UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of TEXAS UTILITIES ELECTRIC COMPANY, ET AL. (Comanche Peak Steam Electric Station, Units 1 and 2)	Docket Nos. 50-445 and 50-446 (Application for Operating Licenses)

AFFIDAVIT OF JOHN C. FINNERAN, JR. IN SUPPORT OF APPLICANTS' REPLY TO CASE'S ANSWER TO APPLICANTS' MOTION FOR SUMMARY DISPOSITION REGARDING LOCAL DISPLACEMENTS AND STRESSES

I, John C. Finneran, Jr., being first duly sworn hereby depose and state, as follows: I am the Project Pipe Support Engineer for the Comanche Peak Steam Electric Station. In this position I oversee the design work of all pipe support design organizations for Comanche Peak. A statement of my educational and professional qualifications was received into evidence as Applicants' Exhibit 142B.

Q. What is the purpose of this affidavit?

A. This affidavit provides information in support of Applicants' Reply to CASE's Answer to Applicants' Motion for Summary Disposition Regarding Consideration of Local Displacements and Stresses. I address below the arguments CASE presents in the affidavit of Mr. Doyle ("Affidavit"). CASE takes issue only with respect to Applicants first statement of material fact.

8410020295 840928
PDR ADOCK 05000445
G PDR

Q. What is your response to CASE's first argument regarding Applicants' motion?

A. CASE disputes Applicants' statement in Attachment A to my original affidavit regarding the effect of neglecting air film insulation in the calculation of the temperature of the tube steel (Affidavit at 3-4). It appears CASE misunderstands Applicants' statement and the principles of air film insulation. CASE seems to believe that the "air film" which Applicants mentioned is located at the interface, or point of contact, between the tube steel and the pipe. There is no air film at the point of contact of the pipe and box frame. This phenomenon occurs over the remainder of the surface area of the box frame. Its insulating effect serves to reduce the rate of heat transfer from the frame to the surrounding atmosphere, thereby causing the frame to expand further and reduce the stress between the pipe and frame. Thus, neglecting this effect as Applicants have done is conservative.

Further, for the situation CASE apparently envisions to exist regarding air film, a gap between the frame and the pipe would have to be present. However, were such a gap to exist, which it does not, the pipe would be able to expand through that gap before contacting the frame thereby reducing the ultimate stress between the pipe and the frame. CASE apparently does not recognize this consideration.

Finally, I note that we have recently performed, at the request of the NRC Staff, a finite difference analysis of the temperature distribution within the box frame of this support. This analysis was provided to CASE with Applicants' letter to the NRC Staff, dated September 24, 1984. A copy of the results of that analysis is attached hereto as Attachment A. As demonstrated therein, Applicants' initial assumption for the temperature distribution in the box frame was very conservative. Applicants originally assumed an average temperature within the frame of 203°F. The finite difference analysis found that the <u>minimum</u> temperature within the frame is actually 206°F. The average temperature in the frame is greater than 220°F. At this higher temperature the frame will expand more than originally assumed and, thus, the stresses in the pipe and the frame will decrease. Accordingly, Applicants' original simplifying assumption was conservative, as we indicated at that time.

Q. What is your reply to CASE's second point?

A. CASE contends that the temperature gradient in the tube steel will vary along the tube from that existing through the tube at the point of contact of the frame and the pipe (Affidavit at 4). However, CASE does not point to any particular effect it believes this varying temperature gradient will have on Applicants' analysis. Consequently, it is not possible to respond directly to CASE's argument. It should be noted, nonetheless, that Applicants' finite

difference analysis mentioned above demonstrated that the temperature gradients along the tube are, in fact (as originally assumed) nearly linear across the frame and along the length of the tube away from the point of contact between the frame and the pipe (Attachment A; sh. 11 of 11). Thus, although the gradients do vary, Applicants' assumption of linearity for taking an average temperature of the tube was reasonable and, in fact, conservative given the conclusion from the finite element analysis that the lowest temperature in the frame (206°F) is actually higher than the average temperature (203°F) originally assumed. Thus, the expansion of the frame will actually be greater than initially estimated.

Q. What is your response to CASE's third assertion?

A. CASE asserts that the expansion of the frame calculated by Applicants will actually be "far less" because of the thermal gradients (Affidavit at 4). As I have already noted, Applicants' original assessment was appropriate and very conservative, actually underestimating the expansion of the frame. CASE's assertion to the contrary is simply wrong.

CASE also claims that the thermal gradients within the box frame will give rise to differential expansion of the frame, creating internal thermal stresses (Affidavit at 4-5). The Board has already ruled that such internal thermal

stresses need not be considered under the ASME Code (Memorandum and Order (Thermal Stress in Pipe Supports), July 6, 1983).

