5. DETAILED ANALYSIS:

d. PRESSURE AND THERMAL INTERACTION:

4. REDUNDANT FORCES:

THE ABOVE MATRIX WITH THE GIVEN LOADING VECTORS FOR PRESSURE AND THE TRANSIEN CONDITIONS FOR BOTH RANGE OF STRESS AND PEAK STRESS GIVE THE FOLLOWING VALUES FOR THE REDUNDANT FORCES.

— FOR RANGE OF STRESS —

TRANSIENT		H_1 KIP/IN	M_1 IN-KIP/IN	H_2 KIP/IN	M_2 IN-KIP/IN	H_3 KIP/IN	M_3 IN-KIP/IN	H_4 KIP/IN	M_4 IN-KIP/IN
1	DESIGN PRESSURE ONLY	-1.4880P	-4.0236P	-1.4597P	-3.5635P	0.9949P	51.5286P	-29.8560P	-110.4336P
2	100% POWER	5.4218	-1.9247	2.9411	9.2769	1.6582	53.9849	-5.6804	13.1555
3	425	5.7652	-1.8840	2.9719	9.9809	1.5267	53.8035	-5.7380	10.7364
4	435	5.9028	-1.8822	3.0245	10.2647	1.5114	53.9330	-5.7330	10.7487
5	447	6.0690	-1.8299	3.0865	10.6073	1.3483	53.2669	-5.8186	7.0657
6	500	6.2067	-0.3096	2.7739	11.9022	0.3808	32.3727	-3.3944	1.4660
7	STEADY STATE	6.2340	0.9222	2.3724	12.6809	-0.6379	5.6658	-0.1588	-0.2734
8	100%	0.8400	2.7851	-0.4398	3.4015	-2.2358	-47.0402	5.3413	-13.1506
9	425	0.4919	2.7183	-0.5732	2.6625	-2.0994	-46.7069	5.3900	-10.7289
10	435	0.3387	2.6930	-0.6270	2.3680	-2.0822	-46.7841	5.3859	-10.7136
11	447	0.1653	2.6543	-0.6907	2.0043	-1.9219	-46.3401	5.4718	-7.1183
12	500	0.0249	1.1797	-0.3880	0.7599	-0.9844	-25.7664	3.1338	-1.6585
13		6.2340	0.9222	2.3724	12.6809	-0.6379	5.6658	-0.1588	-0.2734
14	—f	6.3407	0.9380	2.4131	12.8981	-0.6488	5.7628	-0.1616	-0.2781
15		6.3435	0.9384	2.4141	12.9037	-0.6491	5.7653	-0.1616	-0.2782
16		6.3366	0.9374	2.4115	12.8898	-0.6484	5.7591	-0.1614	-0.2779
17		0	0	0	0	0	0	0	0
18	NO 2.0 PPM	4.1645	-2.0371	2.2937	6.7150	0.9230	45.0705	-2.6381	10.5043
19	SS	4.2388	0.6271	1.6131	0.6224	-0.4337	3.8525	-0.1080	-0.1559
20	CO 300 PPM	0.1437	2.5950	-0.5902	2.1894	-1.2013	-38.8940	2.5159	-7.1246
21	—m	6.3407	0.9380	2.4131	12.8981	-0.6488	5.7628	-0.1616	-0.2781
22		6.2340	0.9222	2.3724	12.6809	-0.6379	5.6658	-0.1588	-0.2734

COMBUSTION ENGINEERING, INC.
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NUMBER 5-211-P | A 143
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DESCRIPTION STRUCTURAL AND FATIGUE EVALUATION OF INLET NOZZLE - VESSEL SUPPORTS
CHECK DATE 1-31-69 BY HELPER

5. DETAILED ANALYSIS:
d. PRESSURE AND THERMAL INTERACTION:
4. REDUNDANT FORCES:

- FOR PEAK STRESS -

TRANSIENT		H_1 KIP/IN	M_1 IN-KIP/IN	H_2 KIP/IN	M_2 IN-KIP/IN	H_3 KIP/IN	M_3 IN-KIP/IN	H_4 KIP/IN	M_4 IN-KIP/IN
a - HEATUP	4.00 HRS	5.4314	-3.3474	2.8545	7.4518	1.1275	-244.7520	-6.9856	-313.7740
	4.25	5.7743	-3.2997	2.9846	8.1440	1.0213	-246.2679	-6.9801	-318.2831
	4.35	5.9120	-3.2958	3.0372	8.4150	1.0037	-247.5879	-6.9811	-319.8529
	4.47	6.2782	-3.2595	3.0993	9.7540	0.8381	-249.7035	-7.0727	-325.1178
	5.00	6.2115	-0.2963	2.7805	11.5336	0.1159	-140.7465	-4.0447	-177.8202
STEADY STATE		6.2340	0.9222	2.3724	12.6809	-0.6379	5.6658	-0.1588	-0.2734
b - COOLDOWN	4.00 HRS	6.9304	4.1928	-0.4532	5.2265	-1.7052	251.6967	6.6465	313.7789
	4.25	6.4774	4.1241	-0.5859	4.4994	-1.5941	253.3645	6.6322	318.2906
	4.35	6.3295	4.1157	-0.6397	4.2136	-1.5744	254.7368	6.6241	319.8880
	4.47	6.1561	4.0938	-0.7035	3.9577	-1.4117	256.8794	6.7259	325.0652
	5.00	6.0201	1.1673	-0.3946	1.1085	-0.7195	147.3529	3.7840	177.6277
c		6.2340	0.9222	2.3724	12.6809	-0.6379	5.6658	-0.1588	-0.2734
d — f		6.3407	0.9380	2.4131	12.6981	-0.6488	5.7628	-0.1616	-0.2781
g		6.3455	0.9394	2.4141	12.9037	-0.6491	5.7653	-0.1616	-0.2782
h		6.3366	0.9374	2.4115	12.9995	-0.6484	5.7591	-0.1614	-0.2779
i		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
j	H.O. 2.0 HRS	4.1737	-3.4366	2.3064	4.9617	0.4129	-257.8999	-5.8922	-321.6793
	SS.	4.2393	0.6271	1.6131	8.6224	-0.4337	3.8525	-0.1080	-0.1859
	C.D 2.0 HRS.	0.2344	4.0746	-0.6030	4.0428	-0.6911	264.0863	3.7700	325.0589
k — m		6.3407	0.9380	2.4131	12.8981	-0.6488	5.7628	-0.1616	-0.2781
n		6.2340	0.9222	2.3724	12.6809	-0.6379	5.6658	-0.1588	-0.2734

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.
CHARGE NO.
DESCRIPTION Structural And Fatigue Evaluation Of Inlet Nozzle - Vessel Supports

NUMBER 5-211-P | A144
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DATE 4-22-68 BY CORRELL
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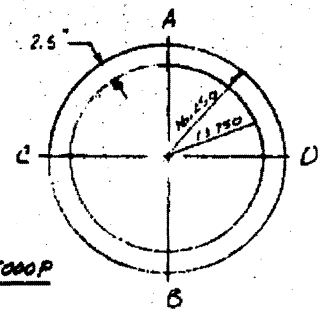
5.0 Detailed Analysis:

5.1 Stresses:

5.1.1 Combined Stresses - Unconcentrated:

For This Section Of The Analysis, Stresses Will Be Calculated At The Ten Locations As Shown On Sheet 17.

Location 1 & 2:



$I = \frac{\pi}{4}(r_o^4 - r_i^4) = 26691\ in^4$

$A = \pi(r_o^2 - r_i^2) = 235.6\ in^2$

Pressure Stress:

$\sigma_1 = \pm \frac{6M_1 R_i}{t_i^2 R_i} + \frac{b_1 P}{2R_i t_i} = \pm 0.9670\,M_1 + 2.5208P$

$\sigma_\theta = \pm \frac{\nu 6M_1 R_i}{t_i^2 R_i} + \frac{EW_{11}}{K_i} + \frac{b_2 P}{t_i} = \pm 0.2901\,M_1 + 0.06667\,EW_{11} + 5.5000P$

$\sigma_r = -P$

Thermal Stress:

$\sigma_1 = \pm \frac{6M_1 R_i}{t_i^2 R_i} = \pm 0.9670\,M_1$

$\sigma_\theta = \pm \frac{\nu 6M_1}{t_i^2}\frac{R_i}{R_i} + \frac{EW_1}{R_i} = \pm 0.2901\,M_1 + 0.06667\,EW_{11}$

Thermal Induced Pipe Reactions:

	Location - 1		Location - 2	
$\sigma_z = -\frac{F_x}{A} \pm \frac{Mc}{I} =$	$-0.00424F_x + 0.00052M_z$	Point A	$-0.00424F_x + 0.00061M_z$	Point A
	$-0.00424F_x - 0.00052M_z$	B	$-0.00424F_x - 0.00061M_z$	B
	$-0.00424F_x + 0.00052M_y$	C	$-0.00424F_x + 0.00061M_y$	C
	$-0.00424F_x - 0.00052M_y$	D	$-0.00424F_x - 0.00061M_y$	D
$\tau_{r\theta} = \frac{FQ}{Ib} \pm \frac{M_t}{2I} =$	$0.00845F_z + 0.00026M_x$	Point A	$0.00845F_z + 0.00031M_x$	Point A
	$0.00845F_z - 0.00026M_x$	B	$0.00845F_z - 0.00031M_x$	B
	$0.00845F_y + 0.00026M_x$	C	$0.00845F_y + 0.00031M_x$	C
$b = 2t_i$	$0.00845F_y - 0.00026M_x$	D	$0.00845F_y - 0.00031M_x$	D

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.
CHARGE NO.
DESCRIPTION STRUCTURAL AND FATIGUE EVALUATION OF INLET NOZZLE - VESSEL SUPPORTS

NUMBER S-211-P | A145
SHEET 27 OF 69
DATE 4-22-68 BY COCKRELL
CHECK DATE 4-22-68 BY HOLLER

5. DETAILED ANALYSIS:

C - STRESSES:

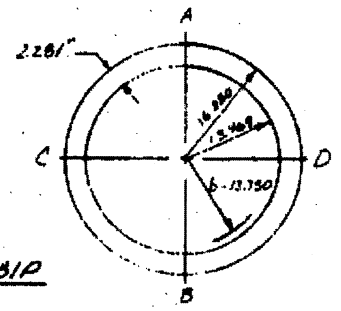
1. COMBINED STRESSES - UNCONCENTRATED:

SEISMIC PIPE REACTIONS:

THE FORMULAS FOR CALCULATING THE STRESSES DUE TO THE SEISMIC PIPE REACTIONS ARE THE SAME AS FOR THE THERMALLY INDUCED PIPE REACTIONS.

NOTE:
THERE WILL BE NO STRESS PRODUCED AT LOCATIONS 1→6 DUE TO THE STATIC LOADING THROUGH SUPPORTS, EARTHQUAKE LOADING THROUGH SUPPORTS, OR DUE TO THERMAL EXPANSION OR CONTRACTION.

LOCATION 3 & 4:



$I = \frac{\pi}{4}(r_o^4 - r_i^4) = 24961\ in^4$

$A = \pi(r_o^2 - r_i^2) = 216.6\ in^2$

PRESSURE STRESS:

$\sigma_x = \pm \frac{6M_1}{t_1^2} + \frac{b^2 P}{2R_1 t_1} = \pm$ 1.1532 M_1 + 2.7428 P

$\sigma_\theta = \pm \frac{\sqrt{6}M_1}{t_1^2} + \frac{EW_{21}}{R_2} + \frac{bP}{t_2} =$ ± 0.3460 M_1 + 0.0662 EW_{21} + 6.0231 P

$\sigma_r = -P$

THERMAL STRESS

$\sigma_x = \pm \frac{6M_1}{t_1^2} =$ ± 1.1532 M_1

$\sigma_\theta = \pm \frac{\sqrt{6}M_1}{t_1^2} + \frac{EW_{21}}{R_2} =$ ± 0.3460 M_1 + 0.0662 EW_{21}

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5- DETAILED ANALYSIS:

2.* STRESSES:

1.* COMBINED STRESSES - UNCONCENTRATED:

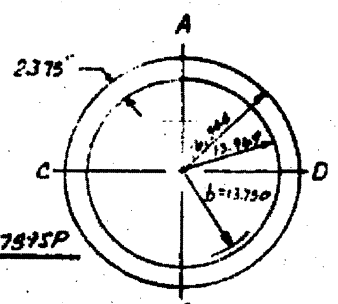
THERMAL INDUCED PIPE REACTIONS:

	LOCATION - 3		LOCATION - 4	
$\sigma_1 = -\frac{F_z}{A} \pm \frac{M_c}{I}$	$= -0.00462 F_x + 0.00056 M_z$	POINT A	$= -0.00462 F_x + 0.00065 M_z$	POINT A
	$= -0.00462 F_x - 0.00056 M_z$	B	$= -0.00462 F_x - 0.00065 M_z$	B
	$= -0.00462 F_x + 0.00056 M_y$	C	$= -0.00462 F_x + 0.00065 M_y$	C
	$= -0.00462 F_x - 0.00056 M_y$	D	$= -0.00462 F_x - 0.00065 M_y$	D
$\tau_{M_t} = \frac{FQ}{Ib} + \frac{Mc}{2I}$	$= 0.00926 F_z + 0.00028 M_r$	POINT A	$= 0.00926 F_z + 0.00033 M_r$	POINT A
	$= 0.00926 F_z - 0.00028 M_r$	B	$= 0.00926 F_z - 0.00033 M_r$	B
	$= 0.00926 F_y + 0.00028 M_x$	C	$= 0.00926 F_y + 0.00033 M_x$	C
$b = 2t_2$	$= 0.00926 F_y - 0.00028 M_x$	D	$= 0.00926 F_y - 0.00033 M_x$	D

SEISMIC PIPE REACTIONS:

THE FORMULAS FOR CALCULATING THE STRESSES ARE THE SAME AS FOR THE THERMAL INDUCED PIPE REACTIONS.

