#7

OSC 1522

Design Report #7

Thermal Mechanical Stress Analysis

of

High Pressure Injection Nozzle

B&W Contract No. 620-0003-50
Customer: Duke Power Company

FOR INFORMATION ONLY

Prepared By: W.L. Tanksley and Associates, Inc.

Reviewed By: Robert Tornow

Approved By: James P. Butt

Report #7 - "Thermal Mechanical Stress Analysis of High Pressure Injection Nozzle"

Replace entire report with the "Thermal Mechanical Analysis of 2-1/2 Sch 160 make-up and High Pressure Injection Nozzle" for 620-0009-50 as modified in FCA 04-3601-00 (Reference #4), B&W Document 32-1128224-02 (Reference #1), and the changes to the 620-0009-50 report described below:

1. Page iii - Reference A.1 - 150156E-6 should be 131924E-9.

2. Page iii - Reference B.1 - Add "As modfied by FCA 04-3599-00.

REV.	DATE
0	12-69
1	5-72

0005130281

REVISION PAGE

REV. NO.	PAGE	DESCRIPTION	DATE	BY/APP.
0	ALL	INITIAL RELEASE	6-73	FLB/
		The changes below indicate the modifications required to update the 620-0008-50 analysis to the requirements of 620-0009-50.		
	i	Added last sentence in Scope.		
		Changed 70°-90°F to 70°-95°F in 4th line of Discussion.		
		Eliminate all but 1st sentence in Conclusion.		
	ii	Omitted primary stress results in Results Section.		
	iii	Reference A.1 revised for NSS-9 contract.		
		Reference B.1 revised for NSS-9 contract.		
	1.0	Added explanation for a dimensional change on nozzle.		
	1.1	Added NSS-9 dimensions (asteriked) to nozzle sketch.		
	3-56	Add statement at bottom of page.		
	3-65	Omitted Case-2 earthquake loading.		
	3-66	Omitted all reference to piping reaction stresses.		
	5-21	Omitted all references to earthquake loadings.		
	5-22 to 5-31	Omitted all reference to piping reaction stresses.		
1	ii 5-21 5-24 5-25 5-28 5-29 5-30 5-31	Added note referencing fatigue analysis with pipe loads contained in Section "F".	10/29/73	DMcK/DM3

Revisions For B&W Report # 5

.	Date	Page	Revision Comments	By	A
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8-72

SCOPE:

This report contains the Thermal/Mechanical Analysis of the make-up nozzle and high pressure injection nozzle. These nozzles have the same geometry but are used for different purposes. They are located in the cold legs on the discharge side of the pumps. This report contains the justification of primary plus secondary stress limits and the fatigue analysis as defined in B31.7 "Nuclear Piping Code". Satisfaction of basic pressure sizing criteria and reinforcement calculations are found in Report 1 "Code Sizing Calculation". Piping reaction loads and stresses can be found in Report #4, "Piping Reactions".

DISCUSSION:

The make-up nozzle and high pressure injection nozzles have the same pressure, branch moment loading and run moment loading, but have different temperature distributions. The make-up nozzle is predominately cold in that it has a fairly constant flow and is at a temperature of 70°-95°F. The HPI is only used for a sudden pressure drop condition, and thus is at a temperature consistent with the cold leg temperature, 550°-575°F, when it is shocked with 60°F water. The critical stress location in the make-up nozzle occurs near the nozzle to run pipe intersection whereas the critical stress in the high pressure injection nozzle occurs outside the thermal sleeve in the upper part of the nozzle.

The analysis has essentially the same format for both nozzles. First, the temperature distribution is evaluated for various transient conditions and time-temperature plots for selected nodes are made to select critical times. These times are then used to calculate stresses, and thus stress ranges can be determined for thermal stresses. Secondly, stresses are calculated for pressure loading, and the stresses are then combined to obtain the total stress picture. Finally a fatigue analysis is performed to demonstate acceptable performance during the design duration.

CONCLUSION:

The make-up nozzle and high pressure injection nozzle meet all the requirements of B31.7 1968 Draft.

JMS
8-72

RESULTS

Primary + Secondary Stresses

Branch Intersection Make-Up Nozzle

$S = 21.1$ ksi $< 3\ S_m = 53.4$ ksi

End of HPI Nozzle

$S = 107$ ksi $> 3\ S_m = 51.3$ ksi

An elastic plastic analysis was performed. Range of primary + secondary stresses occurring more than 250 cycles.

$S = 9.85$ ksi $< 3\ S_m = 51.3$ ksi

Fatigue Usage Factors

Branch Intersection make-up nozzle

$U = .045 < 1.0$

End of HPI Nozzle

$U = .953 < 1.0$

NOTE: This fatigue analysis includes thermal and mechanical discontinuity stresses only. For inclusion of stresses due to run and branch pipe motions, see Section "F".

D.MCK.
10/29/73
REV. 1

REFERENCES

A. Drawings

1. Babcock and Wilcox Drawing 150156E-6 "Assembly and Detail for 2-1/2" Pressure Injection Nozzle"

B. Codes and Specs.

1. General Functional Specifications for Reactor Coolant System Components, CS(F)-3-92/NSS-9/0372.

2. Nuclear Power Piping, USAS B31.7, 1968 Draft.

C. Computer Programs

1. 91167 - "Temperature Distribution"

2. 91032 - "Temperature Interpolation"

3. 169 - "Ring Thermal Stresses"

4. 91079 - "Thermal Stresses and Motions from a Radial Temperature Gradient In a Long Cylinder, Short Cylinder, or Spherical Segment"

5. 91191 - "Annular Plate Thermal Motions"

6. 91060 - "Interaction Analysis"

D. General

1. Tentative Structural Design Basis for Reactor Pressure Vessels, U.S. Department of Commerce, Office of Technical Service.