Q. What is your response to CASE's fourth argument?

A. CASE again asserts that the thermal gradients within the box frame are not linear (relying on CASE Exhibits 669B, Items 13E-13J) and, thus, stresses will be higher due to "direct bending . . . only as a result of thermal constraint" (Affidavit at 5). In the first instance, it is not possible to draw any meaningful conclusion by comparing CASE's exhibits with the support at issue here. Heat flow calculations involve many parameters and are highly dependent on configuration, proximity to the pipe, number of and extent of contact points with the pipe, etc. None of the configurations in CASE's exhibits are similar to the support involved here. Finally, to the extent CASE again argues that stresses resulting from "thermal constraint" need be considered, as I already noted the Board previously ruled that such stresses need not be considered.

Q. What is your reply to CASE's final argument?

A. CASE's final assertion is that Applicants' employed an incorrect value for Young's Modulus in calculating the expansion of the frame (Affidavit at 5). CASE apparently assumed Applicants employed an AISC formula for calculating the coefficient of thermal expansion. However, because this support is an ASME support, Applicants utilized the value

for the coefficient of thermal expansion set forth in Appendix I to Section III of the ASME Code. Applicants used the value set forth in Table I-50 (Attachment B) for the coefficient at $200^{\circ}F$ (6.38×10^{-6}) adjusted for the $203^{\circ}F$ temperature assumed for the frame (6.387×10^{-6}). Finally, it should be noted that although CASE apparently contends Applicants should have used the coefficient CASE derived, CASE does not acknowledge that to do so would be less conservative in that the expansion of the frame would be greater and, thus, lower stresses would be created in the frame and the pipe.

Q. Do you have any further comments regarding CASE's assertions?

A. To summarize my previous comments, I note that none of CASE's arguments raised valid concerns. CASE has failed to point to any significant effect that should have been, but was not, considered in Applicants' analysis.

John C. Finneran, Jr.

John C. Finneran, Jr.

STATE OF TEXAS
COUNTY OF SOMERVELL

Subscribed and sworn to before me this 28th day of September, 1984.

Notary Public

MY COMMISSION EXPIRES MARCH 28, 1988

EBASCO SERVICES INCORPORATED

BY J. SHIN DATE 9/19/84 SHEET 8 OF

CHKD. BY [illegible] DATE 9/19/84 OFS NO. 2970.002 DEPT. NO. 462

CLIENT TUGC

PROJECT COMANCHE PEAK S.E.S.

SUBJECT 3-D OPEN END BOX BEAM

Assumptions

1) Pipe surface temperature 350°F

2) Hollow box beams are located vertically.

3) Passing connecting air inside hollow box beam is 104°F.

To find temperature distribution, a model for computer code HEATING 5 is utilized.

Proper natural heat convection inside gap between pipe and box beam, and inside hollow box beam is included. Radiation between pipe and box beams, and conduction thru direct contact are calculated with the proper input data by HEATING 5 in 3-D model. Also natural convection at the surface of box beams are accounted in the model.

The results are shown in ~~the next~~ page 11 of calculation

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PROJECT COMANCHE PEAK S.E.S.

SUBJECT 3-D OPEN END BOX BEAM

References)

1) FLOW OF FLUIDS THROUGH VALVES, FITTINGS AND PIPE BY CRANE

2) Heat Transfer by A. J. Chapman Macmillan Co.