LOCATION 5-6:



PRESSURE STRESS:

$$\sigma_x = \pm \frac{6M_2}{t_{2a}^2} + \frac{b^2 P}{2R_2 t_{2a}} = \pm 1.0637 M_2 + 26.362 P$$

$$\sigma_\theta = \pm \frac{\nu 6M_2}{t_{2a}^2} + \frac{EW_{2a}}{R_2} + \frac{bP}{t_{2a}} = \pm 0.3191 M_2 + 0.0662 EW_{2a} + 5.7975 P$$

$$\sigma_r = -P$$

$$I = \frac{\pi}{4}(r_o^4 - r_i^4) = 26.138 \text{ in}^4$$

$$A = \pi(r_o^2 - r_i^2) = 226.2 \text{ in}^2$$

THERMAL STRESS:

$$\sigma_x = \pm \frac{6M_2}{t_{2a}^2} = \pm 1.0637 M_2$$

$$\sigma_\theta = \pm \frac{\nu 6M_2}{t_{2a}^2} + \frac{EW_{2a}}{R_2} = \pm 0.3191 M_2 + 0.0662 EW_{2a}$$

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NUMBER 5-211-P | A147
SHEET 39 OF 49
DATE 4-22-69 BY COCHRELL
CHECK DATE 4-17-69 BY HERKER

5. DETAILED ANALYSIS:

e. STRESSES:

1. COMBINED STRESSES - UNCONCENTRATED:

THERMAL INDUCED PIPE REACTIONS:

SINCE THE PIPE REACTIONS ARE APPLIED AT THE SKIRT END OF THE NOZZLE, THE PIPE REACTIONS MUST BE RESOLVED TO THE CROSS SECTION OF INTEREST. THIS IS DONE AS FOLLOWS.

$\bar{F}_x = F_x = 14.8$ $\quad \bar{M}_x = M_x = -3783$
$\bar{F}_y = F_y = -92$ $\quad \bar{M}_y = M_y + 2.923 F_z = 4579.4$
$\bar{F}_z = F_z = 27.5$ $\quad \bar{M}_z = M_z - 2.923 F_y = 7710.0$

	LOCATION - 5		LOCATION - 6	
$\sigma_x = -\frac{\bar{F}_x}{A} \pm \frac{\bar{M}c}{I}$	$= -0.00442\bar{F}_x + 0.00053\bar{M}_y$	POINT A	$= -0.00442\bar{F}_x + 0.00062\bar{M}_z$	POINT A
	$= -0.00442\bar{F}_x - 0.00053\bar{M}_z$	B	$= -0.00442\bar{F}_x - 0.00062\bar{M}_z$	B
	$= -0.00442\bar{F}_x + 0.00053\bar{M}_y$	C	$= -0.00442\bar{F}_x + 0.00062\bar{M}_y$	C
	$= -0.00442\bar{F}_x - 0.00053\bar{M}_y$	D	$= -0.00442\bar{F}_x - 0.00062\bar{M}_y$	D
$\tau_{TQ} = \frac{\bar{F}Q}{b'} \pm \frac{Mc}{2I}$	$= 0.00881\bar{F}_z + 0.00026\bar{M}_x$	POINT A	$= 0.00881\bar{F}_z + 0.00031\bar{M}_x$	POINT A
	$= 0.00881\bar{F}_z - 0.00026\bar{M}_x$	B	$= 0.00881\bar{F}_z - 0.00031\bar{M}_x$	B
$b' = 2t_{PL}$	$= 0.00881\bar{F}_y + 0.00026\bar{M}_x$	C	$= 0.00881\bar{F}_y + 0.00031\bar{M}_x$	C
	$= 0.00881\bar{F}_y - 0.00026\bar{M}_x$	D	$= 0.00881\bar{F}_y - 0.00031\bar{M}_x$	D

SEISMIC PIPE REACTIONS:

THE FORMULAS FOR CALCULATING THE STRESSES DUE TO THE SEISMIC PIPE REACTIONS ARE THE SAME AS FOR THE THERMAL INDUCED PIPE REACTIONS.

COMBUSTION ENGINEERING, INC.
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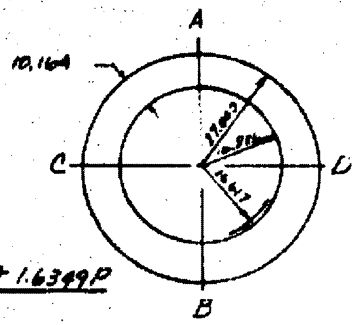
SHEET 40 OF 69
DATE 4-22-69 BY Cockrell
CHECK DATE 4-22-69 BY Henker

5. Detailed Analysis:

e. Stresses:

1. Combined Stresses - Unconcentrated:

Location 7&8:



$I = \frac{\pi}{4}(r_o^4 - r_i^4) = 35427.0 in^4$

$A = \pi(r_o^2 - r_i^2) = 140.0 in^2$

Pressure Stress:

$$\sigma_x = \pm \frac{6M_x}{t_{sn}^2}\frac{R_s}{R_{sn}} + \frac{b^2 P}{2t_{sn}t_{sn}} = \pm 0.0574 M_x + 0.6197 P$$

$$\sigma_\theta = \pm \frac{\nu 6 M_x}{t_{sn}^2}\frac{R_s}{R_{sn}} + \frac{EW_{sn}}{R_{sn}} + \frac{bP}{t_{sn}} = \pm 0.0172 M_x + 0.0456 EW_{sn} + 1.6349 P$$

$$\sigma_r = -P$$

Thermal Stress:

$$\sigma_x = \pm \frac{6M_x}{t_{sn}^2}\frac{R_s}{R_{sn}} = \pm 0.0574 M_x$$

$$\sigma_\theta = \pm \frac{\nu 6 M_x}{t_{sn}^2}\frac{R_s}{R_{sn}} + \frac{EW_{sn}}{R_{sn}} = \pm 0.0172 M_x + 0.0456 EW_{sn}$$

Thermal Induced Pipe Reactions:

Since The Pipe Reactions Are Applied At The Small End Of The Nozzle, The Pipe Reactions Must Be Resolved To The Cross Section Of Interest. This Is Done As Follows.

$\bar{F}_x = F_x = 14.8$ $\quad \bar{M}_x = M_x = -3783$
$\bar{F}_y = F_y = -92$ $\quad \bar{M}_y = M_y + 30.313 F_z = 5332.6$
$\bar{F}_z = F_z = 27.5$ $\quad \bar{M}_z = M_z - 30.313 F_y = 10229.8$

	Location - 7		Location - 8	
$\sigma_x = -\frac{\bar{F}_x}{A} \pm \frac{\bar{M}c}{I} =$	$-0.00071 F_x + 0.00005 \bar{M}_z$	Point A	$-0.00071 F_x + 0.00005 \bar{M}_z$	Point A
	$-0.00071 F_x - 0.00005 \bar{M}_z$	B	$-0.00071 F_x - 0.00005 \bar{M}_z$	B
	$-0.00071 F_x + 0.00005 \bar{M}_y$	C	$-0.00071 F_x + 0.00005 \bar{M}_y$	C
	$-0.00071 F_x - 0.00005 \bar{M}_y$	D	$-0.00071 F_x - 0.00005 \bar{M}_y$	D

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.
CHARGE NO.
DESCRIPTION Structural And Fatigue Evaluation Of Inlet Nozzle - Vessel Supports

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SHEET 41 OF 69
DATE 4-22-69 BY CRCrozel
CHECK DATE 4-22-69 BY Henker

5. Detailed Analysis:

e. Stresses:

1. Combined Stresses - Unconcentrated:

	Location - 7		Location - 8	
$T_{xo} = \frac{Fa}{Ib'} \pm \frac{Mc}{I}$	$= 0.00138\bar{F}_z + 0.000024\bar{M}_y$	Point A	$= 0.00138\bar{F}_z + 0.000039\bar{M}_y$	Point A
	$= 0.00138\bar{F}_x - 0.000024\bar{M}_y$	B	$= 0.00138\bar{F}_x - 0.000038\bar{M}_y$	B
$b' = 2t_{da}$	$= 0.00138\bar{F}_y + 0.000024\bar{M}_x$	C	$= 0.00138\bar{F}_y + 0.000038\bar{M}_x$	C
	$= 0.00138\bar{F}_y - 0.000024\bar{M}_x$	D	$= 0.00138\bar{F}_y - 0.000038\bar{M}_x$	D

Seismic Pipe Reactions:

In Setting Up Equations To Account For The Seismic Pipe Reactions, The Forces Exerted On The Nozzle Which Are Applied Thru The Support Pad Must Be Resolved To The Cross Section Of Interest. These Forces Are Labeled H And V As Shown On Sheet 9. The Values For The Design Earthquake And The No Loss Of Function Condition Which Will Be Considered Are Presented In The Table On Sheet 9. The Equations For Stress Will Be The Same For The Seismic Conditions As For The Thermal Induced Pipe Reactions Except The Values For $\bar{F}_x$, $\bar{F}_y$, $\bar{F}_z$, $\bar{M}_x$, $\bar{M}_y$, And $\bar{M}_z$ Will Be As Follows.

$\bar{F}_x = F_x = -57.9$ $\quad \bar{M}_x = M_x - 27H = -1492.7$
$\bar{F}_y = F_y + V = -340.2$ $\quad \bar{M}_y = M_y + 30.313F_z + 120H = 23715.1$
$\bar{F}_z = F_z + H = 649.4$ $\quad \bar{M}_z = M_z - 30.313F_y - 13.0V = 15192.6$

Static Loading Through Supports:

The Equations For Stress Are The Same As For The Thermally Induced Pipe Reactions With The Following Values For $\bar{F}_y$ & $\bar{M}_z$.

$\bar{F}_y = V = 561.1$ See Sheet 14 For Values Of V With Or Without $\bar{M}_z = -13.0V = -7294.3$ The Dynamic Load Of Tripped Control Rods.

5- DETAILED ANALYSIS:

C- STRESSES:

1- COMBINED STRESSES - UNCONCENTRATED:

EARTHQUAKE LOADING THRU SUPPORTS:

THE EQUATIONS FOR STRESS DUE TO THE EARTHQUAKE LOADING THROUGH THE SUPPORTS WILL BE THE SAME AS FOR THE THERMAL INDUCED PIPE REACTIONS WITH THE FOLLOWING VALUES FOR $\bar{F}_y$, $\bar{F}_z$, $\bar{M}_x$, $\bar{M}_y$, AND $\bar{M}_z$

$\bar{F}_y = V = -126.4$ $\quad \bar{M}_x = -27H = -9090.9$

$\bar{F}_z = H = 336.7$ $\quad \bar{M}_y = 13H = 4377.1$

$\bar{M}_z = -13V = 1643.2$

THERMAL EXPANSION AND CONTRACTION:

THE EQUATIONS FOR STRESS DUE TO EXPANSION AND CONTRACTION ARE AS FOLLOWS WITH THE VALUES FOR $\bar{F}_x$ AND $\bar{M}_z$ EQUAL TO.

$\bar{F}_x = F = 165.3$ } SEE SHEET 16 FOR VALUES OF F.
$\bar{M}_z = 28F = 4713.9$

$\sigma_x = -\frac{\bar{F}_x}{A} \pm \frac{\bar{M}_z c}{I}$

	LOCATION - 7		LOCATION - 8	
	$= -0.00071\,\bar{F}_x + 0.00005\,\bar{M}_z$	POINT A	$= -0.00071\,\bar{F}_x + 0.00008\,\bar{M}_z$	POINT A
	$= -0.00071\,\bar{F}_x - 0.00005\,\bar{M}_z$	B	$= -0.00071\,\bar{F}_x - 0.00008\,\bar{M}_z$	B
	$= -0.00071\,\bar{F}_x$	C	$= -0.00071\,\bar{F}_x$	C
	$= -0.00071\,\bar{F}_x$	D	$= -0.00071\,\bar{F}_x$	D

	LOCATION - 7	LOCATION - 8	
σ_x	$= 0.00069\,F$	$= 0.00153\,F$	POINT A
	$= -0.00211\,F$	$= -0.00295\,F$	B
	$= -0.00071\,F$	$= -0.00071\,F$	C
	$= -0.00071\,F$	$= -0.00071\,F$	D

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.
CHARGE NO.
DESCRIPTION STRUCTURAL AND FATIGUE EVALUATION OF INLET NOZZLE - VESSEL SUPPORTS

NUMBER S-211-P | A151
SHEET 43 OF 69
DATE 4-27-68 BY CROCKETT
CHECK DATE 4-27-68 BY HELLER

5- DETAILED ANALYSIS:

a. STRESSES:

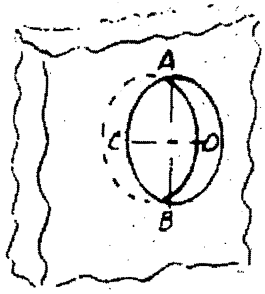
1- COMBINED STRESSES - UNCONCENTRATED:

LOCATION 9 & 10:

PRESSURE STRESS:

NOTE HERE THAT IT WILL BE NECESSARY TO CALCULATE STRESSES IN BOTH THE LONGITUDINAL AND CIRCUMFERENTIAL DIRECTIONS FOR PRESSURE

POINTS A & B (LONGITUDINAL PLANE):



$$\sigma_x = \pm\frac{6M_a}{t_s^2} - \frac{H_a}{t_s} + \frac{V_a \sin\phi}{t_s} = \underline{\pm 0.05192\,M_a - 0.09302\,H_a + 0.0882P}$$

$$\sigma_\theta = \pm\frac{\nu 6M_a}{t_s^2} + \frac{EW_{ca}}{R_s \sin\phi} + \frac{b_s P}{t_s} = \underline{\pm 0.01558\,M_a + 0.0462\,EW_{ca} + 7.9477P}$$

$$\sigma_r = -P$$

POINTS C & D (CIRCUMFERENTIAL PLANE):

$$\sigma_x = \pm\frac{\nu 6M_a}{t_s^2} + \frac{EW_{ca}}{R_s \sin\phi} + \frac{b_s' P}{2R_s t_s} = \underline{\pm 0.01558\,M_a + 0.0462\,EW_{ca} + 3.7297P}$$

$$\sigma_\theta = \pm\frac{6M_a}{t_s^2} - \frac{H_a \cos\phi}{t_s} + \frac{V_a \sin\phi}{t_s} = \underline{\pm 0.05192\,M_a - 0.0918H_a + 0.0882P}$$

$$\sigma_r = -P$$

THERMAL STRESS:

POINTS A & B (LONGITUDINAL PLANE):

$$\sigma_x = \pm\frac{6M_a}{t_s^2} - \frac{H_a}{t_s} = \underline{\pm 0.05192\,M_a - 0.0930H_a}$$

$$\sigma_\theta = \pm\frac{2\nu 6M_a}{t_s^2} + \frac{EW_{ca}}{R_s \sin\phi} = \underline{\pm 0.01558\,M_a + 0.0462\,EW_{ca}}$$