2. Stress Concentration Design Factors, By R.E. Peterson, John Wiley and Sons, 1966.

SECTION 1

This section contains a sketch of the make-up nozzle (identical to high pressure injection nozzle) demonstrating dimensions used in the analysis. This sketch appears on Page 1-1. The dimensions with asteriks are those for the NSS-9 nozzle, which are different from those analyzed. The change will have little effect on the final stress results. This reasoning is justified by a review of similar geometry nozzles, using the dimensions with asteriks, which were analyzed for similar thermal transients. The results indicate that a small change in piping dimensions have a negligible effect on the stress levels. The ratio of actual stress to allowable stress for the nozzle to pipe intersection is 0.395 which allows for a reasonable increase in stresses due to a change in geometry.

Stress concentration factors are also determined in this section.

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T-HB
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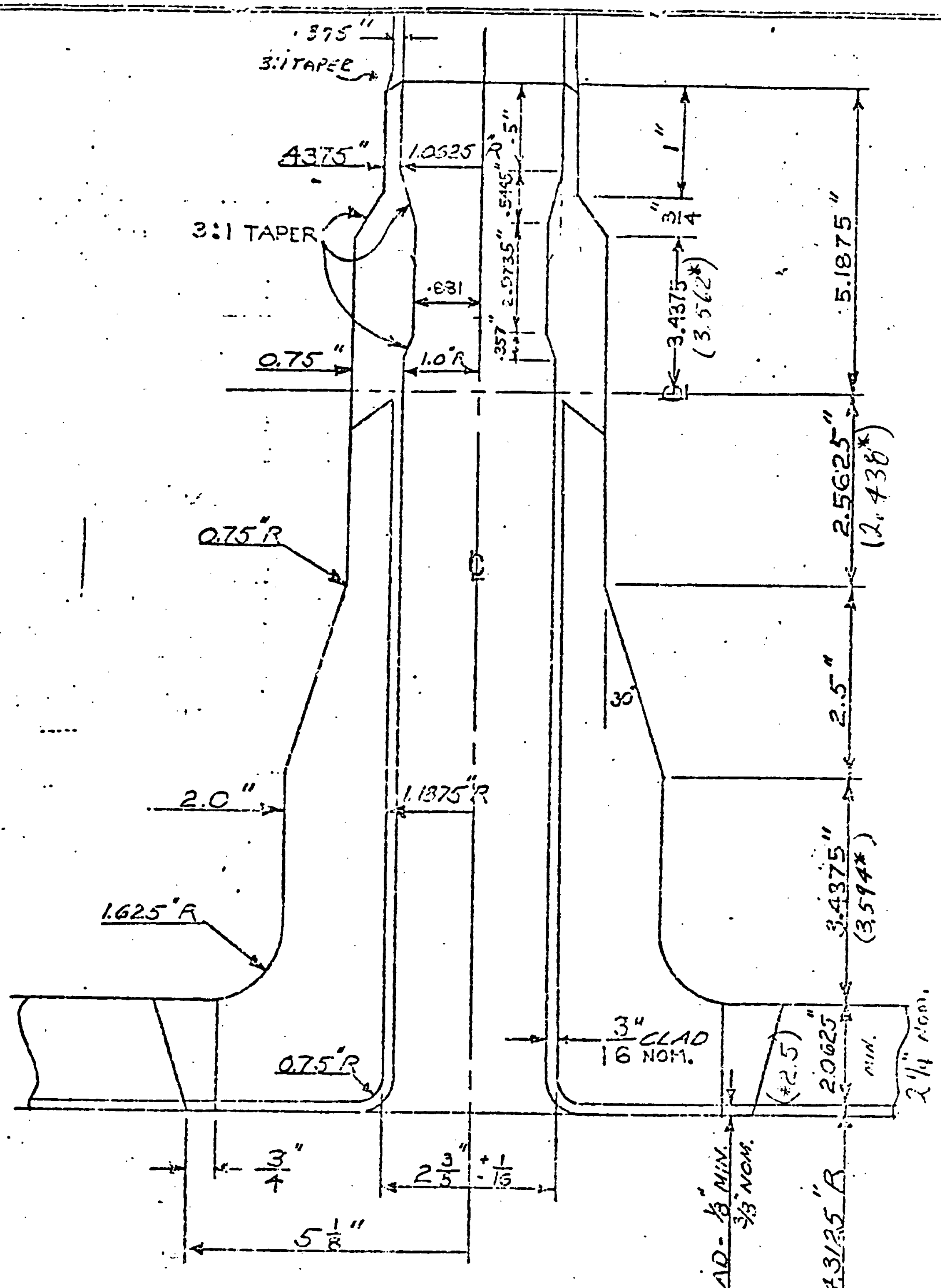

REFERENCE: B&W DWG. 150156E6

2½" SCH. 160 PRESSURE INJECTION

D.H.
6-73

BABCOCK & WILCOX

DEPARTMENT BY C.W. ZINN DATE 10-29-7

2½" SCH 160 HIGH PRESSURE INJECTION NOZZLE JOB NO.