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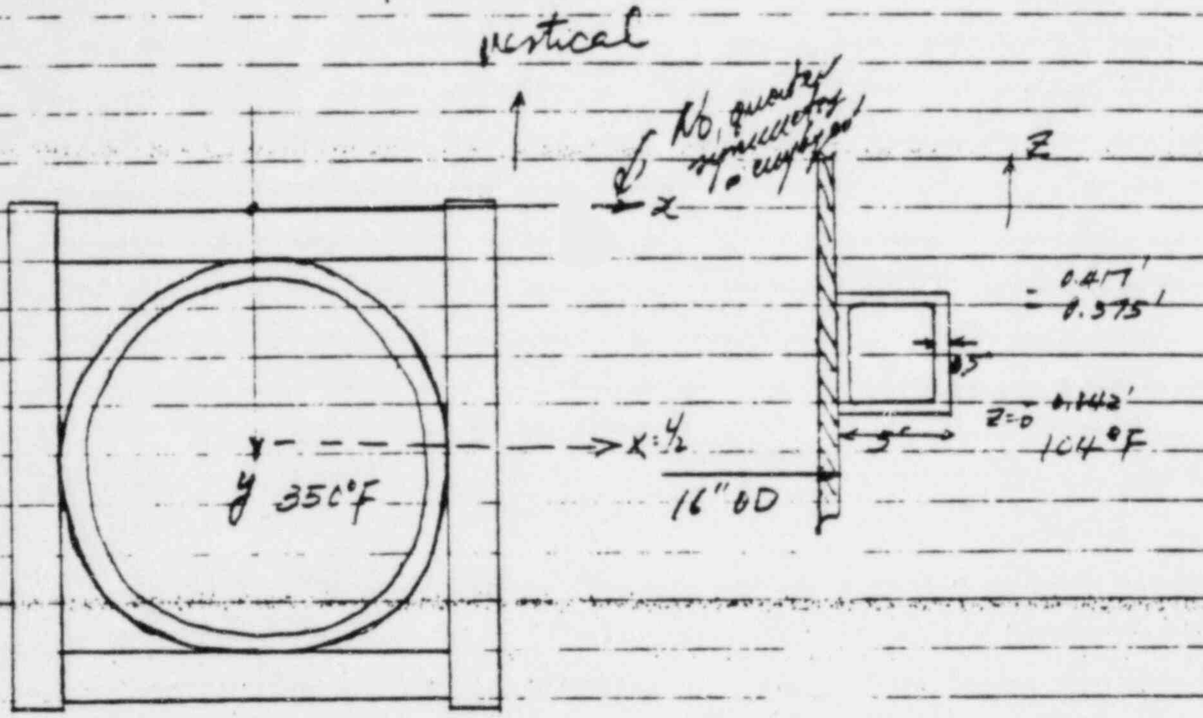
SUBJECT 3-D OPEN END BOX BEAMS



Purpose: To find out temperature distribution of the box beam

Major assumptions

1) Pipe surface temperature 350°F ✓

2) Hollow box beams are located vertically as shown in the Figure. ✓

3) No significant pressure is applied between pipe and box beam (or line contact)

4) Symmetry with respect to z = ~~x~~ L/2

Note a pipe expands more contact will be made and heat will transfer more readily

5) Passing convecting air inside hollow box beam is 104°F, this is conservative since air will be hotter

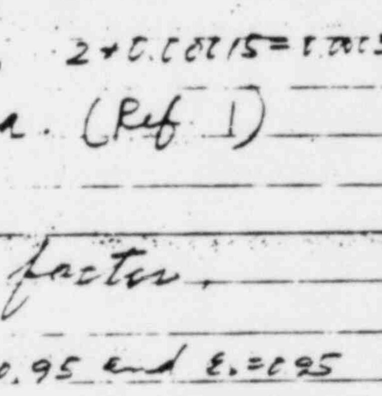
6) Air temperature of the gap between pipe and box beam is 104°F for conservatism — OK

To find temperature distribution a model for computer code HEATING 5 is considered as depicted in the next page. (one quadrant considered)

Since height of roughness of commercial stainless steel is 0.00015 inches, 2*0.00015=0.0003 is assumed as direct contact area. (Ref 1)

Now to find radiation shape factor.

for gray body emissivity $\varepsilon_1 = 0.95$ and $\varepsilon_2 = 0.95$ (Ref 2 Pg 426)



$$q_{12} = \frac{A_1 F_{1-2} \sigma (T_1^4 - T_2^4)}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1}$$