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.
CHARGE NO. 6866
DESCRIPTION Structural And Fatigue Evaluation Of Inlet Nozzle - Vessel Support

NUMBER 5-211-P | A 152
SHEET 44 OF 69
DATE 4-22-68 BY Cockrell
CHECK DATE 4-22-68 BY Hollrer

5. Detailed Analysis:

a. Stresses:

1. Combined Stresses - Unconcentrated:

Points C & D (Circumferential Plane):

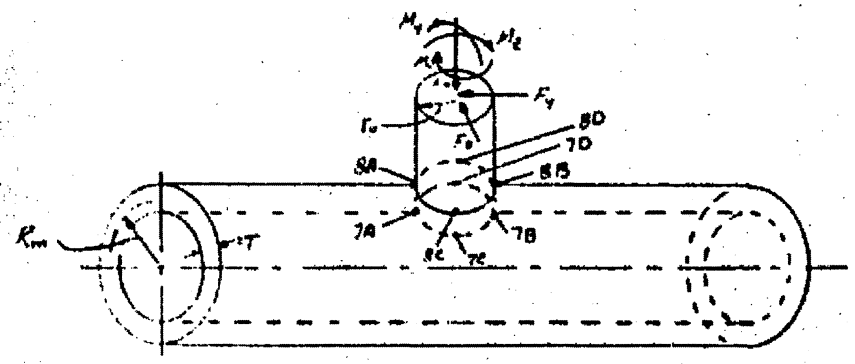
$$\sigma_x = \pm \frac{6M_t}{t^2} + \frac{EW_{x0}}{r_s \sin\phi} = \pm 0.2155 B M_t + 0.0462 E W_{x0}$$

$$\sigma_\theta = \pm \frac{6M_a}{t^2} - \frac{\mu E W_{x0}}{t_s} = \pm 0.05192 M_a - 0.09181 W_{x0}$$

Thermal Induced Pipe Reactions:

The Stresses in the Vessel Wall Due to the Thermally Induced Pipe Reactions will be Calculated by the Method Outlined in Ref 14 for a Cylindrical Attachment to a Cylindrical Shell. Since the Pipe Reactions are Applied at the Small End of the Nozzle, they must be Resolved to the Mid-Radius of the Vessel Wall. This is done by the following Relationship of Forces.

$F_x = F_1 = 14.8$ $\quad \bar{M}_x = M_x = -5783$
$F_y = F_{11} = -92$ $\quad \bar{M}_y = M_y + 35.695 F_z = 5490.4$
$F_z = F_2 = 27.5$ $\quad \bar{M}_z = M_z - 35.695 F_y = 10724.3$



$R_m = 91.032"$
$T = 10.75"$
$r_o = 27"$

With the Geometric Parameters of $\gamma = \frac{R_m}{T} = 8.5$ and $\beta = 0.875 \frac{r_o}{R_m} = 0.260$ and the Curves in Ref 14 we get the Following Expressions for Stress.

COMBUSTION ENGINEERING, INC. NUMBER S-211-P | A1S1
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN. SHEET 45 OF 69
CHARGE NO. DATE 4-22-69 BY Bowers
DESCRIPTION Structural And Extreme Examination CHECK DATE 4-22-69 BY Heller
Of Inlet Nozzle - Vessel Support

5. Detailed Analysis:

e. Stresses:

1. Combined Stresses - Unpenetrated:

$$\sigma_A = -\left(\frac{M_x}{F_x/R_m}\right)\frac{\bar{F}_x}{R_m T} \pm \left(\frac{M_x}{F_x}\right)\frac{6\bar{F}_z}{T^2} \pm \left(\frac{N_x}{\bar{M}_y/R_m\beta}\right)\frac{\bar{M}_y}{R_m^2 \beta T} \pm \left(\frac{M_x}{\bar{M}_y/R_m\beta}\right)\frac{6\bar{M}_y}{R_m\beta T^2} \pm \left(\frac{N_x}{\bar{M}_z/R_m^2\beta}\right)\frac{\bar{M}_z}{R_m^2\beta T} \pm \left(\frac{M_x}{\bar{M}_z/R_m\beta}\right)\frac{6\bar{M}_z}{R_m\beta T^2}$$

$$= -(1.44)\frac{\bar{F}_x}{978.58} \pm (0.972)\frac{6\bar{F}_z}{115.56} \pm (0.50)\frac{\bar{M}_y}{23162} \pm (0.055)\frac{6\bar{M}_y}{2735.2} \pm (0.25)\frac{\bar{M}_z}{23162} \pm (0.027)\frac{6\bar{M}_z}{2735.2}$$

Location - 9		Location - 10	
$-0.00143\bar{F}_x + 0.00374\bar{F}_y + 0.000012\bar{M}_z - 0.00315\bar{M}_z$	Point A	$-0.00143\bar{F}_x - 0.00374\bar{F}_y + 0.000012\bar{M}_z + 0.00315\bar{M}_z$	Point A
$-0.00143\bar{F}_x + 0.00374\bar{F}_y - 0.000012\bar{M}_z + 0.00315\bar{M}_z$	B	$-0.00143\bar{F}_x - 0.00374\bar{F}_y - 0.000012\bar{M}_z - 0.00315\bar{M}_z$	B
$-0.00143\bar{F}_x + 0.00374\bar{F}_y + 0.000022\bar{M}_y - 0.00012\bar{M}_y$	C	$-0.00143\bar{F}_x - 0.00374\bar{F}_x + 0.000022\bar{M}_y + 0.00012\bar{M}_y$	C
$-0.00143\bar{F}_x + 0.00374\bar{F}_x - 0.000022\bar{M}_y + 0.00012\bar{M}_y$	D	$-0.00143\bar{F}_x - 0.00374\bar{F}_x - 0.000022\bar{M}_y - 0.00012\bar{M}_y$	D

$$\sigma_B = -\left(\frac{M_B}{F_x/R_m}\right)\frac{\bar{F}_x}{R_m T} \pm \left(\frac{M_B}{F_x}\right)\frac{6\bar{F}_z}{T^2} \pm \left(\frac{N_B}{\bar{M}_y/R_m^2\beta}\right)\frac{\bar{M}_y}{R_m^2\beta T} \pm \left(\frac{M_B}{\bar{M}_y/R_m\beta}\right)\frac{6\bar{M}_y}{R_m\beta T^2} \pm \left(\frac{N_B}{\bar{M}_z/R_m^2\beta}\right)\frac{\bar{M}_z}{R_m^2\beta T} \pm \left(\frac{M_B}{\bar{M}_z/R_m\beta}\right)\frac{6\bar{M}_z}{R_m\beta T^2}$$

$$= -(1.25)\frac{\bar{F}_x}{978.58} \pm (0.094)\frac{6\bar{F}_z}{115.56} \pm (0.27)\frac{\bar{M}_y}{23162} \pm (0.097)\frac{6\bar{M}_y}{2735.2} \pm (1.00)\frac{\bar{M}_z}{23162} \pm (0.042)\frac{6\bar{M}_z}{2735.2}$$

Location - 9		Location - 10	
$-0.00128\bar{F}_x + 0.00489\bar{F}_y + 0.000043\bar{M}_z - 0.000092\bar{M}_z$	Point A	$-0.00128\bar{F}_x - 0.00489\bar{F}_y + 0.000043\bar{M}_z + 0.000092\bar{M}_z$	Point A
$-0.00128\bar{F}_x + 0.00489\bar{F}_y - 0.000043\bar{M}_z + 0.000092\bar{M}_z$	B	$-0.00128\bar{F}_x - 0.00489\bar{F}_x - 0.000043\bar{M}_z - 0.000092\bar{M}_z$	B
$-0.00128\bar{F}_x + 0.00489\bar{F}_y + 0.000012\bar{M}_y - 0.00021\bar{M}_y$	C	$-0.00128\bar{F}_x - 0.00489\bar{F}_x + 0.000012\bar{M}_y + 0.00021\bar{M}_y$	C
$-0.00128\bar{F}_x + 0.00489\bar{F}_y - 0.000012\bar{M}_y + 0.00021\bar{M}_y$	D	$-0.00128\bar{F}_x - 0.00489\bar{F}_x - 0.000012\bar{M}_y - 0.00021\bar{M}_y$	D

$$\tau_{sp} = \pm\frac{\bar{F}_z}{\pi r_o T} \pm \frac{\bar{F}_x}{\pi r_o T} + \frac{\bar{M}_x}{2\pi r_o T}$$

Location 9&10		
$= 0.00110\bar{F}_z + 0.00002\bar{M}_x$	Point A	
$= -0.00110\bar{F}_z + 0.00002\bar{M}_x$	B	
$= 0.00110\bar{F}_y + 0.00002\bar{M}_x$	C	
$= -0.00110\bar{F}_y + 0.00002\bar{M}_x$	D	

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.
CHARGE NO.
DESCRIPTION Structural And Fatigue Evaluation Of Inlet Nozzle - Vessel Support

NUMBER 5-211-P | A154
SHEET 46 OF 69
DATE 4-22-69 BY Cockrell
CHECK DATE 4-22-69 BY Herrer

5. Detailed Analysis:

c. Stresses:

1. Combined Stresses - Unconcentrated:

Seismic Pipe Reactions

The Equations For Stress For The Seismic Pipe Reactions Will Be The Same As For The Thermally Induced Pipe Reactions. The Values For $\bar{F}_x$, $\bar{F}_y$, $\bar{F}_z$, $\bar{M}_x$, $\bar{M}_y$, And $\bar{M}_z$ Will Be As Follows. See Sheet 13 For Values Of H And V.

$\bar{F}_x = F_x = -57.9$ $\quad \bar{M}_x = M_x - 27H = -14927.5$
$\bar{F}_y = F_y + V = -340.2$ $\quad \bar{M}_y = M_y + 35.688 F_z + 18.375 H = 27205.6$
$\bar{F}_z = F_z + H = 649.4$ $\quad \bar{M}_z = M_z - 35.688 F_y - 18.375 V = 17321.1$

Static Loading Through Supports:

The Equations For Stress Are The Same As For The Thermally Induced Pipe Reactions With The Following Values For $\bar{F}_y$ And $\bar{M}_z$

$\bar{F}_y = V = 561.1$ See Sheet 14 For Values Of V With Or Without The Dynamic Load Of Tripped Control Rods.
$\bar{M}_z = -18.375 V = -10310.2$

Earthquake Loading Through Supports:

The Equations For Stress Are The Same As For The Thermally Induced Pipe Reactions With The Following Values For $\bar{F}_y$, $\bar{F}_z$, $\bar{M}_x$, $\bar{M}_y$, And $\bar{M}_z$.

$\bar{F}_y = V = -126.4$ $\quad \bar{M}_x = -27H = -9090.9$
$\bar{F}_z = H = 336.7$ $\quad \bar{M}_y = 18.375 H = 6186.9$
$\bar{M}_z = -18.375 V = 2322.6$

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.
CHARGE NO.
DESCRIPTION Structural And Fatigue Evaluation Of Inlet Nozzle - Vessel Supports

NUMBER S-211-P | A155
SHEET 41 OF 69
DATE 4-22-69 BY Cockrell
CHECK DATE 4-27-69 BY Heller

5- Detailed Analysis:

"e" Stresses:

1. Combined Stresses - Unreinforced:

Thermal Expansion And Contraction:

The Equations For Stress Are The Same As For The Thermally Induced Pipe Reactions With The Following Values For $\bar{F}_x$ & $\bar{M}_z$

$\bar{F}_x = F = \pm 164.3$ kips
$\bar{M}_z = .24F = \pm 4712.4$ in-kips

Consider Criterion 5.b.1:

The Cross Section Of Interest Is The Section Shown On Sheet 40 For Locations 7 & 8. Since There Is Bending In Two Directions, The Following Relationships Will Be Used To Determine The Maximum Effect Of Bending By The Thermal And Design Seismic Pipe Loads, Nozzle, Etc.

$$\sigma_x = -\frac{\bar{F}_x}{A} \pm \frac{c}{I}\sqrt{\bar{M}_y^2 + \bar{M}_z^2} = -1.00071\,\bar{F}_x \pm 0.00005\sqrt{\bar{M}_y^2 + \bar{M}_z^2} \quad \text{Inside}$$
$$= -0.00071\,\bar{F}_x \pm 0.00008\sqrt{\bar{M}_y^2 + \bar{M}_z^2} \quad \text{Outside}$$

$$T_{xy} = \frac{Q}{Ic}\left[\bar{F}_y \sin\theta + \bar{F}_z \cos\theta\right] \pm \frac{\bar{M}_t c}{2I} = 0.00139\left[\bar{F}_y \sin\theta + \bar{F}_z \cos\theta\right] \pm 0.00074\bar{M}_t \quad \text{Inside}$$
$$= 0.00138\left[\bar{F}_y \sin\theta + \bar{F}_z \cos\theta\right] \pm 0.00009\bar{M}_t \quad \text{Outside}$$

$$\theta = \tan^{-1}\frac{\bar{M}_y}{\bar{M}_z}$$

Location	Pressure Stress			Due To Ext. Loads, Weight Etc.		Principal Stresses			Stress Intensity		
	σ_1	σ_θ	σ_r	σ_x	τ_{xy}	σ_1	σ_2	σ_3	$\sigma_1-\sigma_2$	$\sigma_1-\sigma_3$	$\sigma_2-\sigma_3$
7	1.55	4.09	-2.5	1.99	0.17	4.14	3.49	-2.5	0.65	6.64	5.99
	↓	↓	-2.5	-2.17	1.50	4.53	-1.06	-2.5	5.59	7.03	1.44
8	↓	↓	0	3.24	-0.21	4.95	4.03	0	0.92	4.95	4.03
	↓	↓	0	-3.42	1.90	4.64	-2.42	0	7.06	4.64	-2.42

$SI_{max} = \sigma_1 - \sigma_2 = \underline{7.06\ KSI} < S_m = 26.7\ KSI$ Location 8

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.
CHARGE NO.
DESCRIPTION: STRUCTURAL AND FATIGUE EVALUATION OF INLET NOZZLE - VESSEL SUPPORTS

NUMBER S-211-P | A156
SHEET 48 OF 69
DATE 4-22-69 BY COCKRELL
CHECK DATE 4-22-69 BY HEILREF

5. DETAILED ANALYSIS:

a. STRESSES:

1. COMBINED STRESSES - UNCONCENTRATED:

CONSIDER CRITERION 5.b.2:

CUT	BODY	$\frac{P^2D}{2Rt}$	$\frac{6P}{t}$	$\frac{EW}{R}$	σ_x	σ_θ	σ_r	STRESS INTENSITY $\sigma_x-\sigma_\theta$	$\sigma_x-\sigma_r$	$\sigma_\theta-\sigma_r$
1	1	6.30	13.75	3.16	6.30	16.91	-1.25	-10.61	7.55	18.16
1	2	6.96	15.07	1.90	6.96	16.97	↓	-10.11	8.11	18.22
2	2	6.59	14.97	-3.59	6.59	10.88		-4.29	7.84	12.13
4	4	1.55	4.09	17.79	1.55	21.88		-20.33	7.80	23.13
4	5 LONG AXIS	7.16	19.97	11.15	7.16	31.02		-23.86	8.41	32.27
4	5 CIRC AXIS	9.32	7.07	11.15	20.47	7.07	↓	13.40	21.72	8.32

$S.I._{MAX} = \sigma_\theta - \sigma_r = \underline{32.27\ KSI} < 1.5 S_M = 40\ KSI$ CUT 4 BODY 5 LONGITUDINAL AXIS

SEE SHEET POINTS 9 & 10

CONSIDER CRITERION 5.b.3:

LOCATION	PRESSURE STRESS σ_x	σ_θ	σ_r	STRESS DUE TO PIPE LOADS, WEIGHT ETC σ_x	σ_θ	$\tau_{x\theta}$	PRINCIPAL STRESS σ_1	σ_2	σ_3	STRESS INTENSITY $\sigma_1-\sigma_2$	$\sigma_1-\sigma_3$	$\sigma_2-\sigma_3$
9A	7.16	31.02	-2.5	4.53	1.30	1.20	32.34	11.67	-2.5	20.67	34.84	14.17
B	7.16	31.02	↓	4.01	2.11	1.56	33.24	11.06	↓	22.18	35.74	13.56
C	20.47	7.07		3.85	7.42	1.61	24.58	14.22		10.36	27.08	16.72
D	20.47	7.07	↓	4.29	8.64	-1.25	24.79	15.55	↓	9.24	27.29	18.05
10A	7.16	31.02	0	3.36	2.57	1.20	33.60	10.51	0	23.09	33.60	10.51
B	7.16	31.02	↓	6.73	6.24	1.56	37.37	13.79	↓	23.58	37.37	13.79
C	20.47	7.07		6.62	9.93	1.61	27.12	16.97		10.15	27.12	16.97
D	20.47	7.07	↓	5.86	8.74	-1.25	26.48	15.66	↓	10.82	26.48	15.66

$S.I._{MAX} = \sigma_1 - \sigma_3 = \underline{37.4\ KSI} < 1.5 S_m = 40 KSI$ LOCATION 10B

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.
CHARGE NO.
NUMBER S-211-P | A157
SHEET 49 OF 69
DATE 4-22-69 BY SCKERTLL
CHECK DATE 4-22-69 BY HENNER
DESCRIPTION STRUCTURAL AND FATIGUE EVALUATION OF INLET NOZZLE - VESSEL SUPPORTS

5- DETAILED ANALYSIS:

E- STRESSES:

1- COMBINED STRESSES - UNCONCENTRATED:

CONSIDER CRITERION 5.6.4:

SAFE END

$$\sigma_1 = -\frac{F_x}{A} \pm \frac{c}{I}\sqrt{M_y^2 + M_z^2} = -0.00434\,F_x \pm 0.00092\sqrt{M_y^2 + M_z^2} \quad \text{POINT 1}$$

$$= -0.00424\,F_x \pm 0.00061\sqrt{M_y^2 + M_z^2} \quad \text{POINT 2}$$

$$T_{x\theta} = \frac{Q}{Ib}\left[F_y \sin\theta + F_z \cos\theta\right] \pm \frac{M_x c}{2I} = 0.00445\left[F_y \sin\theta - F_z \cos\theta\right] \pm 0.00026\,M_x \quad \text{POINT 1}$$

$$= 0.00845\left[F_y \sin\theta + F_z \cos\theta\right] \pm 0.00031\,M_x \quad \text{POINT 2}$$

$$\theta = \tan^{-1}\frac{M_y}{M_z}$$

LOCATION	PRESSURE STRESS			STRESS DUE TO SUSTN. LOADS		PRINCIPAL STRESS			STRESS INTENSITY		
	σ_x	σ_θ	σ_r	σ_x	$\tau_{x\theta}$	σ_1	σ_2	σ_3	$\sigma_1-\sigma_2$	$\sigma_1-\sigma_3$	$\sigma_2-\sigma_3$
1	6.30	16.91	-2.5	8.74	1.39	17.50	14.25	-2.5	3.25	20.00	16.75
			-2.5	-8.24	0.87	16.95	-1.98	-2.5	18.93	19.45	0.52
2			0	10.21	1.43	19.16	16.28	0	2.88	19.16	16.28
			0	-9.71	0.83	16.94	-3.44	0	20.38	16.94	-3.44

$S_{J_{max}} = \sigma_1 - \sigma_2 = 20.38\ \text{KSI} < 1.5\,S_m = 25.05\ \text{KSI}$ LOCATION - 2

SAMPLE END OF NOZZLE

$$\sigma_\theta = -\frac{F_x}{A} \pm \frac{c}{I}\sqrt{M_y^2 + M_z^2} = -0.00462\,F_x \pm 0.00056\sqrt{M_y^2 + M_z^2} \quad \text{POINT 3}$$

$$= -0.00462\,F_x \pm 0.00065\sqrt{M_y^2 + M_z^2} \quad \text{POINT 4}$$

$$T_{x\theta} = \frac{Q}{Ib}\left[F_y \sin\theta + F_z \cos\theta\right] \pm \frac{M_x c}{2I} = 0.00926\left[F_y \sin\theta + F_z \cos\theta\right] \pm 0.00024\,M_x \quad \text{POINT 3}$$

$$= \left[F_y \sin\theta + F_z \cos\theta\right] \pm 0.00033\,M_x \quad \text{POINT 4}$$

$$\theta = \tan^{-1}\frac{M_y}{M_z}$$

LOCATION	PRESSURE STRESS			STRESS DUE TO SUSTN. LOADS		PRINCIPAL STRESS			STRESS INTENSITY		
	σ_x	σ_θ	σ_r	σ_x	$\tau_{x\theta}$	σ_1	σ_2	σ_3	$\sigma_1-\sigma_2$	$\sigma_1-\sigma_3$	$\sigma_2-\sigma_3$
3	6.96	16.97	-2.5	9.41	1.51	18.17	15.07	-2.5	3.10	20.67	17.57
			-2.5	-8.87	0.97	17.02	-2.06	-2.5	19.08	19.52	0.44
4			0	10.88	1.56	18.96	15.75	0	3.21	18.96	15.75
			0	-10.34	0.92	17.01	-3.52	0	20.53	17.01	-3.52

$S_{J_{max}} = \sigma_1 - \sigma_3 = 20.67\ \text{KSI} < 1.5\,S_m = 40.05\ \text{KSI}$ LOCATION 3

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.
CHARGE NO.
DESCRIPTION STRUCTURAL AND FATIGUE EVALUATION OF INLET NOZZLE - VESSEL SUPPORTS

NUMBER S-214-P | A157
SHEET 49 OF 69
DATE 4-22-69 BY SCHEFFEL
CHECK DATE 4-22-69 BY HENKER

5- DETAILED ANALYSIS:

e. STRESSES:

1. COMBINED STRESSES - UNCONCENTRATED:

CONSIDER CRITERION 5.D.4:

SAFE END

$$\sigma_1 = -\frac{F_1}{A} \pm \frac{C}{I}\sqrt{M_y^2 + M_z^2} = -0.00434\,F_1 \pm 0.00052\sqrt{M_y^2 + M_z^2} \quad \text{POINT 1}$$

$$= -0.00424\,F_1 \pm 0.00061\sqrt{M_y^2 + M_z^2} \quad \text{POINT 2}$$

$$T_{r\theta} = \frac{Q}{Ib}\left[F_y \sin\theta + F_z \cos\theta\right] \pm \frac{M_x C}{2I} = 0.00495\left[F_y \sin\theta + F_z \cos\theta\right] \pm 0.00026\,M_x \quad \text{POINT 1}$$

$$= 0.00845\left[F_y \sin\theta + F_z \cos\theta\right] \pm 0.00031\,M_x \quad \text{POINT 2}$$

$\theta = \tan^{-1}\frac{M_y}{M_z}$

LOCATION	PRESSURE STRESS			STRESS DUE TO SPRING LOADS		PRINCIPAL STRESS			STRESS INTENSITY		
	σ_r	σ_θ	σ_r	σ_z	$\tau_{r\theta}$	σ_1	σ_2	σ_3	$\sigma_1-\sigma_2$	$\sigma_1-\sigma_3$	$\sigma_2-\sigma_3$
1	6.30	16.91	-2.5	8.74	1.39	17.50	14.25	-2.5	3.25	20.00	16.75
			-2.5	-8.24	0.87	16.95	-1.98	-2.5	18.93	19.45	0.52
2			0	10.21	1.43	19.16	16.28	0	2.88	19.16	16.28
			0	-9.71	0.83	16.94	-3.44	0	20.38	16.94	-3.44

$S_{I_{max}} = \sigma_1 - \sigma_2 = 20.38\ \text{KSI} < 1.5 S_m = 25.05\ \text{KSI}$ LOCATION - 2

SMALL END OF NOZZLE

$$\sigma_\theta = -\frac{F_2}{A} \pm \frac{C}{I}\sqrt{M_y^2 + M_z^2} = -0.00462\,F_2 \pm 0.00056\sqrt{M_y^2 + M_z^2} \quad \text{POINT 3}$$

$$= -0.00462\,F_2 \pm 0.00065\sqrt{M_y^2 + M_z^2} \quad \text{POINT 4}$$

$$T_{r\theta} = \frac{Q}{Ib}\left[F_y \sin\theta + F_z \cos\theta\right] \pm \frac{M_x C}{2I} = 0.00926\left[F_y \sin\theta + F_z \cos\theta\right] \pm 0.00029\,M_x \quad \text{POINT 3}$$

$$= \left[F_y \sin\theta + F_z \cos\theta\right] \pm 0.00033\,M_x \quad \text{POINT 4}$$

$\theta = \tan^{-1}\frac{M_y}{M_z}$

LOCATION	PRESSURE STRESS			STRESS DUE TO SPRING LOADS		PRINCIPAL STRESS			STRESS INTENSITY		
	σ_r	σ_θ	σ_r	σ_z	$\tau_{r\theta}$	σ_1	σ_2	σ_3	$\sigma_1-\sigma_2$	$\sigma_1-\sigma_3$	$\sigma_2-\sigma_3$
3	6.96	16.97	-2.5	9.41	1.51	18.17	15.07	-2.5	3.10	20.67	17.57
			-2.5	-8.81	0.97	17.02	-2.06	-2.5	19.09	19.52	0.44
4			0	10.88	1.56	18.96	15.75	0	3.21	18.96	15.75
			0	-10.34	0.92	17.01	-3.52	0	20.53	17.01	-3.52

$S_{I_{max}} = \sigma_1 - \sigma_3 = 20.67\ \text{KSI} < 1.5 S_m = 40.05\ \text{KSI}$ LOCATION 3

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.
CHARGE NO.
DESCRIPTION STRUCTURAL AND FATIGUE EVALUATION OF INLET NOZZLE - VESSEL SUPPORT

NUMBER 5-211-P | A158
SHEET 50 OF 69
DATE 4-22-69 BY COCKRELL
CHECK DATE 4-22-69 BY HENKER

5. DETAILED ANALYSIS:

e. STRESSES:

(1) COMBINED STRESSES - UNCONCENTRATED:

CONSIDER CRITERION 5.D.5:

NOTE HERE THAT THE RANGE OF STRESS INTENSITY WAS CALCULATED AT THE TEN LOCATIONS AS SHOWN ON SHEET 11 FOR THE FOUR ORIENTATIONS A, B, C AND D. THE FOLLOWING TABLE GIVES THE RANGE OF STRESS INTENSITY FOR EACH LOCATION AND ORIENTATION. STRESSES AND STRESS INTENSITIES PRODUCING THESE RANGE OF STRESS INTENSITIES WILL NOT BE PRESENTED FOR ALL LOCATIONS AND ORIENTATIONS. ONLY STRESSES AND STRESS INTENSITIES AT THE LOCATION AND ORIENTATION WHICH PRODUCED THE HIGHEST RANGE OF STRESS WILL BE PRESENTED. THIS WAS LOCATION-10B.

LOCATION AND ORIENTATION	S.I. RANGE
1A	24.31
B	26.83
C	27.26
D	28.17
2A	33.31
B	33.46
C	33.48
D	35.27
3A	31.14
B	39.14
C	34.36
D	39.90
4A	37.49
B	35.45
C	36.78
D	37.35

LOCATION AND ORIENTATION	S.I. RANGE
5A	28.12
B	25.30
C	26.89
D	26.43
6A	36.70
B	37.07
C	36.70
D	36.70
7A	19.29
B	19.28
C	18.44
D	18.44
8A	33.28
B	33.28
C	33.33
D	33.33

LOCATION AND ORIENTATION	S.I. RANGE
9A	41.44
B	43.28
C	29.32
D	29.32
10A	42.75
B	45.54
C	32.20
D	31.05

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.