28 IN. I.D. PIPE SHEET 1-1

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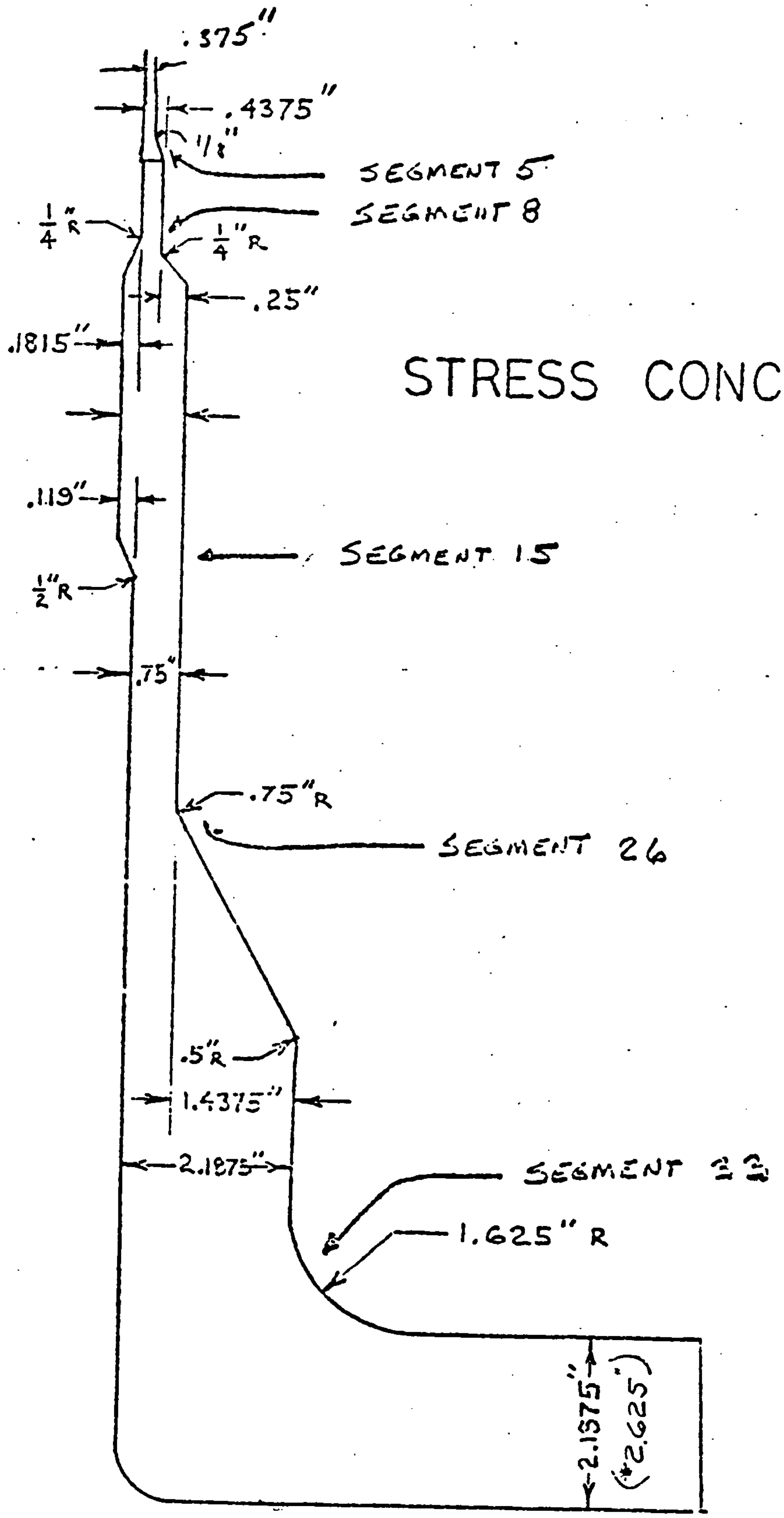
STRESS CONCENTRATION FACTO



BABCOCK & WILCOX

DEPARTMENT

BY C.W. ZINN

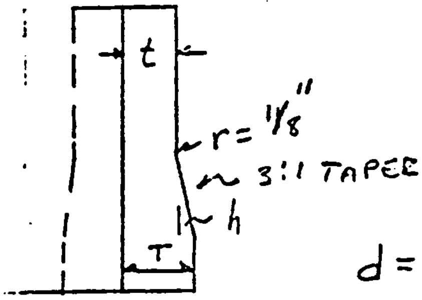
STRESS CONCENTRATION FACTORS

DATE 11-19-70

JOB NO. 620-00

SEGMENT 5
(OUTSIDE)