0.1549857×10^{-8} $\quad \sigma : 0.1713 \times 10^{-8}$

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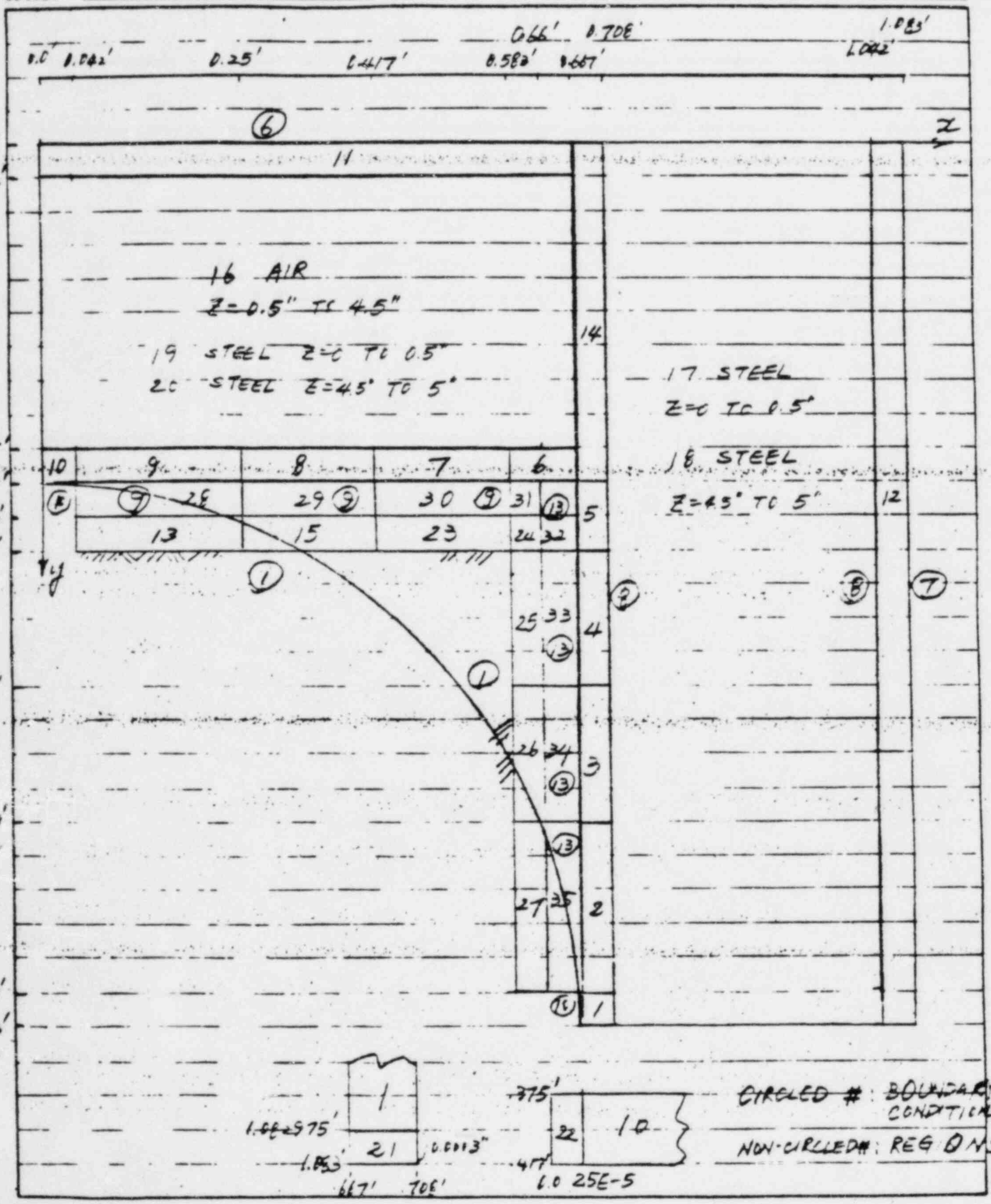
SUBJECT 3-D OPEN END BOX BEAMS



Where regions 13, 15, 22, 24, 25, 26 and 27 signify the pipe surface for this model and regions 28, 29, 30, 31, 32, 33, 34 and 35 are for 2 gap.

FROM PAGE 3

Two parallel plates in the sub-divided region For gaps 35 and 28 (Ref 2 page 320)

2.5" long 0.5" gap

$R_1 = \frac{L}{D} = \frac{5}{0.5} = 10$

$R_2 = \frac{W}{D} = \frac{2.5}{0.5} = 5$

$F_{12} = 0.75 \rightarrow 1.1624 \times 10^{-9}$

$q_{12} = A \frac{\sigma (T_1^4 - T_2^4)}{f}$

2" long 1" gap for gaps 34 and 29

$R_1 = \frac{5}{1} = 5$

$R_2 = \frac{2}{1} = 2$

$F_{12} = 0.53 \rightarrow 8.2142 \times 10^{-10}$

2" long 3" gap for gaps 33 and 30

$R_1 = 1.667$

$R_2 = 0.667$

$F_{12} = 0.2 \rightarrow 3.0997 \times 10^{-10}$

0.5" long 6.5" gap

$F_{12} = 0.0075 \rightarrow 1.1624 \times 10^{-11}$

The foregoing radiation is between the pipe and box beams.

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SUBJECT 3-D OPEN END BOX BEAMS

To calculate natural convection in the gap between the pipe and the box beam.