NUMBER S-311-P | A159
SHEET 51 OF 59
CHARGE NO.
DATE 4-22-63 BY COFFELL
DESCRIPTION STRUCTURAL AND FATIGUE EVALUATION OF INLET NOZZLE - VERTICAL SUPPORTS
CHECK DATE 4-22-63 BY HELLER

3. DETAILED ANALYSIS:

e. STRESSES:

1. COMBINED STRESSES - UNCONCENTRATED:

LOCATION 10B

TRANSIENT		PRESSURE STRESS			THERMAL STRESS		THERMAL GRADIENT RADIAL STRESS			SEISMIC OBE STRESS			SEISMIC AND STRESS			STATIC WEIGHT STRESS		
		σ_r	σ_θ	σ_z	σ_r	σ_θ	σ_r	σ_θ	$\tau_{r\theta}$	σ_r	σ_θ	$\tau_{r\theta}$	σ_r	σ_θ	$\tau_{r\theta}$	σ_x	σ_θ	$\tau_{r\theta}$
a - HEATUP	4 HRS	10.16	16.70	0	-0.15	-1.09	-1.62	-1.39	-0.09	-2.50	-1.98	-1.01	-0.19	-0.16	-0.01	1.67	1.39	0
	4.25	17.87	29.35		-0.02	-1.11	-1.73	-1.46	-0.10				-0.09	-0.08	-0.31			
	435	19.54	30.46		-0.02	-1.11	-1.77	-1.50	-0.10				-0.05	-0.04	0			
	4.47	19.35	31.78		0.17	-1.13	-1.81	-1.54	-0.11				0	0	0			
	5.00	19.35	31.78		0.24	-0.66	-1.81	-1.54	-0.11	2.50	1.98	1.01	0.19	1.03	-0.01			
b - CONSTANT	4.10	10.16	16.70		-0.15	-1.09	-1.62	-1.38	-0.09				-0.19	-0.16	-0.01			
	4.25	17.87	29.35		-0.02	-1.11	-1.73	-1.46	-0.10				-0.09	-0.08	-0.31			
	4.35	18.54	30.48		-0.02	-1.11	-1.77	-1.50	-0.10				-0.05	-0.04	0			
	4.47	19.35	31.78		0.17	-1.13	-1.81	-1.54	-0.11				0	0	0			
	5.00	19.35	31.78		0.24	-0.66	-1.81	-1.54	-0.11	2.50	1.98	1.01	0.19	1.03	-0.01			
c - SHUTDOWN	4.10	10.16	16.70		-0.15	-1.09	-1.62	-1.38	-0.09				-0.19	-0.16	-0.01			
	4.25	17.87	29.35		-0.02	-1.11	-1.73	-1.46	-0.10				-0.09	-0.08	-0.31			
	4.35	18.54	30.48		-0.02	-1.11	-1.77	-1.50	-0.10				-0.05	-0.04	0			
	4.47	19.35	31.78		0.17	-1.13	-1.81	-1.54	-0.11				0	0	0			
	5.00	19.35	31.78		0.24	-0.66	-1.81	-1.54	-0.11	2.50	1.98	1.01	0.19	1.03	-0.01			
SEISMIC - STATIC					0.03	0.03	-1.81	-1.54	-0.11	-2.50	-1.98	-1.01	-1.81	-1.54	-0.11			
					0.03	0.03	-1.81	-1.54	-0.11	2.50	1.98	1.01	-1.81	-1.54	-0.11			
					0.03	0.03	-1.81	-1.54	-0.11	0	0	0	-1.81	-1.54	-0.11			
d - STATIC	4 HRS	2.71	4.45		0.19	1.03	-0.19	-0.16	-0.01	-2.50	-1.98	-1.01						
	4.25				0.06	1.04	-0.09	-0.08	-0.31									
	4.35				0.06	1.04	-0.05	-0.04	0									
	4.47				-0.14	1.06	0	0	0									
	5.00				-0.21	0.61	0	0	0									
	4.10				0.19	1.03	-0.19	-0.16	-0.01	2.50	1.98	1.01						
	4.25				0.06	1.04	-0.09	-0.08	-0.31									
	4.35				0.06	1.04	-0.05	-0.04	0									
	4.41				-0.14	1.06	0	0	0									
	5.00				-0.21	0.61	0	0	0									

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.
CHARGE NO.
DESCRIPTION Structural And Fatigue Evaluation Of Inlet Nozzle - Vessel Supports

NUMBER 5.211-P | A160
SHEET 52 OF 69
DATE 4-22-6[illegible] BY Cocerelli
CHECK DATE 4-22-6[illegible] BY Heiker

5. Detailed Analysis:
e. Stresses:
1- Combined Stresses - Uncoincentrated:

LOCATION 108

Transient		Pressure Stress		Thermal Stress		Thermal Linear + Pipe Reaction Stress			Seismic + Pipe Reaction Stress			Seismic Weight Stress		
		σ_z	σ_θ	σ_r	σ_θ	σ_r	σ_θ	$\tau_{r\theta}$	σ_r	σ_θ	$\tau_{r\theta}$	σ_r	σ_θ	$\tau_{r\theta}$
c	20 min	19.35	31.78	0	0.03	-0.03	-1.81	-1.54	-0.11	0	0	1.67	1.39	0
d	20 min	19.35	31.78											
e	1.65 sec	18.49	30.23											
	225 sec	19.56	32.14											
f	40 sec	19.15	32.77											
	1000 sec	19.43	31.93											
	2400 sec	18.40	30.23											
g	2 min	20.38	33.48											
	3.2 min	20.21	33.20											
	18.4 min	18.49	30.37											
h	10 sec	19.09	31.36											
	165 sec	16.42	26.98											
i	220 min	26.81	44.04	0	0	0	0	0	0	0	0			
j	20 hrs	10.75	17.66	-0.30	-0.50	-1.22	-1.04	-0.08						
	30 hrs			0.02	-0.02	-1.22	-1.04	-0.08						
	5.5 hrs	21.50	35.32											
	6.0 hrs	2.71	4.45	0.14	0.48	0	0	0						
k	~	20.21	33.20	0.03	-0.03	-1.81	-1.54	-0.11						
	~	18.49	30.37											
l	12 sec	19.35	31.78											
m	10 sec	23.73	38.99											
	28 sec	18.23	29.95											
	110 sec	12.38	20.34											
n	33 sec	2.58	4.24											
	54 sec	6.02	9.89											

5. DETAILED ANALYSIS:
e. STRESSES:
1- COMBINED STRESSES - UNCONCENTRATED:

LOCATION 10B

Transient		Earthquake Loading Through Supports Stresses σ_x	σ_θ	$\tau_{x\theta}$	Expansion and Contraction Stress σ_x	σ_θ	Total Stress σ_x	σ_θ	σ_r	$\tau_{x\theta}$	Principal Stress σ_1	σ_2	σ_3	Stress Intensity $\sigma_1-\sigma_2$	$\sigma_1-\sigma_3$	$\sigma_2-\sigma_3$
a - Heating	4.00 HRS	-0.39	-0.31	-0.55	-1.64	-1.67	5.53	11.65	0	-1.66	12.07	5.11	0	6.96	12.07	5.11
	4.25	→	→	→	→	→	13.27	24.21	→	-1.67	24.46	13.02	→	11.44	24.46	13.02
	4.25	→	→	→	→	→	13.90	25.29	→	-1.67	25.52	13.66	→	11.86	25.52	13.66
	4.47	→	→	→	→	→	14.96	26.54	→	-1.67	26.78	14.62	→	12.16	26.78	14.62
	5.00	→	→	→	→	→	14.92	27.01	→	-1.67	27.24	14.69	→	12.54	27.24	14.69
	4.00	0.39	0.31	0.55	→	→	11.29	16.24	→	1.47	16.64	10.99	→	5.75	16.64	10.99
	4.25	→	→	→	→	→	19.03	28.90	→	1.46	29.01	18.81	→	10.20	29.01	18.81
	4.35	→	→	→	→	→	19.67	29.59	→	1.46	30.10	19.47	→	10.63	30.10	19.47
	4.47	→	→	→	→	→	20.62	31.13	→	1.46	31.33	20.42	→	10.91	31.33	20.42
	5.00	→	→	→	→	→	20.68	31.60	→	1.46	31.79	20.49	→	11.30	31.79	20.49
Steady-State		-0.39	-0.31	-0.55	0	0	16.35	29.31	→	-1.67	29.52	16.14	→	13.39	29.52	16.14
		0.39	0.31	0.55	→	→	22.11	33.90	→	1.46	34.28	21.93	→	12.14	34.08	21.93
		0	0	0			19.23	31.61	→	-2.11	31.61	19.23	→	12.39	31.61	19.23
b - Cooldown	4.00 HRS	-0.38	-0.31	-0.55	1.64	1.67	3.14	6.09	→	-1.58	6.77	2.45	→	4.32	6.77	2.45
	4.25	→	→	→	→	→	3.11	6.18	→	-1.57	6.84	2.45	→	4.40	6.94	2.45
	4.35	→	→	→	→	→	3.15	6.22	→	-1.57	6.97	2.49	→	4.59	6.97	2.49
	4.47	→	→	→	→	→	3.00	6.29	→	-1.57	6.40	2.37	→	4.53	6.90	2.37
	5.00	→	→	→	→	→	2.93	5.93	→	-1.57	6.51	2.25	→	4.26	6.51	2.25
	4.00	0.39	0.31	0.55	→	→	9.39	10.67	→	1.55	11.58	7.99	→	3.59	11.59	7.99
	4.25	→	→	→	→	→	9.97	10.77	→	1.56	11.65	7.99	→	3.66	11.65	7.99
	4.35	→	→	→	→	→	9.91	10.81	→	1.56	11.68	8.03	→	3.65	11.69	8.03
	4.47	→	→	→	→	→	9.76	10.97	→	1.57	11.70	7.93	→	3.77	11.70	7.93
	5.00	→	→	→	→	→	9.69	10.42	→	1.57	11.34	7.77	→	3.57	11.94	7.77

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.
CHARGE NO. _____
DESCRIPTION: Structural And Fatigue Evaluation Of Inlet Nozzle - Vessel Shroud

NUMBER 5-211-P | A162
SHEET 54 OF 69
DATE 4-22-69 BY J. Kessel
CHECK DATE 4-22-69 BY Hauser

5. Detailed Analysis:
e. Stresses:
1. Combined Stresses - Operating Conditions:

LOCATION 10B

Transient		Fatigues Longitudinal Torsion Shells Stress			Expansion And Contraction Stress		Total Stress				Principal Stress			Stress Intensity		
		σ_z	σ_θ	$\tau_{r\theta}$	σ_z	σ_θ	σ_r	σ_θ	σ_r	$\tau_{r\theta}$	σ_1	σ_2	σ_3	$\sigma_1-\sigma_2$	$\sigma_1-\sigma_3$	$\sigma_2-\sigma_3$
c	20 min	0	0	0	0	0	19.23	31.61	0	-0.11	31.61	19.23	0	12.38	31.61	19.23
d	20 min						19.23	31.61			31.61	19.23		12.37	31.61	19.23
e	100 sec						18.29	30.05			30.05	18.29		11.77	30.05	18.29
	175 sec						19.45	31.96			31.96	19.45		12.51	31.96	19.45
f	40 sec						19.64	32.59			32.60	19.83		12.76	32.60	19.83
	100 sec						19.32	31.75			31.75	19.32		12.43	31.75	19.32
	240 sec						19.29	30.05			30.05	19.29		11.77	30.05	18.29
g	2 min						20.27	32.30			32.30	20.26		13.04	32.30	20.26
	3.2 min						20.09	33.02			33.02	20.09		12.93	33.02	20.09
	10 min						18.37	30.19			30.19	18.37		11.82	30.19	18.37
h	10 sec						18.98	31.18			31.18	18.97		12.21	31.18	18.97
	65 sec						16.31	26.80			26.80	16.31		10.50	26.80	16.31
i	220 min						28.54	45.54		0	45.54	28.54		16.99	45.54	28.54
j	H.U. 2.0 HCS						10.90	17.51		-0.08	17.51	10.90		6.61	17.51	10.90
	S.S.						21.97	35.65		-0.08	35.65	21.96		13.68	35.65	21.96
	C.D 3.0 HCS						4.61	6.33		0	6.33	4.51		1.81	6.33	4.51
k	~						20.09	33.02		-0.11	33.02	20.09		12.93	33.02	20.09
	~						18.37	30.19			30.19	18.37		11.82	30.19	18.37
l	12 sec						19.23	31.61			31.61	19.23		12.37	31.61	19.23
m	10 sec						23.62	39.81			39.81	23.62		15.19	39.81	23.62
	28 sec						19.12	29.77			29.77	18.11		11.66	29.77	18.11
	160 sec						12.27	20.16			20.16	12.27		7.90	20.16	12.27
n	33 sec						2.46	4.06			4.07	2.46		1.61	4.07	2.46
	54 sec						5.90	9.71			9.71	5.90		3.81	9.71	5.90

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.
CHARGE NO.
DESCRIPTION STRUCTURAL AND FATIGUE EVALUATION OF INLET NOZZLE - VESSEL SUPPORTS

NUMBER S-211-P | A163
SHEET 55 OF 69
DATE 4-22-69 BY CERRELL
CHECK DATE 4-22-69 BY HEILNER

5. DETAILED ANALYSIS:

C. STRESSES:

1. COMBINED STRESSES - UNCONCENTRATED:

CONSIDER STRESSES DURING NO LOSS OF FUNCTION SEISMIC LOADING:

IN THIS SECTION THE ALLOWABLE STRESSES LISTED ON SHEET 7 FOR CRITERIA 5.6.1, 5.6.3, AND 5.6.4 WILL BE INCREASED BY A FACTOR OF 1.2; SEE REF. 20.