REF: SEE PAGE 1-10



$t = .375 \quad T = .4375$

$h = .0625 \quad \beta = 72°$

$d = 2t = .75 \quad D = 2T = .875$

$D/d = 1.167 \quad r/d = .167 \quad K_o^{TENSION} = 1.53 \quad K_o^{BEND} = 1$

$$\frac{K'-1}{K_o-1} = 1 - \left[\frac{\beta-\alpha}{90-\alpha}\right]^{1+2.4\sqrt{r/h}}$$

$$\alpha = \sin^{-1}\left[1 - h/r\right] = \sin^{-1}\left[1-.5\right] = 30°$$

$$K'-1/K_o-1 = 1 - \left[\frac{72}{60}\right]^{1+2.4\sqrt{2}} = .79$$

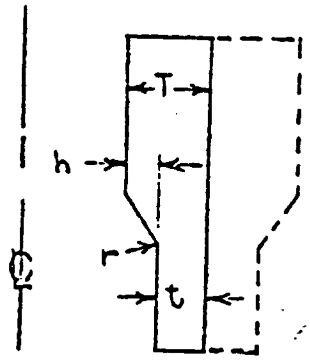
$K'_{TEN} = 1 + .53(.79) = 1.42$ OUTSIDE

$K'_{BEN} = 1 + .48(.79) = 1.38$ OUTSIDE

0005192294

SEGMENT 15

(INSIDE)



USE SAME REFERENCES AS ON PREVIO[US]
PAGE

$h = .119''$ $\quad r/d = .3$

$T = .869''$ $\quad D/d = 1.16$

$t = .75''$

$r = .5$ $\quad$ FROM FIG. 57 & 60 OF REF.

$\beta \approx 72°$ $\quad K_o^T = 1.39 \quad K_o^B = 1.34$

FROM REF. 1 A.7.2.4-2

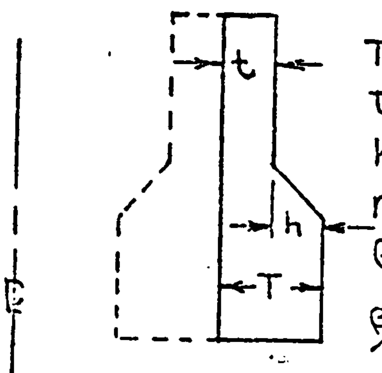
$$\left[\frac{K'-1}{K_o-1}\right] = 1 - \left[\frac{\beta-\alpha}{90-\alpha}\right]^{1+2.4\sqrt{r/h}} \qquad \alpha = \sin^{-1}\left[1-\frac{h}{r}\right]$$

$$\alpha \approx 49.7° \qquad \left[\frac{K'-1}{K_o-1}\right] = 1-[.5533]^{5.92} \qquad K' = 1 + .97($$

$\therefore \quad K_o^T = 1.38 \qquad K_o^B = 1.33$

SEGMENT 26

(OUTSIDE)



$T = 2.1875''$

$t = .75''$ $\quad$ FROM FIG. A.7-1 OF REF. 1

$h = 1.438''$ $\quad K_o^T = 1.52 \quad K_o^B = 1.29$

$r = .75''$

$\beta \approx 70°$ $\quad$ FROM FIG. A.7-2 OF REF. 1

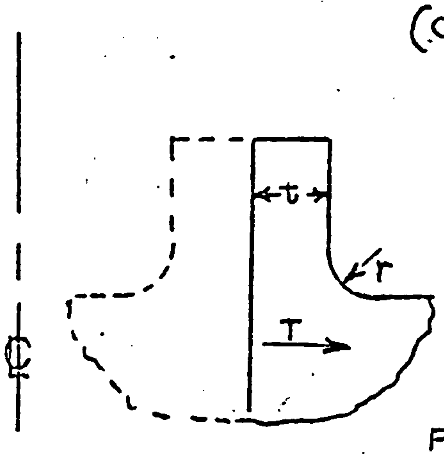
$\beta/90 = .78$ $\quad \left[\frac{K'-1}{K_o-1}\right] = .48 \quad K' = 1 + .48(K_o-1)$

$r/d = .5 \quad r/t = 1.0 \qquad \therefore \quad K_o^T = 1.25 \quad K_o^B = 1.14$

$D/d = 2.92 \quad r/h = .522$

SEGMENT 33-7

(OUTSIDE)



$t = 2.1875''$

$r = 1.625''$

$D = 2T$

$d = 2t$

$r/t = .74$

FROM FIG. A.7-1 OF REFERENCE 1

$K_o^T = 1.63$ $K_o^B = 1.37$

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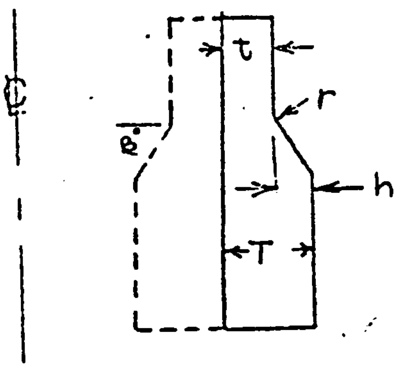
SEGMENT 8

(OUTSIDE)



REF: 1. "TENTATIVE STRUCTURAL DESIGN BA[SIS] FOR REACTOR PRESSURE VESSELS", U.S. DEPT. OF COMMERCE, OFFICE OF TECHNICAL SERVICE.