Chapman (Ref 2) pg 277, 275 and 418

Heat transfer coefficient for air

for B.C ⑨ horizontal plates

$$h = 0.12\left(\frac{\Delta t}{L}\right)^{1/4} = \frac{0.12}{\left(\frac{5}{12}\right)^{1/4}}(\Delta t)^{1/4} = 0.15(\Delta t)^{1/4}$$

for B.C ⑬ vertical plates

$$h = 0.29\left(\frac{\Delta t}{L}\right)^{1/4} = \frac{0.29}{\left(\frac{8}{12}\right)^{1/4}}(\Delta t)^{1/4} = 0.32(\Delta t)^{1/4}$$

Heat transfer coeff. for B.C ⑥, ⑦ and 8

Grashoff number should be calculated.

$$N_{Gr} = (\beta \Delta t)\left(\frac{L^3 g}{\nu^2}\right)$$

Let's set $\left(\frac{260+340}{2} + 104\right)/2 = 202 \rightarrow 200°F$

$N_{Pr} = 0.694$, $\nu = 0.8636\ ft^2/hr$

$L = \frac{26}{12} = 2.17 (ft)$

$\Delta t = \frac{260+340}{2} - 104 = 196 (°F)$

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SUBJECT 3-D OPEN END BOX BEAMS

$\beta = \frac{1}{T} = \frac{1}{460+200} = \frac{1}{660}$: ~~expansion coeff for air~~

$N_{Gr} P_r = \frac{196}{660} \left(\frac{26}{12}\right)^3 \frac{32.2 * 3600^2}{0.8636^2} * 0.694$

$= 1.17 * 10^9 > 10^9$

turbulent flow!

$h = 0.19 (\Delta t)^{1/3}$ for vertical plates

$h = 0.22 (\Delta t)^{1/3}$ for horizontal plates

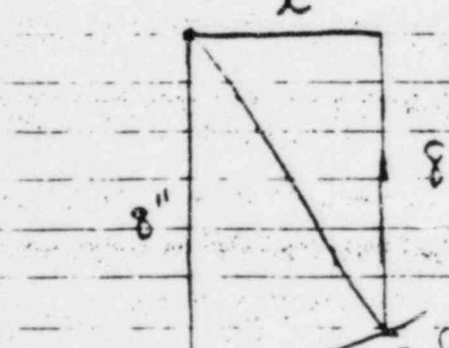
This is ok for heat transfer from plate up, but overestimates heat transfer from plate down, which is ok since it will lead to cooler frame under surface

891/9-81

Assuming conduction through an air space, an effective interface heat transfer coefficient may be calculated assuming that the heat is transferred through the air space only by conduction. This is a good approximation.

$$h_i = \frac{k}{\delta} = \frac{.022}{\delta} \qquad l = \sqrt{16\delta - \delta^2}$$

	δ (in)	δ (ft)	h_i (BTU/hr ft² °F)	l (in)
direct contact area	0	0	∞	0
	.00015	.0000125	1760	
	.0003	.000025	880	.069
gap conduction	.001	.0000833	264	.126
	.002		132	.179
	.004		66	
	.008		33	
	.016		16.5	.506
	.032		8.25	.715
	.064		4.125	1.00
	.128	.0106667	2.0625	1.43



$$(8-\delta)^2 + l^2 = 8^2$$

$$l^2 = 8^2 - (8-\delta)^2$$

$$l = \sqrt{64 - (8-\delta)^2}$$

$$l = \sqrt{16\delta - \delta^2}$$

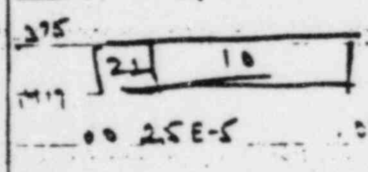
Height of roughness of commercial stainless steel 0.00015 inches. Assuming direct contact as 2ε or 0.0003 inches.

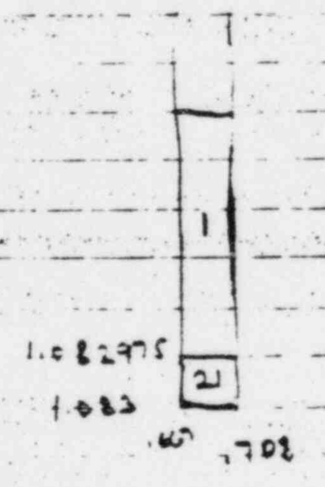
Update 1

Add 2 regions in contact and change the BC for regions ① and ⑩ to include heat conduction through air. $h_{eq} = 53$ corresponding to equivalent gap of .008"
length of contact .0023"

Regions 21 and 22 will have BC 1 (ie contact temp of 350°)

Region 1 and 10 will have new BC 10, with h = 53 and radiation of shape factor 1.0 ie 15.5E-10





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OFS NO. 2970.002 DEPT. NO. 460

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PROJECT COMANCHE PEAK S.E.S

SUBJECT 3-D OPEN END BOX BEAMS

HEATING5 computer code was run with the foregoing model and input data.