CONSIDER CRITERION 5.6.1:

LOCATION	PRESSURE STRESS			STRESS DUE TO EXTERNAL LOADS		PRINCIPAL STRESS			STRESS INTENSITY		
	σ_x	σ_θ	σ_r	σ_x	$\tau_{x\theta}$	σ_1	σ_2	σ_3	$\sigma_1-\sigma_2$	$\sigma_1-\sigma_3$	$\sigma_2-\sigma_3$
7	1.55	4.09	-2.5	3.08	-0.36	4.81	3.91	-2.5	0.90	7.31	6.41
			-2.5	-3.22	1.78	4.60	-2.18	-2.5	6.78	7.10	0.32
8	↓	↓	0	4.97	-0.99	6.87	3.34	0	3.13	6.87	3.34
			0	-5.11	2.41	4.79	-4.26	0	9.05	4.79	-4.26

$S.I._{MAX} = \sigma_1 - \sigma_3 = \underline{9.05\ KSI} < 1.2S_m = 32.04\ KSI$ LOCATION 8

CONSIDER CRITERION 5.6.3:

LOCATION	PRESSURE STRESS			STRESSES DUE TO EXTERNAL LOADS			PRINCIPAL STRESS			STRESS INTENSITY		
	σ_x	σ_θ	σ_r	σ_x	σ_θ	$\tau_{x\theta}$	σ_1	σ_2	σ_3	$\sigma_1-\sigma_2$	$\sigma_1-\sigma_3$	$\sigma_2-\sigma_3$
9A	7.16	31.02	-2.5	5.24	1.63	1.02	32.67	12.26	-2.5	20.41	35.17	14.76
B	7.16	31.02	↓	5.49	2.70	2.66	34.06	12.32	↓	21.74	36.56	14.82
C	20.47	7.07	↓	5.70	11.48	2.32	26.82	17.90	↓	8.92	29.32	20.40
D	20.47	7.07	↓	7.04	13.84	-0.52	27.55	20.87	↓	6.68	30.05	23.37
10A	7.16	31.02	0	5.06	4.27	0.98	35.34	12.18	0	23.16	35.34	12.18
B	7.16	31.02	↓	7.52	6.98	2.61	38.29	14.39	↓	22.90	38.29	16.39
C	20.47	7.07	↓	8.48	13.66	2.81	29.56	20.04	↓	9.52	29.56	20.04
D	20.47	7.07	↓	9.56	14.51	-0.51	30.06	21.56	↓	8.50	30.06	21.56

$S.I._{MAX} = \sigma_1 - \sigma_3 = \underline{38.3\ KSI} < 1.2(1.5S_m) = 48.1\ KSI$ LOCATION 10B

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.
CHARGE NO.
DESCRIPTION STRUCTURAL AND FATIGUE EVALUATION OF INLET NOZZLE - VESSEL SUPPORT

NUMBER S-211-P | A164
SHEET 56 OF 69
DATE 4-22-69 BY COFFREY
CHECK DATE 4-23-69 BY HELLER

5- DETAILED ANALYSIS:

e- STRESSES

1- COMBINED STRESSES - UNCONCENTRATED:

CONSIDER CRITERION 5.b.4:

SAFE END

LOCATION	PRESSURE STRESS			STRESS DUE TO SEISMIC LOADS		PRINCIPAL STRESSES			STRESS INTENSITY		
	σ_1	σ_θ	σ_r	σ_x	$\tau_{r\theta}$	σ_1	σ_2	σ_3	$\sigma_1-\sigma_2$	$\sigma_1-\sigma_3$	$\sigma_2-\sigma_3$
1	6.30	16.91	-2.5	13.71	2.46	21.37	15.55	-2.5	5.82	23.87	18.05
			-2.5	-13.01	1.00	16.95	-6.75	-2.5	23.70	19.45	-4.25
2			0	16.02	3.60	23.37	15.96	0	7.50	23.37	15.96
			0	-15.32	0.86	16.94	-9.05	0	25.99	16.94	-9.05

$S.I_{max} = \sigma_1 - \sigma_2 = 25.99\ KSI < 1.2(1.5S_m) = 30.06\ KSI$ LOCATION 2

SMALL END OF NOZZLE

LOCATION	PRESSURE STRESS			STRESS DUE TO SEISMIC LOADS		PRINCIPAL STRESS			STRESS INTENSITY		
	σ_1	σ_θ	σ_r	σ_x	$\tau_{r\theta}$	σ_1	σ_2	σ_3	$\sigma_1-\sigma_2$	$\sigma_1-\sigma_3$	$\sigma_2-\sigma_3$
3	6.96	16.77	-2.5	14.76	2.67	22.84	15.75	-2.5	7.09	25.34	18.25
			-2.5	-14.00	1.11	17.02	-7.19	-2.5	24.21	19.52	-4.69
4			0	17.07	2.81	24.92	15.98	0	8.94	24.92	15.98
			0	-16.31	0.97	17.01	-9.49	0	26.50	17.01	-9.49

$S.I_{max} = \sigma_1 - \sigma_2 = 25.07\ KSI < 1.2(1.5S_m) = 48.06\ KSI$ LOCATION 3

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.
CHARGE NO.
DESCRIPTION STRUCTURAL AND FATIGUE EVALUATION OF INLET NOZZLE - VESSEL SUPPORT

NUMBER S-211-P | A165
SHEET 57 OF 69
DATE 4-22-69 BY COCKRELL
CHECK DATE 4-22-69 BY HELKER
REVISED 4-14-69 BY CAMPBELL

5. DETAILED ANALYSIS:

e. STRESSES:

1. COMBINED STRESSES - UNCORRENTATED:

CONSIDER THE COMBINED FORCES ON THE PAD:

THE MAXIMUM AND MINIMUM VERTICAL FORCE ON THE INLET NOZZLE PADS WAS FOUND TO BE,

$\bar{V}_{MAX}$ = 1204.3 KIPS
$\bar{V}_{MIN}$ = 9.7 KIPS

} NOTE HERE THAT THESE FORCES WERE DETERMINED USING THE DESIGN SEISMIC PIPE LOADS, THERMAL INDUCED PIPE LOADS AND THE SEISMIC SHOCK FACTORS GIVEN IN REF 20

NOTE THAT SINCE THE MINIMUM VALUE OF V IS POSITIVE, THE VESSEL WILL NOT LIFT OFF THE SUPPORT STRUCTURE UNDER THE DESIGN CONDITIONS.

THE MAXIMUM HORIZONTAL FORCE ON THE INLET NOZZLE PADS WAS FOUND TO BE,

$\bar{H}_{MAX}$ = 1026.5 KIPS SEE NOTE ABOVE FOR $\bar{V}_{MAX}$ & $\bar{V}_{MIN}$.

THE ABOVE MAXIMUM FORCES PRODUCE BEARING STRESSES ON THE CYL. SHELL TO,

$\sigma_{BRG} = \frac{\bar{V}_{MAX}}{A} = \frac{1204.3}{19 \times 12} = 5.5$ KSI

$\sigma_{BRG} = \frac{\bar{H}_{MAX}}{A} = \frac{1026.5}{25 \times 10} = 4.1$ KSI

} $< S_y = 14.5$ KSI @ 400°F

NOTE THAT THE BEARING STRESS ON THE BOTTOM OF THE PAD IS 5.0 KSI WHEN CONSIDERING DEAD WEIGHT AND THERMAL PIPE REACTIONS ONLY. THIS COMPARES WITH A DESIGNED BEARING STRESS OF 5.0 KSI. THIS STRESS BECOMES 4.0 KSI WHEN CONSIDERING THREE SUPPORT ONLY.

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.
CHARGE NO.
DESCRIPTION Structural And Fatigue Evaluation Of Inlet Nozzle - Vessel Supports

NUMBER S-211-P | A166
SHEET 58 OF 69
DATE 4-22-69 BY Cockerell
CHECK DATE 4-22-69 BY Heller

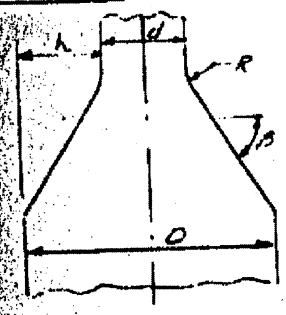
5- Detailed Analysis:

c. Stresses:

2. Peak Stresses:

The following values of stress concentration factors will be used to calculate peak stresses at locations 6, 8 and 10. The stress concentration factors at all other locations will be one; hence, the expressions for peak stress will be the same as those given on sheets 36-47 with the following exceptions (1) the term $\frac{E\alpha_i}{(1-\nu)}(T_m - T)$ is added to reflect the stress due to the radial gradient (2) the $\frac{6M}{t^2}$ and $\frac{\nu 6M}{t^2}$ terms for stresses due to thermal effects will include the thermal moment due to the radial gradient, and (3) for location 10, the pressure stress will be calculated using the stress indices given in 1-612 of Section III.

Location 6:



$D = 26.062"$ $h = 10.75$ $\beta = 55°$ $\Delta = \frac{D}{d} = 5.713$

$d = 4.562$ $R = 3.219$ $\frac{h}{90} = .144$ $\frac{h}{R} = 3.34$

From Equations 6.20 and 6.24 of Ref 11:

$K_{TO} = 1.42$

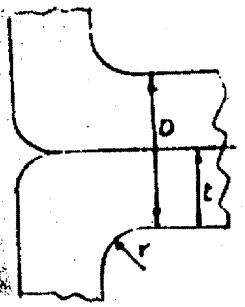
$K_{BO} = 1.22$

From Equation 6.22 of Ref 11:

$K_T = 1.27$

$K_B = 1.14$

Location 8 & 10



$t = 10.696"$ $r = 5.375$

$D = 21.372"$ $\frac{r}{t} = 0.503$

For $\frac{r}{t} = 0.503$

$K_T = 1.80$
$K_B = 1.50$
} From Fig. A.7-1 Ref 3

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.
CHARGE NO.
DESCRIPTION: STRUCTURAL AND FATIGUE EVALUATION OF INLET NOZZLE - VESSEL SUPPORTS

NUMBER S-311-P | A167
SHEET 59 OF 69
DATE 4-22-54 BY STRELL
CHECK DATE 4-22-54 BY HELPER

5. DETAILED ANALYSIS:

a. STRESSES:

#2. PEAK STRESS:

THE FOLLOWING EXPRESSIONS FOR STRESS WILL BE USED TO CALCULATE PEAK STRESSES AT LOCATIONS 6, 8 AND 10.

LOCATION 6:

PRESSURE STRESS:

$$\sigma_x = -\frac{6M_2}{t^2_{2A}}K_B + \frac{b^2P}{R_2 t_{2A}}K_T = -1.2126M_2 + 3.3454P$$

$$\sigma_\theta = -\frac{\nu 6M_2}{t^2_{2A}}K_B + \frac{EW_{2L}}{R_2} + \frac{bP}{t_{2A}} = -0.3639M_2 + 0.0662EW_{2L} + 5.7995P$$

$$\sigma_r = 0$$

THERMAL STRESS:

$$\sigma_x = -\frac{6(M_2 - M_{2T})}{t^2_{2A}}K_B + \frac{E\alpha_i}{(1-\nu)}(T_m - T)K_T = -1.2126M_2 + 1.8143E\alpha_i(T_m - T)$$

$$\sigma_\theta = -\frac{\nu(M_2 - M_{2T})}{t^2_{2A}}K_B + \frac{EW_{2L}}{R_2} + \frac{E\alpha_i}{(1-\nu)}(T_m - T) = -0.3639(M_2 + M_{2T}) + 0.0662EW_{2L} + 1.4286E\alpha_i(T_m - T)$$

THERMAL INDUCED PIPE REACTIONS:

$$T_x = -\frac{F_x}{A}K_1 + \frac{M_z}{I}K_2 =$$

$-0.00561F_x + 0.00071M_z$ PART A
$-0.00561F_x - 0.00071M_z$ B
$-0.00561F_x + 0.00071M_y$ C
$-0.00561F_x - 0.00071M_y$ D

$$T_m = \frac{F_R}{A}K_1 \pm \frac{M_R}{I}K_2 =$$

$0.01004F_z + 0.00035M_x$ PART A
$0.01004F_z - 0.00035M_x$ B
$0.01004F_y + 0.00035M_x$ C
$0.01004F_y - 0.00035M_x$ D

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.
CHARGE NO.
DESCRIPTION Structural And Fatigue Evaluation Rx Inlet Nozzle - Vessel Support

NUMBER S-211-P | A168
SHEET 60 OF 129
DATE 4-22-69 BY Cockrell
CHECK DATE 4-22-69 BY Hellner

3. Detailed Analysis:

Piping Stresses:

2nd Peak Stresses:

Seismic Pipe Reactions:

The Formulas For Calculating The Stresses Due To The Seismic Pipe Reactions Are The Same As For The Thermal Induced Pipe Reactions.

Location B:

Pressure Stress

$$\sigma_x = -\frac{6M_a}{t_{sa}^2}\frac{R_i}{R_{sa}}K_B + \frac{b^2P}{2R_{sa}t_{sa}}K_x = \underline{-0.0861\,M_a + 1.1155P}$$

$$\sigma_{\theta i} = -\frac{\nu 6M_a}{t_{sa}^2}\frac{R_i}{R_{sa}}K_B + \frac{EM_a}{R_{sa}} + \frac{bP}{t_{sa}} = \underline{-0.0259M_a + 0.0456EM_a + 1.6399P}$$

$$\sigma_r = 0$$

Thermal Stress

$$\sigma_x = -\frac{6(M_a+M_{a'})}{t_{sa}^2}\frac{R_i}{R_{sa}}K_B + \frac{E\alpha_i}{(1-\nu)}(T_m - T)K_T = \underline{-0.0861(M_a+M_{a'}) + 2.5714E\alpha_i(T_m-T)}$$

$$\sigma_{\theta i} = -\frac{\nu 6(M_a+M_{a'})}{t_{sa}^2}\frac{R_i}{R_{sa}}K_B + \frac{EM_{a'}}{R_{sa}} + \frac{E\alpha_i}{(1-\nu)}(T_m-T) = \underline{-0.0258(M_a+M_{a'}) + 0.0456EM_{a'} + 1.4296E\alpha_i(T_m-T)}$$

Thermal Induced Pipe Reactions:

$$\sigma_x = -\frac{F_x}{A}K_T \pm \frac{Mc}{I}K_B = -0.00128F_x + 0.00012M_z$$
$$= -0.00128F_x - 0.00012M_z$$
$$= -0.00128F_x + 0.00012M_y$$
$$= -0.00128F_x - 0.00012M_y$$

$$\tau_{xy} \quad \frac{F_z}{A}K_V \pm \frac{Mc}{J}K_B = 0.00207F_z + 0.000057M_x$$
$$= 0.00207F_z - 0.000057M_x$$
$$= 0.00207F_y + 0.000057M_x$$
$$= 0.00207F_y - 0.000057M_x$$

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.
CHARGE NO.
DESCRIPTION: STRUCTURAL AND FATIGUE EVALUATION OF INLET NOZZLE - VESSEL SUPPORTS

NUMBER 5-211-P | A169
SHEET 61 OF 69
DATE 4-22-63 BY COCKRELL
CHECK DATE 4.22.63 BY HOLDER

5. DETAILED ANALYSIS:

e. STRESSES:

2. PEAK STRESSES:

THE EQUATIONS FOR STRESS DUE TO SEISMIC PIPE REACTIONS, STATIC LOADING THROUGH SUPPORTS, EARTHQUAKE LOADING THROUGH SUPPORTS, AND THERMAL EXPANSION & CONTRACTION ARE THE SAME AS FOR THE THERMAL INDUCED PIPE REACTIONS. THE VALUES OF F_x, F_y, F_z, M_x, M_y, AND M_z ARE THE SAME AS THOSE LISTED ON SHEETS 40 → 42.