2. "STRESS CONCENTRATION DESIGN FAC[TORS]" BY R. E. PETERSON

$t = .4375''$ $\quad d = 2t = .875''$
$T = .75''$ $\quad D = 2T = 1.5''$
$r = .25''$ $\quad r/d = .286$
$h = .25''$ $\quad D/d = 1.71$
$\beta \approx 72^\circ$ $\quad \beta/90 = .8$
$r/h = 1.0$

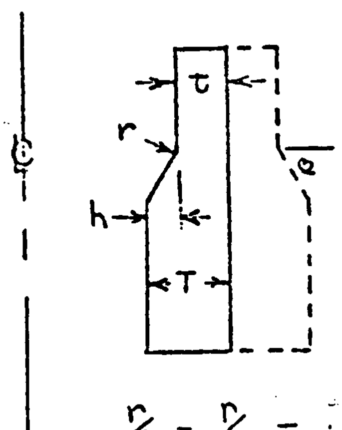
FROM REF. 2 FIGURES 57 & 60
$K_o^T = 1.6 \qquad K_o^B = 1.36$

FROM REF. 1 FIGURE A.7-2

$$\left[\frac{K'-1}{K_o-1}\right] = .53 \qquad K' = 1 + .53(K_o - 1)$$

$$\therefore \quad K'_T = 1.32 \qquad K'_B = 1.19$$

(INSIDE)



$t = .4375''$
$T = .5565''$
$h = .119''$
$r = .25''$
$\beta \approx 72^\circ$

FROM REF. 2 FIGURES 57 & 6[0]
$K_o^T = 1.48 \qquad K_o^B = 1.35$

FROM REF. 1 ARTICLE A.7.2.[illegible]

FOR $r > h$ $\quad \left[\frac{K'-1}{K_o-1}\right] = 1 - \left[\frac{\beta-\alpha}{90-\alpha}\right]^{1+2.4\sqrt{r/h}}$ where $\alpha = \sin$ [illegible]

$r/d = r/2t = .286$
$D/d = 2T/2t = 1.27$
$r/h = 2.1$
$\beta/90 = .8$

$\alpha = 31.5^\circ \qquad \left[\frac{K'-1}{K_o-1}\right] = 1 - \left[\frac{72^\circ - 31.5^\circ}{90^\circ - 31.5^\circ}\right]^{4.48} \qquad K' = 1 +$

$$\therefore \quad K'_T = 1.39 \qquad K'_B = 1.28$$

BABCOCK & WILCOX DEPARTMENT	BY C. W. ZINN	DATE 11-15-7[illegible]
STRESS CONCENTRATION FACTOR		JOB NO. [illegible]

SATISFICATION OF PRIMARY STRESS LIMITS

— AT NOZZLE END —

LONGITUDINAL PRESSURE MEMBRANE STRESS

376 TP

$= \frac{PR}{2t} = \frac{2500(2.275)}{4(.375)} = 4.8 \text{ KSI} < 1.5 S_m @ 650°F$
$= 1.5(16.6) = 24.9 \text{ KSI}$

— AT BRANCH INTERSECTION —

CIRCUMFERENTIAL PRESSURE MEMBRANE STRESS IN RUN PIPE $= \frac{PR}{t} = \frac{2500(16.5625)}{2.25} = 18.4$ KSI

ALLOWABLE STRESS $= 1.5 S_m = 1.5(17.9) = 26.1$ KSI A-105-

18.4 KSI < 26.1 KSI

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SECTION 2

This section contains temperature transient analysis of the make-up nozzle. A survey of the functional specification was made and a composite transient curve developed for the cold leg fluid and the make-up fluid. Of primary importance was to select transients which would reflect maximum temperature differentials in the nozzle. This differential is dependent upon temperatures of the corresponding fluid, rates of change of the fluids, and flow rates.

The make-up nozzle has two predominant temperatures 95°F (normal operation and essentially constant for all transients) and 70°F (For the feed and bleed operation). It has a predominant flow rate of 13 GPM but can go as high as 100 GPM or as low as 1.5 GPM. In particular it has a flow rate of 40 GPM during feed and bleed when the fluid temperature is 70°F.

The cold leg fluid goes through several changes in temperature but the most predominant temperatures are 555°F for 8% and 100% power levels and 575°F for 15% power. The temperature does go as high as 590 for the reactor trip.

Consequently the temperature transient curve was made to reflect these variations in fluid temperature and flow rates. The pictorial diagram is shown on the following page.