The results are shown in the next pages.

INPUT DATA

```
COPYBF,ATAPE,HTR.
REWIND,HTR.
COPY,HTR,PHEATS.
REWIND,HTR,PHEATS.
BEGIN,HEATS,HTR,0,0,0,0,0,0.
ATTACH,MFPROC,ID=SCS,PW=ITEL.
MFPROC,OUTPUT.
MFADDRS. M ZUZOVSKY EBASCO SERVICES INC  TWO WORLD TRADE CENTER
MFADDRS. 89TH FLOOR    NEW YORK, N.Y. 10048
MFINFOR. SEND BY FIRST CLASS MAIL-MAKE TWO COPIES
MFPRINT. TUSG - TEMPERATURE IN BOX BEAM AROUND PIPE  2
EXIT(U)
TUSG - TEMPERATURE IN TUBE STEEL FRAME 2
     3000         6        35         2         0         0         4        13
       11        11         4                   0

        1       750     5.E-6
        1         1      .667      .708   1.042 1.082975      0.0      .417
        1                  10         8                              8         8
        2         1      .667      .708      .833     1.042      0.0      .417
        1                  13         8                              8         8
        3         1      .667      .708      .667      .833      0.0      .417
        1                  13         8                              8         8
        4         1      .667      .708      .500      .667      0.0      .417
        1                  13         8                              8         8
        5         1      .667      .708      .417      .500      0.0      .417
        1                  13         8                              8         8
        6         1      .583      .667      .375      .417      0.0      .417
        1                                                8         8         8
        7         1      .417      .583      .375      .417      0.0      .417
        1                                                8         8         8
        8         1      .250      .417      .375      .417      0.0      .417
        1                                                8         8         8
        9         1      .042      .250      .375      .417      0.0      .417
        1                                                8         8         8
       10         1    2.5E-5     0.042      .375      .417      0.0      .417
        1                                               10         8         8
       11         1       0.0      .708       0.0      .042      0.0      .417
        1                                      8                   8         8
       12         1     1.042     1.083       0.0     1.083       0.      .417
        1                   8         7                            8         8
       13         1      .042      .250      .400      .500        .0      .417
        1                                                1
       14         1      .667      .708      .042      .417      0.0      .417
        2                             8                            8         8
       15         1      .250      .417      .042        .5        .0      .417
        1                                                1
       16         2       0.0      .667      .042      .375      .042      .375
        2
       17         1      .708     1.042       0.0     1.083      0.0      .042
        2                                      8                   8         8
       18         1      .708     1.042       0.0     1.083      .375      .417
        2                                      8                   8         8
       19         1       0.0      .667      .042      .375      0.0      .042
        2                                                          6
       20         1       0.0      .667      .042      .375      .375      .417
        2                                                                    6
       21         1      .667      .708  1.082975     1.083      0.0      .417
        1                   1                                      8         8
       22         1       0.0    2.5E-5      .375      .417      0.0      .417
        1                                                1         6         6
       23         1      .417      .583      .400      .500        .0      .417
        1                                                1
```

		1					
26	1	.583	.66	.667	.833	.0	.417
1		1					
27	1	.583	.66	.833	1.042	.0	.417
1		1					
28		.042	.25	.417	.420	.0	.417
				2	2		
29		.250	.417	.417	.420	.0	.417
				3	3		
30		.417	.583	.417	.420	.0	.417
				4	4		
31		.583	.66	.417	.420	.0	.417
				5	5		
32		.660	.667	.420	.500	.0	.417
				5	5		
33		.660	.667	.500	.667	.0	.417
				4	4		
34		.660	.667	.667	.833	.0	.417
				3	3		
35		.660	.667	.833	1.042	.0	.417
				2	2		
2	AIR	.0170					
1	CSTEEL	25.70					
1	350.						
2	250.						
3	200.						
4	150.						
1	2	350.					
2	3						
	11.65E-10						
3	3						
	8.21E-10						
4	3						
	3.100E-10						
5	3						
	.116E-10						
6	1	104.0					
		.220	.333				
7	1	104.0					
		.190	.332				
8	1	104.0					
		.190	.333				
9	1	104.0					
		.150	.25				
10	1	350.0					
53.	15.5E-10						
11	3						
		.239	.25				
12	2	104.					
13	1	104.					
		.320	.25				
0.0	2.5E-5	.042	.250	.417	.583	.660	.667
.708	1.042	1.083					
1	1	2	2	2	1	1	1
3	1						
0.0	.042	.375	.417	.420	.500	.667	.833
1.042	1.042875	1.083					
1	2	1	1	1	2	2	2
1	1						
0.0	.042	.375	.417				
1	3	1					

