		
1. Are local assumptions documented, justified and verified?	☑	☐
2. Have Internal and External assumptions and contingencies which must be cleared by CENP or the customer been listed on a Contingencies and Assumptions form?	☐	☑
3. Is the Project Manager responsible for clearing the Assumptions / Contingencies identified on the form?	☐	☑

[redacted]

Other Design Document Checklist

Assessment of Significant Design Changes	Yes	N/A
1. Have significant design-related changes that might impact this document been considered?	☑	☐
2. If any such changes have been identified, have they been adequately addressed?	☑	☐
Selection of Design Inputs		
1. Are the design inputs documented?	☑	
2. Are the design inputs correctly selected and traceable to their source?	☑	
3. Are references as direct as possible to the original source or documents containing collection/tabulations of inputs?	☑	
4. Is the reference notation appropriately specific to the information utilized?	☑	
5. Are the bases for selection of all design inputs documented?	☑	☐
6. Is the verification status of design inputs transmitted from customers appropriate and documented?	☐	☑
7. Is the verification status of design inputs transmitted from ABB CENS appropriate and documented?	☐	☑
8. Is the use of customer-controlled sources such as Tech Specs, UFSARs, etc. authorized, and does the authorization specify amendment level, revision number, etc.?	☐	☑
9. a. Is the document accurate and complete and, if applicable, has proper assembly and/or operational sequencing been detailed?	☑	☐
b. If required, has mock-up testing been performed to verify the document's accuracy, completeness and proper assembly or operational sequencing?	☑	☐
References		
1. Are all references listed?	☑	☐
2. Do the reference citations include sufficient information to assure retrievability and unambiguous location of the referenced material?	☑	☐
3. Do the item numbers in the document agree with the item numbers on the reference?	☑	☐
Section 2: Other Potentially Applicable Topic Areas - use appropriate sections of the Design Analysis Verification Checklist (QP 3.4, Exhibit 3.4 - 3) and attach.	**Yes**	**N/A**
1. Use of Computer Software	☐	☑
2. Applicable Codes and Standards	☑	☐
3. Literature Searches and Background Data	☑	☐
4. Methods	☑	☐
5. Hand Calculations	☑	☐
6. List of Computer Software	☐	☑
7. List of optical disks (CD-ROM), computer disks or Microfiche	☐	☑

[redacted]

Other Design Document Checklist

Independent Reviewer's Comments				
Comment Number	Reviewer's Comment	Response Required?	Author's Response	Response Accepted?
1.	This report is a correction	NO.		
	from 0.80/.20 feedwater			
	flow split in CSE-00-130			
	to 0.85/0.15. This			
	decreases the max. axial			
	loads by ~2%.			

Checklist completed by:

	Printed Name	Signature	Date
Independent Reviewer	J. G. THAKKAR	J. G. Thakkar	3/12/2001

W[redacted]

ATTACHMENT 3

References

(5) E-mail Note from Steve Swilley to David Stepnick on "Sleeving", February 16, 2001.

[redacted]

sswilley@txu.com
02/16/2001 03:31 PM

To: David G. Stepnick/CENO/USNUS/BNFL-TEMP@ABB_USSEV_IMS
cc:
Subject: Sleeving
Security Level:? Internal

Dave,
In reviewing Letters CSE-00-128 and CSE-00-130, I noticed in the assumptions stated in Section 8.3 that the Feedwater Flow Split was assumed to be 0.2 when in reality we have an 85:15 split which would be 0.15. I am assuming that would be in the conservative direction since the number was used to calculate downcomer enthalpy but I would like you to confirm that.
You also had mentioned that Kevin Sweeney had some comments to the I800 sleeve report and that you could share those with me.
Steve