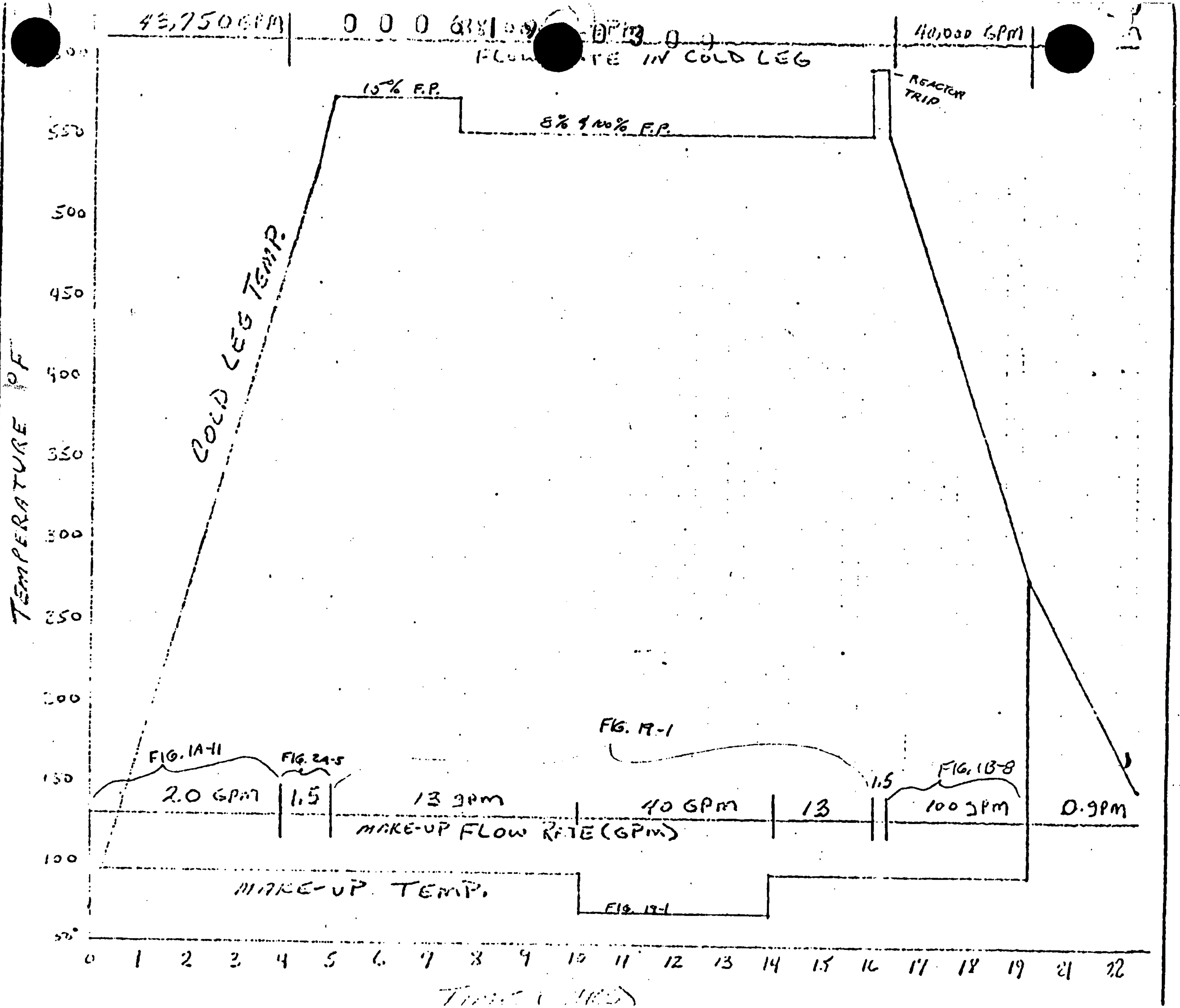
CUSTOMER

SUBJECT MAKE-UP NOZZLE

JOB NO.

BY

DATE



FILM COEFFICIENTS

The film coefficients will be calculated assuming turbulent flow in the cold leg and nozzle. They are calculated for three different cases: 1.) in the cold leg 2.) in the branch pipe and 3.) within the thermal sleeve because of the smaller diameter. In addition the small area of contact of the fluid with the nozzle on the inside of the thermal sleeve ring (see figure on Page 2-3 marked Section 3) was assumed to have a film coefficient of 200 BTU/HR-°F-Ft.^{2} when there was a flow in the cold leg run pipe and 100 when there was no flow in the run pipe. The 100 BTU/HR-°F-Ft.^{2} value was also used as a natural convection value for the run pipe (Cold Leg) when there was no flow during cool-down when decay removal starts.

The film coefficient for no flow in the nozzle was assumed to be 35 BTU/HR-°F-Ft.^{2} This smaller value was chosen because of the smaller diameter and that the water would be closer to stagnant within the nozzle. The thermal model of the nozzle includes water blocks behind the sleeve. It is felt that there will be little or no flow behind the sleeve because of the very small gap between the sleeve and nozzle at the top of the nozzle plus the "Vena Contracta" effect of the flow going from a larger diameter to a smaller diameter at the transition from the branch pipe to the nozzle. Thus only conduction is assumed between the sleeve and the inside of nozzle. At Section 4 metal to metal conduction is assumed but a contact resistance coefficient of 100 BTU/HR-°F-Ft.^{2}. This value results in essentially metal to metal conduction. The rolled-in portion of sleeve is assumed to have metal to metal conduction even though a small gap may exist at certain times within the transient.