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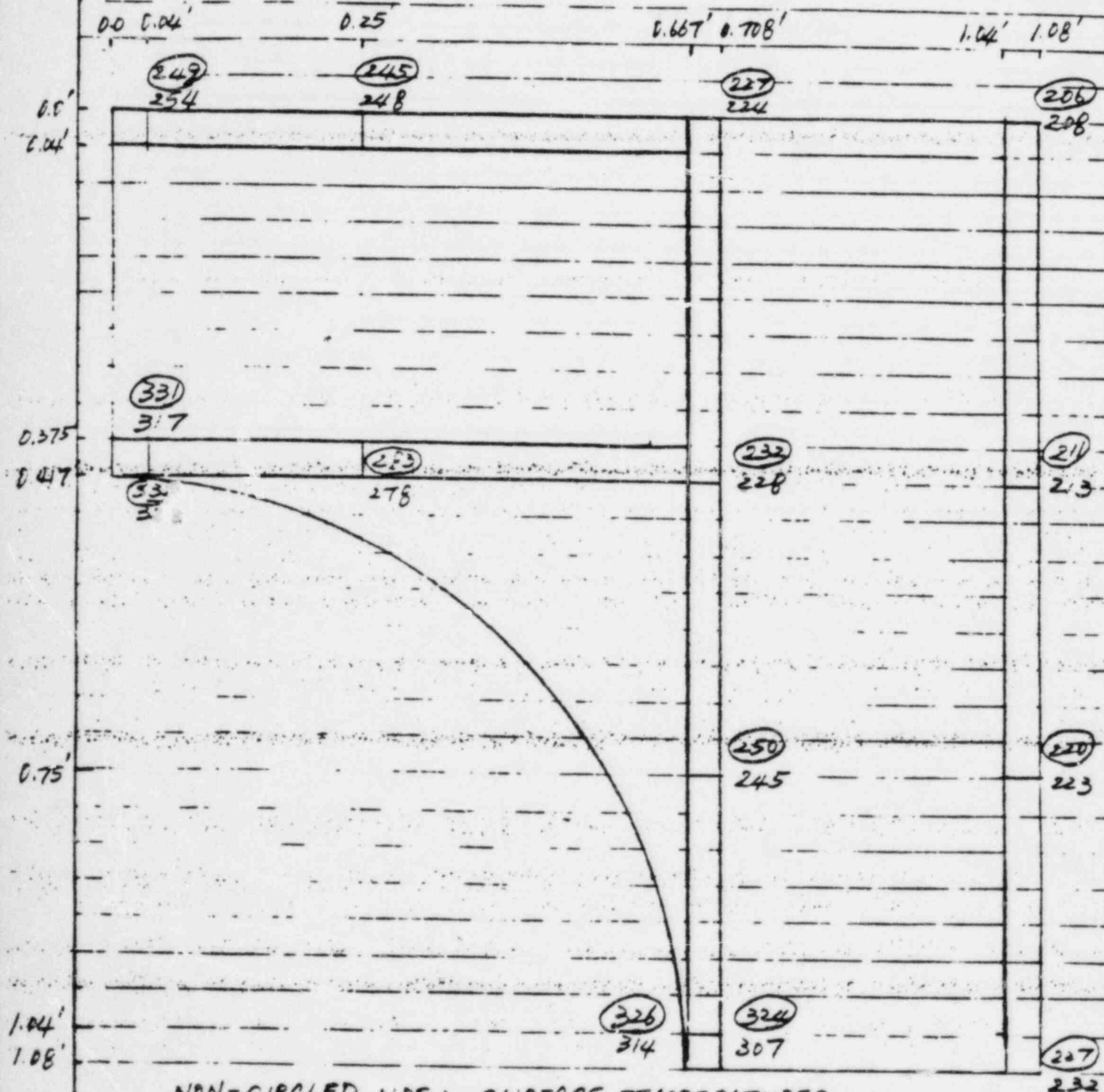
SUBJECT 3-D OPEN END BOX BEAMS



NON-CIRCLED NDS: SURFACE TEMPERATURES IN Z-DIRECTION (Z=0 OR Z=0.417')

CIRCLED NDS : CENTER TEMPERATURES (Z=0.214')