LOCATION 10:

PRESSURE STRESS:

	POINTS A & B LONGITUDINAL PLANE	POINTS C & D CIRCUMFERENTIAL PLANE
$\sigma_x = i_x\left(\frac{Dp}{t} + \frac{p}{2}\right) =$	5.1477 P	= 17.7402 P
$\sigma_\theta = i_\theta\left(\frac{Dp}{t} + \frac{p}{2}\right) =$	10.1373 P	= 21.9641 P
$\sigma_r =$	0	

THERMAL STRESS:

POINTS A & B (LONGITUDINAL PLANE):

$$\sigma_x = -\frac{6}{t_s^2}(M_x + M_{sT})K_B - \frac{M_x}{t_s}K_T + \frac{E\alpha_i}{(1-\nu)}(T_m - T)K_T = \underline{-0.0779(M_x + M_{sT}) - 0.1674\,M_x + 2.5714\,E\alpha_i(T_m - T)}$$

$$\sigma_\theta = -\frac{\nu 6}{t_s^2}(M_x + M_{sT})K_B + \frac{EW_{bg}}{R_s s w \phi} + \frac{E\alpha_i}{(1-\nu)}(T_m - T) = \underline{-0.0234(M_x + M_{sT}) + 0.0462\,EW_{bg} + 1.4286(T_m - T)}$$

POINTS C & D (CIRCUMFERENTIAL PLANE):

$$\sigma_x = -\frac{K_T 6}{t_s^2}(M_x + M_{sT})K_B + \frac{EW_{bg}}{R_s s w \phi} + \frac{E\alpha_i}{(1-\nu)}(T_m - T) = \underline{-0.0234(M_x + M_{sT}) + 0.0462\,EW_{bg} + 1.4286(T_m - T)}$$

$$\sigma_\theta = -\frac{\nu 6}{t_s^2}(M_x + M_{sT})K_B - \frac{M_x \nu}{R_s t_s (1-\nu)}(T_m - T)K_T = \underline{-0.0779(M_x + M_{sT}) - 0.1632\,M_x + 2.57M\,E\alpha_i(T_m - T)}$$

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.
CHARGE NO.

NUMBER S-311-P | A 170
SHEET 62 OF 69
DATE 4-22-69 BY COCKRELL
CHECK DATE 4-22-69 BY HEILKER

DESCRIPTION STRUCTURAL AND FATIGUE EVALUATION OF INLET NOZZLE - VESSEL SUPPORTS

5.0 DETAILED ANALYSIS:

6.0 STRESSES:

6.2 PEAK STRESSES:

THERMAL INDUCED PIPE REACTIONS:

$$\sigma_A = -\left(\frac{N_c}{F_1/R_m}\right)\frac{\bar{F}_1}{R_m T} K_T \pm \left(\frac{M_1}{F_1}\right)\frac{6\bar{F}_1}{T^2} K_B \pm \left(\frac{N_B}{\pi(R_m^2 - R_{in}^2)}\right)\frac{\bar{M}}{R_m^2 \beta T} K_T \pm \left(\frac{M_x}{\pi I R_m \beta}\right)\frac{6\bar{M}}{R_m \beta T^2} K_B$$

$$= -0.00827\,\bar{F}_x + 0.00025\,\bar{M}_z \quad \text{POINT A}$$
$$= -0.00827\,\bar{F}_x - 0.00025\,\bar{M}_z \quad B$$
$$= -0.00827\,\bar{F}_x + 0.00022\,\bar{M}_y \quad C$$
$$= -0.00827\,\bar{F}_x - 0.00022\,\bar{M}_y \quad D$$

$$\sigma_B = -\left(\frac{N_B}{F_1/R_m}\right)\frac{F_1}{R_m T} K_T \pm \left(\frac{M_B}{F_1}\right)\frac{6\bar{F}_1}{T^2} K_B \pm \left(\frac{N_B}{\pi(R_m^2 - R_{in}^2)\beta}\right)\frac{\bar{F}}{R_m^2 \beta T} K_T \pm \left(\frac{M_x}{\bar{I}/R_m \beta}\right)\frac{6\bar{M}}{R_m \beta T^2} K_B$$

$$= -0.00962\,\bar{F}_x + 0.00022\,\bar{M}_z \quad \text{POINT A}$$
$$= -0.00962\,\bar{F}_x - 0.00022\,\bar{M}_z \quad B$$
$$= -0.00962\,\bar{F}_x + 0.00034\,\bar{M}_y \quad C$$
$$= -0.00962\,\bar{F}_x - 0.00034\,\bar{M}_y \quad D$$

$$\tau_{TA} = \pm\frac{\bar{F}}{\pi r_{oT}} K_B + \frac{\bar{M}_z}{2\pi R_{oT}^2} K_B = 0.00165\,\bar{F}_z + 0.00003\,\bar{M}_z \quad \text{POINT A}$$
$$= -0.00165\,\bar{F}_z + 0.00003\,\bar{M}_z \quad B$$
$$= 0.00165\,\bar{F}_y + 0.00003\,\bar{M}_x \quad C$$
$$= -0.00165\,\bar{F}_y + 0.00003\,\bar{M}_x \quad D$$

THE EQUATIONS FOR STRESS DUE TO SEISMIC PIPE REACTIONS, STATIC LOADING THROUGH SUPPORTS, EARTHQUAKE LOADING THROUGH SUPPORTS, AND THERMAL EXPANSION AND CONTRACTION ARE THE SAME AS FOR THE THERMAL INDUCED PIPE REACTIONS. THE VALUES OF $\bar{F}_x$, $\bar{F}_y$, $\bar{F}_z$, $\bar{M}_x$, $\bar{M}_y$, AND $\bar{M}_z$ ARE THE SAME AS THOSE GIVEN ON SHEETS 44 THRU 47.

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.

CHARGE NO.

DESCRIPTION Structural And Fatigue Evaluation Of Inlet Nozzle - Vessel Supports

NUMBER 5-211-P | A171
SHEET 63 OF 69
DATE 4-22-69 BY Cornell
CHECK DATE 4-27-69 BY Heiker

5. Detailed Analysis:

e - Stresses:

2 - Peak Stresses

The following values of ($T_{mean} - T_{surface}$) for the inside and outside surfaces are to be used to calculate peak stresses for the fatigue evaluation.

Transient		Cut-1 Body-1 ΔT_{mean}	Cut-1 Body-1 $\Delta T_{surface}$	Cut-1 Body-2 ΔT_{mean}	Cut-1 Body-2 $\Delta T_{surface}$	Cut-2 Body-2 ΔT_{mean}	Cut-2 Body-2 $\Delta T_{surface}$	Cut-4 Body-4 & Body-5 ΔT_{mean}	Cut-4 Body-4 & Body-5 $\Delta T_{surface}$
2 - Heatup	4.00 Min	-5	3	-4	3	-6	4	-55	30
	4.25	↓	↓	↓	↓	↓	↓	↓	↓
	4.35	↓	↓	↓	↓	↓	↓	↓	↓
	4.47	↓	↓	↓	↓	↓	↓	↓	↓
	5.00	0	0	0	0	-1	1	-28	17
Cooldown	4.00 Min	5	-3	4	-3	6	-4	55	-30
	4.25	↓	↓	↓	↓	↓	↓	↓	↓
	4.35	↓	↓	↓	↓	↓	↓	↓	↓
	4.47	↓	↓	↓	↓	↓	↓	↓	↓
	5.00	0	0	0	0	1	1	28	-17

Transient		For All Nodes ΔT_{mean}	For All Nodes $\Delta T_{surface}$
Steady State		0	0
c	20 min	-7.8	
d	20 min	7.8	
e	30 sec	11.2	
	225 sec	1.7	
f	40 sec	-9.3	
	100 sec	-13.3	
	260 sec	-1.3	
g	2 min	12	
	32 min	15	
	104 min	0	
h	10 sec	-9.5	
	55 sec	8.5	
i	320 min	0	↓
j	N.O. 2 hrs	-9	3
	S.S	0	0
	C.D. 2 hrs	8	-3
k	~	6	0
	~	-6	↓
l	12 sec	333	
m	10 sec	-30.2	↓
	28 sec	-41.2	
	160 sec	-4.8	
n	33 sec	117	↓
	54 sec	197	

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.
CHARGE NO.
NUMBER S-211-P | A172
SHEET 64 OF 64
DATE 4-22-69 BY COCKRELL
CHECK DATE 4-22-69 BY HELLER
DESCRIPTION STRUCTURAL AND FATIGUE EVALUATION OF INLET NOZZLE - VESSEL SUPPORTS

5. Detailed Analysis:

a. Stresses

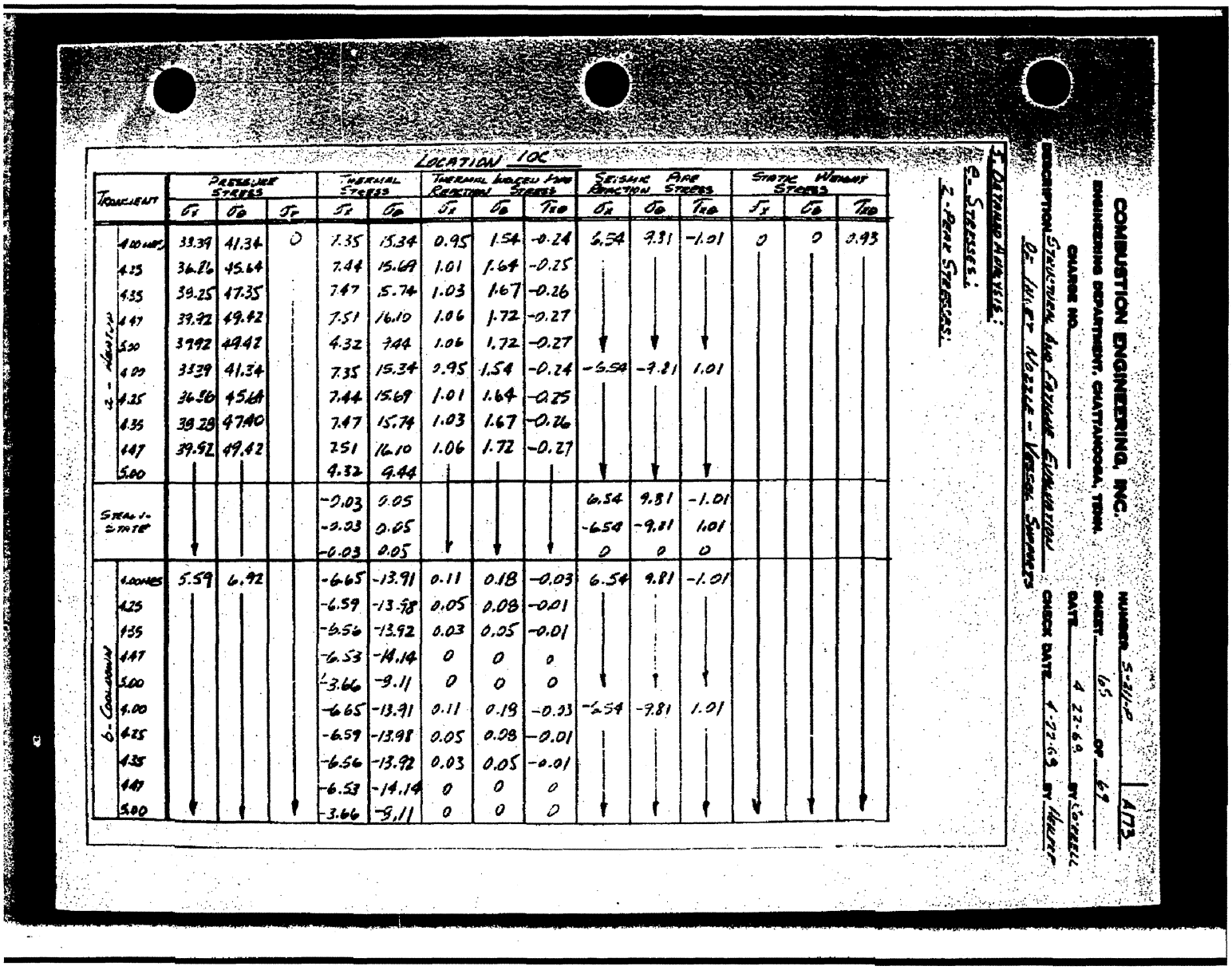
b. Peak Stresses

Note Here That Peak Stresses Were Calculated At The Ten Locations As Shown On Sheet 17 For The Four Orientations A, B, C And D. The Following Table Gives The Overall Usage Factors For Each Location And Each Orientation. Stresses And Stress Intensities Producing These Usage Factors Will Not Be Presented For All Locations And Orientations. Only Stresses And Stress Intensities At The Location And Orientation Which Produced The Highest Overall Usage Factor Will Be Presented. This Was Location 10C.