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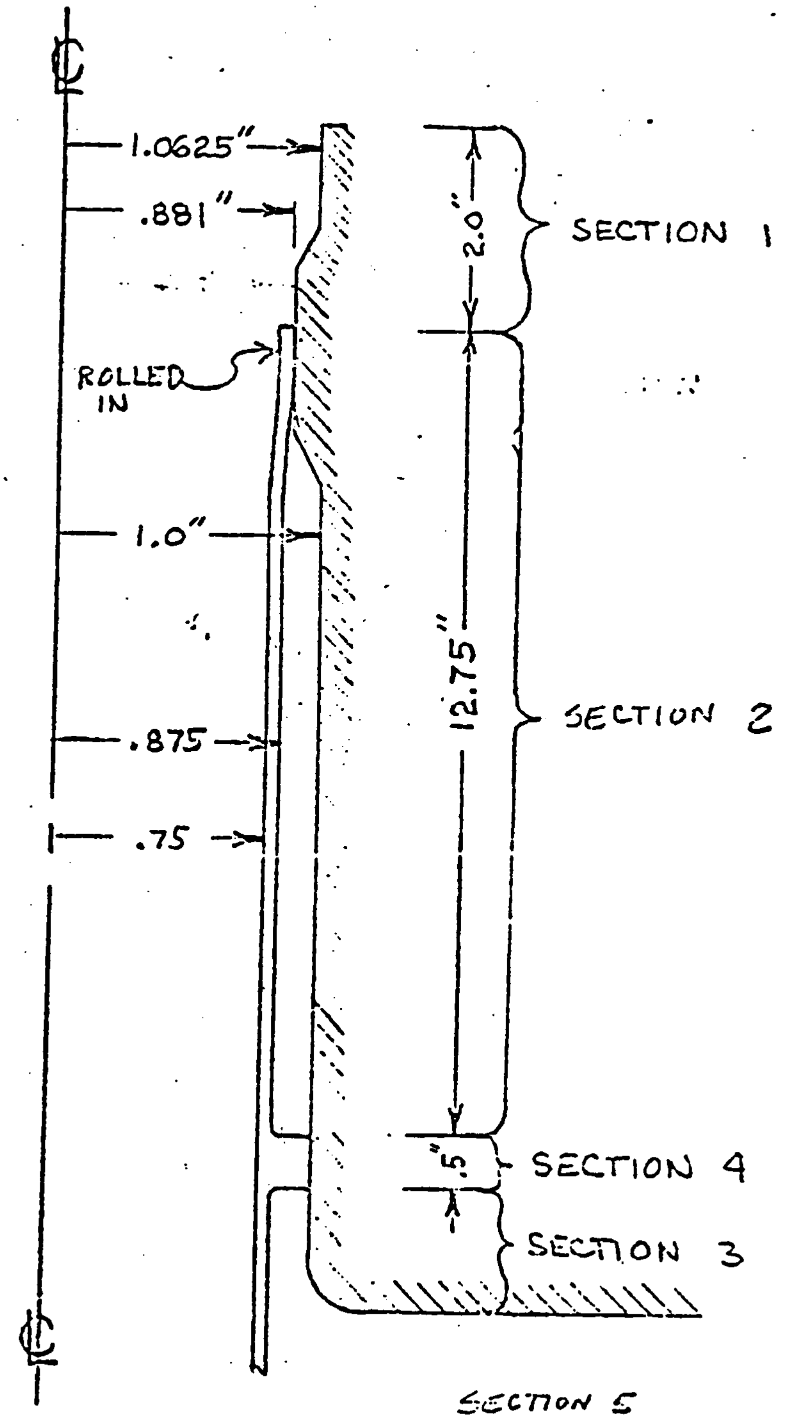

THERMAL SLEEVE GEOMETRY

BABCOCK & WILCOX

DEPARTMENT ___ BY C.W. ZINN | DATE [illegible]

GEOMETRY FOR FILM COEFFICIENTS | JOB NO. [illegible]

FILM COEFFICIENTS

NOZZLE OUTSIDE SLEEVE

FLOW (GPM)	$hD^{.2}$ FROM GRAPH (FOLLOWING PAGE) $D^{.2} = .71$	h BTU/HR-FT²-°F
20	290	410
1.5	35	50
13	210	300
40	520	730
100	1100	1550
	–	–
0	BECAUSE OF LOW TEMPERATURE OF WATER AND THE SMALL DIAMETER A SMALL VALUE FOR NATURAL CONVECTION WILL BE USED	35

NOZZLE INSIDE SLEEVE

	$D^{.2} = .66$	h
1.5	65	100
13	350	530
40	880	1330
100	1800	2730
0	—	35
20	520	790

INLET PIPE

	$D^{.2} = 1.18$	
43,750	3500	3000
88,000	7000	5900
40,000	3800	3200
0	BECAUSE OF LARGER DIAMETER A NATURAL CONVECTION VALUE OF 100 WILL BE USED	100

0006193303

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DEPARTMENT ______ BY ______ DATE ______

TABULATION OF FILM COEFFICIENTS

JOB NO. ______

FILM COEFFICIENTS

CONVERSION FROM GAL/MIN TO Lbs/FT^2-HR.

Lbs/FT^2-HR = (GAL./MIN)(60 MIN/HR)(8.347 Lbs/GAL)/AREA

SECTION 5 AREA$_{INLET}$ = $\pi(14)^2$ = 615.75 IN^2 OR 4.28 FT^2

SECTION 1 (WITHOUT SLEEVE) AREA$_{HPI}$ = $\pi(1.0625)^2$ = 3.547 IN OR .025 FT^2

SECTION 2 (WITH SLEEVE) AREA$_{H.P.I.}$ = $\pi(.75)^2$ = 1.767 IN^2 OR .0123 FT^2

SECTION 1 OUTSIDE SLEEVE — H.P.I. NOZZLE FLOW — SECTION 2 INSIDE SLEVE

259090	⊗ x 13 GPM	x 40,510$^+$	= 526,630	Lbs/FT^2-HR
797200	⊗ x 40 GPM	x 40510$^+$	= 1,620,400	Lbs/FT^2-HR
1993000	⊗ x 100 GPM	x 40,510$^+$	= 4,051,000	Lbs/FT^2-HR
29895	⊗ x 1.5 GPM	x 40,510$^+$	= 60770	lbs/FT^2-HR
398,600	⊗ x 20 GPM	x 40,510	810,200	"