TABLE I-5.0
COEFFICIENTS OF THERMAL EXPANSION

Materials	Coefficient[1]	70	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800
		Temperature (F)															
Carbon steel; Carbon-moly steel; low chrome steels (through 3 Cr)	A	6.07	6.20	6.44	6.67	6.89	7.10	7.33	7.54	7.76	7.96	8.16	8.35	8.54	8.76	8.94	9.16
	B	6.07	6.13	6.25	6.38	6.49	6.60	6.71	6.82	6.92	7.02	7.12	7.23	7.33	7.44	7.54	7.65
	C	0	.0023	.0061	.0099	.0140	.0182	.0226	.0270	.0316	.0362	.0411	.0460	.0511	.0563	.0616	.0670
Intermediate chrome steels (5 Cr through 9 Cr)	A	5.73	5.90	6.13	6.30	6.42	6.54	6.71	6.85	7.03	7.16	7.35	7.47	7.60	7.75	7.90	8.02
	B	5.73	5.79	5.92	6.04	6.12	6.19	6.27	6.34	6.42	6.50	6.58	6.66	6.73	6.80	6.88	6.96
	C	0	.0022	.0058	.0094	.0133	.0171	.0210	.0250	.0293	.0335	.0380	.0424	.0469	.0514	.0562	.0610
High chrome steels (12 Cr through 17 Cr)	A	5.24	5.34	5.53	5.72	5.87	6.05	6.21	6.36	6.50	6.66	6.80	6.94	7.01	7.08	7.21	7.36
	B	5.24	5.29	5.40	5.50	5.58	5.66	5.74	5.81	5.89	5.96	6.05	6.13	6.20	6.26	6.33	6.39
	C	0	.0020	.0053	.0086	.0121	.0156	.0193	.0230	.0269	.0308	.0349	.0390	.0431	.0473	.0516	.0560
Austenitic stainless steel (18 Cr 8 Ni)	A	9.11	9.21	9.39	9.50	9.66	9.73	9.87	9.96	10.09	10.20	10.34	10.43	10.54	10.66	10.81	10.90
	B	9.11	9.16	9.25	9.34	9.41	9.47	9.53	9.59	9.65	9.70	9.76	9.82	9.87	9.93	9.99	10.05
	C	0	.0034	.0090	.0146	.0203	.0261	.0320	.0380	.0441	.0501	.0562	.0624	.0687	.0751	.0815	.0880
25 Cr-20 Ni	A	7.48	7.60	7.78	7.96	8.13	8.27	8.45	8.57	8.74	8.88	9.02	9.16	9.30	9.42	9.56	9.70
	B	7.48	7.54	7.65	7.76	7.84	7.92	8.00	8.08	8.15	8.22	8.30	8.38	8.45	8.52	8.60	8.68
	C	0	.0028	.0074	.0121	.0170	.0218	.0269	.0320	.0372	.0424	.0479	.0533	.0588	.0644	.0702	.0760
Nickel Chrome Iron	A	7.13	7.26	7.46	7.63	7.77	7.91	8.02	8.10	8.16	8.23	8.33	8.43	8.53	8.63	8.73	8.98
	B	7.13	7.20	7.30	7.40	7.48	7.56	7.63	7.70	7.75	7.80	7.85	7.90	7.95	8.00	8.05	8.10
	C	0	.0026	.0070	.0115	.0161	.0209	.0256	.0305	.0353	.0402	.0452	.0502	.0553	.0605	.0657	.0710
Aluminum	A	12.25	12.62	13.12	13.52	13.80	14.06	14.34	14.67	14.95	15.24	15.49	15.79	...	...	...	...
	B	12.25	12.39	12.67	12.90	13.12	13.28	13.44	13.60	13.75	13.90	14.05	14.20	...	...	...	...
	C	0	.0046	.0123	.0200	.0283	.0366	.0453	.0539	.0628	.0717	.0810	.0903	...	...	...	...

NOTE:

1 Coefficient A is the instantaneous coefficient of thermal expansion $\times 10^6$ (in./in./F). Coefficient B is the mean coefficient of thermal expansion $\times 10^6$ (in./in./F) in going from 70 F to indicated temperature. Coefficient C is the linear thermal expansion (in./ft.) in going from 70 F to indicated temperature.

ATTACHMENT B

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
TEXAS UTILITIES ELECTRIC COMPANY, *et al.*	)	Docket Nos. 50-445 and 50-446
	)	
(Comanche Peak Steam Electric Station, Units 1 and 2)	)	(Application for Operating Licenses)

CERTIFICATE OF SERVICE

I hereby certify that copies of "Applicants' Reply to CASE's Answer to Applicants' Motion for Summary Disposition Regarding Local Displacement and Stresses," in the above-captioned matter was served upon the following persons by express delivery (*), or deposit in the United States mail, first class, postage prepaid, this 28th day of September, 1984, or by hand delivery (**) on the 1st day of October, 1984.

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