Location and Orientation	$U_{overall}$
1 A	0.00015
B	0.00013
C	0.00014
D	0.00014
2 A	0
B	0
C	0
D	0
3 A	0.0011
B	0.0015
C	0.0011
D	0.0013
4 A	0.0018
B	0.0013
C	0.0016
D	0.0026

Location and Orientation	$U_{overall}$
5 A	0.00042
B	0.00083
C	0.00049
D	0.00098
6 A	0.0098
B	0.0039
C	0.0098
D	0.0058
7 A	0.0034
B	0.0038
C	0.0037
D	0.0039
8 A	0.0060
B	0.0046
C	0.0059
D	0.0054

Location and Orientation	$U_{overall}$
9 A	0.019
B	0.015
C	0.0032
D	0.0030
10 A	0.0061
B	0.0024
C	0.042
D	0.037



COMBUSTION ENGINEERING, INC. NUMBER S-BWP-1 A173
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN. SHEET 65 OF 69
CHARGE NO. DATE 4-22-69 BY SCHNELL
DESCRIPTION Structural Analysis Equation CHECK DATE 4-22-69 BY Hauser

1. Obtained Results:
2. Stresses:
3. Peak Stresses:

LOCATION 10C

Transient		Pressure Stress σ_x	Pressure Stress σ_θ	Pressure Stress $\tau_{x\theta}$	Thermal Stress σ_x	Thermal Stress σ_θ	Thermal Linear Pipe Reaction Stress σ_x	Thermal Linear Pipe Reaction Stress σ_θ	Thermal Linear Pipe Reaction Stress $\tau_{x\theta}$	Seismic Pipe Reaction Stress σ_x	Seismic Pipe Reaction Stress σ_θ	Seismic Pipe Reaction Stress $\tau_{x\theta}$	Static Weight Stress σ_x	Static Weight Stress σ_θ	Static Weight Stress $\tau_{x\theta}$
2 - Normal	4.00 sec	33.39	41.34	0	7.35	15.34	0.95	1.54	-0.24	6.54	9.81	-1.01	0	0	0.93
	4.25	36.86	45.64		7.44	15.69	1.01	1.64	-0.25						
	4.35	39.25	47.35		7.47	15.74	1.03	1.67	-0.26						
	4.47	39.92	49.42		7.51	16.10	1.06	1.72	-0.27						
	5.00	39.92	49.42		4.32	7.44	1.06	1.72	-0.27						
	4.00	33.39	41.34		7.35	15.34	0.95	1.54	-0.24	-6.54	-9.81	1.01			
	4.25	36.86	45.64		7.44	15.69	1.01	1.64	-0.25						
	4.35	39.25	47.40		7.47	15.74	1.03	1.67	-0.26						
	4.47	39.92	49.42		7.51	16.10	1.06	1.72	-0.27						
	5.00				4.32	4.44									
Steady-State					-0.03	0.05				6.54	9.81	-1.01			
					-0.03	0.05				-6.54	-9.81	1.01			
					-0.03	0.05				0	0	0			
6 - Cooldown	4.00 sec	5.59	6.92		-6.65	-13.91	0.11	0.18	-0.03	6.54	9.81	-1.01			
	4.25				-6.59	-13.98	0.05	0.08	-0.01						
	4.35				-6.56	-13.92	0.03	0.05	-0.01						
	4.47				-6.53	-14.14	0	0	0						
	5.00				-3.66	-9.11	0	0	0						
	4.00				-6.65	-13.91	0.11	0.19	-0.03	-6.54	-9.81	1.01			
	4.25				-6.59	-13.98	0.05	0.08	-0.01						
	4.35				-6.56	-13.92	0.03	0.05	-0.01						
	4.47				-6.53	-14.14	0	0	0						
	5.00				-3.66	-9.11	0	0	0						

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.
CHARGE NO.
DESCRIPTION: STRUCTURAL AND FATIGUE EVALUATION OF INLET NOZZLE - VESSEL SUPPORTS

NUMBER 5-211-P | A174
SHEET 160 OF 69
DATE 4-22-69 BY COCKRELL
CHECK DATE 4-27-69 BY HEILKER

5. DETAILED ANALYSIS:
a. STRESSES:
2. PEAK STRESSES:

LOCATION: 10C

Transient		Pressure Stress			Thermal Inside Surface Stress			Seismic Plus Reaction Stress			Seismic Weight Stress		
		σ_r	σ_θ	$\tau_{r\theta}$	σ_r	σ_θ	$\tau_{r\theta}$	σ_r	σ_θ	$\tau_{r\theta}$	σ_r	σ_θ	$\tau_{r\theta}$
c	20 min	39.92	49.92	0	-0.03	0.05	1.06				0	0	0.93
d	20 min	39.92	49.92										
e	100 sec	37.52	47.00										
	225 sec	40.32	49.97										
f	40 sec	41.16	50.96										
	100 sec	40.29	49.64										
	240 sec	37.96	47.00										
g	2 min	42.04	52.05										
	3.2 min	41.61	51.62										
	10.4 min	38.18	47.22										
h	10 sec	39.38	48.76		↓	↓	↓						
	65 sec	33.88	41.95										
i	220 min	55.44	68.64		0	0	0						
j	ND 20 min	22.15	27.46		-0.02	0.68	0.71	0.71	1.15	-0.18			
	S.S.	44.35	54.91		-0.02	0.03	0.71	0.71	1.15	-0.19			
	CO. 40 MIN	5.59	6.92		0.07	-0.74	0	0	0	0			
k	~	41.69	51.62		-0.03	0.05	1.06				1.72	1.72	-0.27
	~	39.14	47.22										
l	12 sec	39.92	49.42										
m	10 sec	49.96	60.62										
	28 sec	37.61	46.56										
	140 sec	25.55	31.63										
n	33 sec	5.32	6.59		↓	↓	↓	↓	↓	↓	↓	↓	↓
	54 sec	12.48	15.37										

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.
NUMBER 5-211-P | A175
SHEET 6 OF 69
CHARGE NO. _____ DATE 4-22-63 BY S.CARROLL
DESCRIPTION Structural And Fatigue Evaluation Of Inlet Nozzle - Vessel Shell CHECK DATE 4-22-63 BY Hunter

5. Rotated Analysis
2. Stresses
2. Peak Stresses

LOCATION - 10C

Transient		Exchanger Lining Thermal Stresses			Expansion and Contraction Forces		Total Stress				Principal Stresses			Stress Intensity		
		σ_x	σ_θ	$\tau_{x\theta}$	F_x	σ_θ	σ_x	σ_θ	σ_r	$\tau_{x\theta}$	σ_1	σ_2	σ_3	$\sigma_1-\sigma_2$	$\sigma_1-\sigma_3$	$\sigma_2-\sigma_3$
+ Normal	4.00 Min	1.36	2.10	-0.49	-1.39	-1.62	47.97	69.73	0	-0.90	68.77	47.94	0	20.83	68.77	47.94
	4.25	↓	↓	↓	↓	↓	51.60	73.49	↓	-0.82	73.52	51.57	↓	21.95	73.52	51.57
	4.35	↓	↓	↓	↓	↓	53.04	75.29	↓	-0.82	75.32	53.03	↓	22.32	75.32	53.03
	4.47	↓	↓	↓	↓	↓	54.77	77.76	↓	-0.83	77.79	54.74	↓	23.05	77.79	54.74
	5.00	↓	↓	↓	↓	↓	51.58	71.11	↓	-0.93	71.14	51.54	↓	19.60	71.14	51.54
	4.00	-1.36	-2.10	0.49	↓	↓	32.16	44.91	↓	2.19	45.28	31.79	↓	13.49	45.28	31.79
	4.25	↓	↓	↓	↓	↓	35.79	49.67	↓	2.16	50.01	35.46	↓	14.55	50.01	35.46
	4.35	↓	↓	↓	↓	↓	37.26	51.51	↓	2.16	51.84	36.94	↓	14.90	51.84	36.94
	4.47	↓	↓	↓	↓	↓	39.96	52.94	↓	2.15	54.24	38.66	↓	15.59	54.24	38.66
	5.00	↓	↓	↓	↓	↓	35.77	47.29	↓	2.15	47.68	35.38	↓	12.31	47.68	35.38
Steady-State		1.36	2.10	-0.49	0	0	49.85	63.10		-0.53	63.15	43.80		14.34	63.15	49.80
		-1.36	-2.10	0.49	↓	↓	33.05	39.78		2.15	39.95	32.38		7.57	39.95	32.38
		0	0	0	↓	↓	40.95	51.19		0.66	51.23	40.91		10.32	51.23	40.91
- Cooldown	4.00 Min	1.36	2.10	-0.49	1.39	1.62	9.57	6.49		-0.59	6.55	3.52		-1.97	6.55	3.52
	4.25	↓	↓	↓	↓	↓	9.57	6.32		-0.58	6.39	3.49		-2.10	6.39	3.49
	4.35	↓	↓	↓	↓	↓	9.58	6.34		-0.57	6.42	3.50		-2.09	6.42	3.50
	4.47	↓	↓	↓	↓	↓	9.58	6.07		-0.56	6.17	3.48		-2.32	6.17	3.48
	5.00	↓	↓	↓	↓	↓	11.45	12.10		-0.56	11.17	12.38		-1.20	11.17	12.38
	4.00	-1.36	-2.10	0.49	↓	↓	-7.24	-17.33		1.97	-17.49	-7.09		-10.39	-17.49	-7.09
	4.25	↓	↓	↓	↓	↓	-7.24	-17.50		1.99	-17.65	-7.09		-10.56	-17.63	-7.08
	4.35	↓	↓	↓	↓	↓	-7.23	-17.48		1.99	-17.63	-7.08		-10.56	-17.63	-7.08
	4.47	↓	↓	↓	↓	↓	-7.22	-17.75		2.00	-17.89	-7.33		-10.91	-17.89	-7.08
	5.00	↓	↓	↓	↓	↓	-4.34	-11.72		2.00	-12.01	-4.05		-7.95	-12.01	-4.06

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.

CHARGE NO.

DESCRIPTION Structural And Fatigue Evaluation Of Inlet Nozzle - Vessel Supports

NUMBER S-211-P- L176
SHEET 60 OF 69
DATE 4-22-69 BY JCKERELL
CHECK DATE 4-22-69 BY HEILPER

5. Detailed Analysis:
c. Stresses:
2. Peak Stresses:

LOCATION: 10L

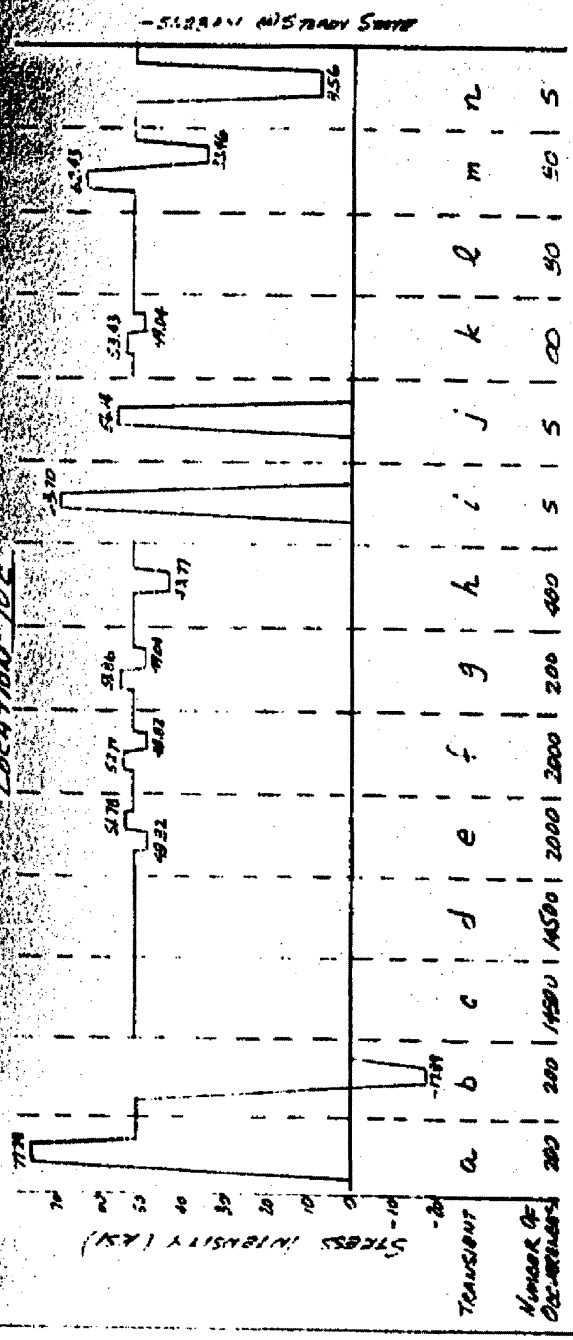
Transient	Extremity Local Stress		Examine Adj. Stress		Total Stress			Principal Stress			Stress Intensity	
	σ_r	σ_θ	$\tau_{r\theta}$	σ_r	σ_θ	σ_z	$\tau_{r\theta}$	σ_1	σ_2	σ_3	$\sigma_1-\sigma_3$	$\sigma_2-\sigma_3$
C 20 min	0	0	0	0	51.19	0	0.46	51.23	40.91	0	51.23	40.91
J 20 min	—	—	—	—	—	—	—	—	—	—	—	—
e 100 sec	—	—	—	—	49.77	—	—	49.32	39.55	—	49.32	39.55
222 sec	—	—	—	—	51.74	—	—	51.78	41.35	—	51.78	41.35
f 40 sec	—	—	—	—	52.73	—	—	52.77	42.15	—	52.77	42.15
100 sec	—	—	—	—	51.41	—	—	51.45	41.38	—	51.45	41.08
240 sec	—	—	—	—	46.77	—	—	49.82	38.95	—	49.82	38.95
g 2 min	—	—	—	43.08	53.52	—	—	53.86	43.04	—	53.86	43.04
3.2 min	—	—	—	42.72	53.38	—	—	53.43	42.68	—	53.43	42.68
186 min	—	—	—	37.18	48.99	—	—	49.04	39.13	—	49.04	39.13
L 10 sec	—	—	—	40.42	50.53	—	—	50.57	40.37	—	50.57	40.37
65 sec	—	—	—	34.92	43.72	—	—	43.77	34.87	—	43.77	34.87
i 120 min	—	—	—	55.44	69.66	—	0.93	69.70	55.37	—	69.70	55.37
j No. zones	—	—	—	22.16	29.38	—	0.74	29.37	22.78	—	29.37	22.78
S.S. 3.0 min	—	—	—	45.04	56.09	—	0.74	56.14	44.99	—	56.14	44.99
CD 3.0 min	—	—	—	5.46	6.17	—	0.93	6.88	4.96	—	6.88	4.96
k 〃	—	—	—	42.72	53.38	—	0.66	53.43	42.68	—	53.43	42.68
〃	—	—	—	39.18	48.99	—	—	49.04	39.13	—	49.04	39.13
ℓ 12 sec	—	—	—	40.15	51.19	—	—	51.23	40.91	—	51.23	40.91
m 10 sec	—	—	—	50.00	62.39	—	—	62.43	49.96	—	62.43	49.96
28 sec	—	—	—	38.64	48.33	—	—	48.38	38.60	—	48.38	38.60
180 sec	—	—	—	26.58	33.40	—	—	33.46	26.52	—	33.46	26.52
n 33 sec	—	—	—	6.36	8.36	—	—	5.56	6.16	—	5.56	6.16
54 sec	—	—	—	13.45	17.14	—	—	17.26	13.34	—	17.26	13.34

COMBUSTION ENGINEERING, INC.
ENGINEERING DEPARTMENT, CHATTANOOGA, TENN.
CHARGE NO.
DESCRIPTION STRUCTURAL AND FATIGUE EVALUATION OF INLET NOZZLE - VESSEL SUPPORTS

NUMBER S-211-P | A177
SHEET 69 OF 69
DATE 4-22-69 BY COFFELL
CHECK DATE 4-22-69 BY HENKER

5. DETAILED ANALYSIS:

5.1 FATIGUE EVALUATION:



S_{max}	S_{min}	S_{alt}	Number of Occurrences	N^*	U
72.79	-17.99	47.84	200	4900	0.0409
63.70	0	31.85	5	14000	[illegible]
62.43	8.56	26.94	5	34000	0.[illegible]
62.43	33.46	14.49	75	460000	[illegible]
56.14	0	28.07	5	[illegible]	[illegible]
53.96	43.77	5.05	200	∞	0

* FROM FIG N-415(a) REFERENCE 1

$U_{CYCL} = 0.942$