INLET PIPE FLOW SECTION 5

310°F	43,750 GPM x 107.0*	= 4,681,250	Lbs/FT^2-HR
575°F	88,000 GPM x 83.4	= 7,339,755	Lbs/FT^2-HR
400°F	40,000 GPM x 99.7	= 3,988,000	Lbs/FT^2-HR

*. CONVERSION COEFFICIENTS

@ 95°F + (60 MIN/HR)(8.304 Lbs/GAL)/(.0123 FT^2) = 40,510 Lbs-MIN/HR-GAL

@ 95°F ⊗ (60 MIN/HR)(8.304 Lbs/GAL)/(.025 FT^2) = 19,930 Lb-MIN/HR-GAL

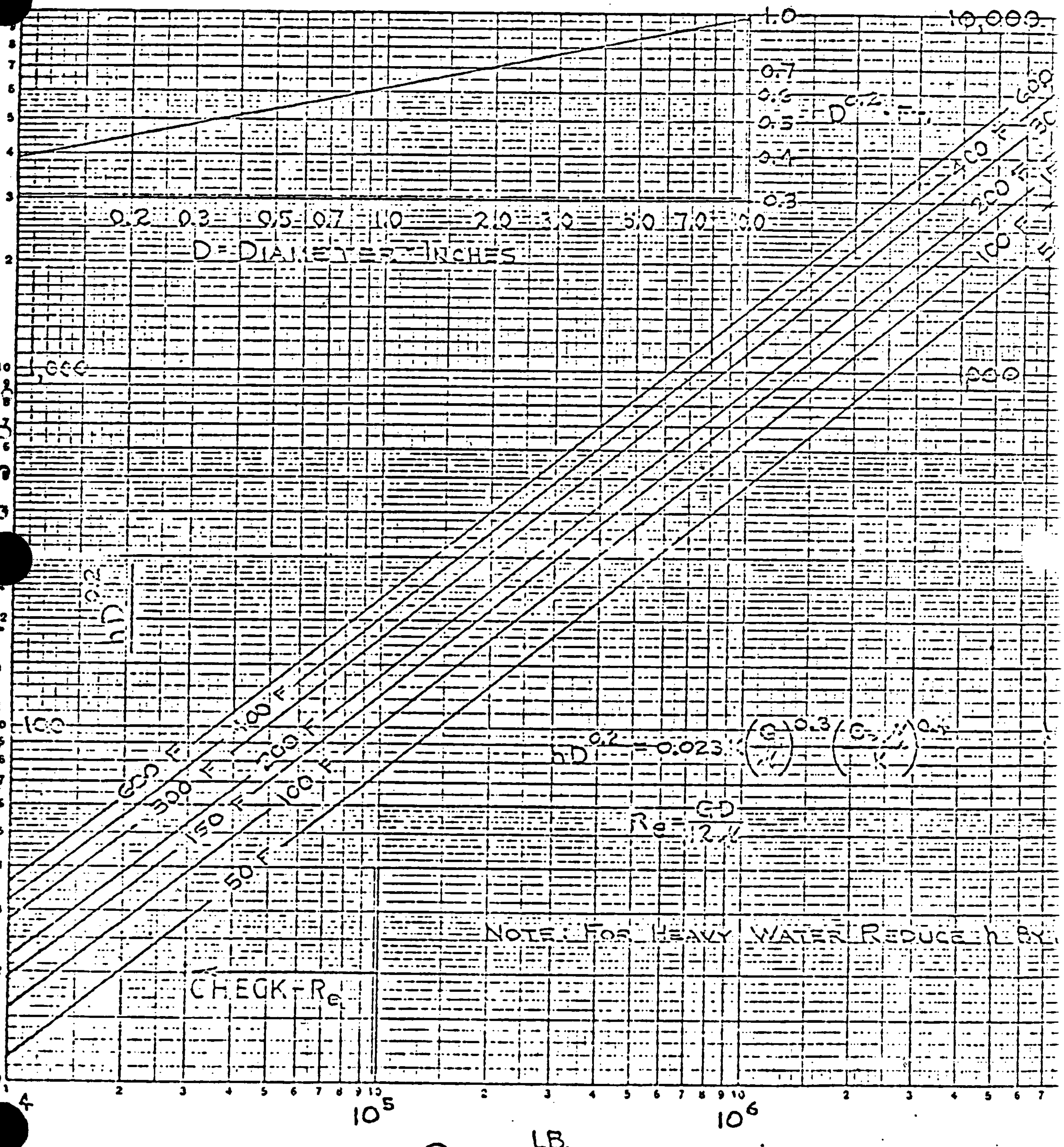
AT 310° * (60 MIN/HR)(7.618 Lbs/GAL)/(4.28 FT^2) = 107 Lbs-MIN/HR-GAL

REYNOLD'S NUMBER FOR 29895 LBS/FT^2-HR FLOW

$$Re = \frac{GD}{12\mu} = \frac{(29895)(1.06)2}{(12)(1.25)} = 2862 > 2100$$

THEREFORE GRAPH ON THE FOLLOWING PAGE IS ACCEPTABLE FOR ALL THE FLOW CONDITIONS

BABCOCK & WILCOX DEPARTMENT BY C. W. ZINN	DATE 11-18-70
FILM COEFFICIENTS	JOB NO. 620-00[illegible]
	SHEET 2-5 OF



WATER FILM COEFFICIENT FOR REYNOLDS NUMBERS ABOVE 2100: FROM H.T. 41-1

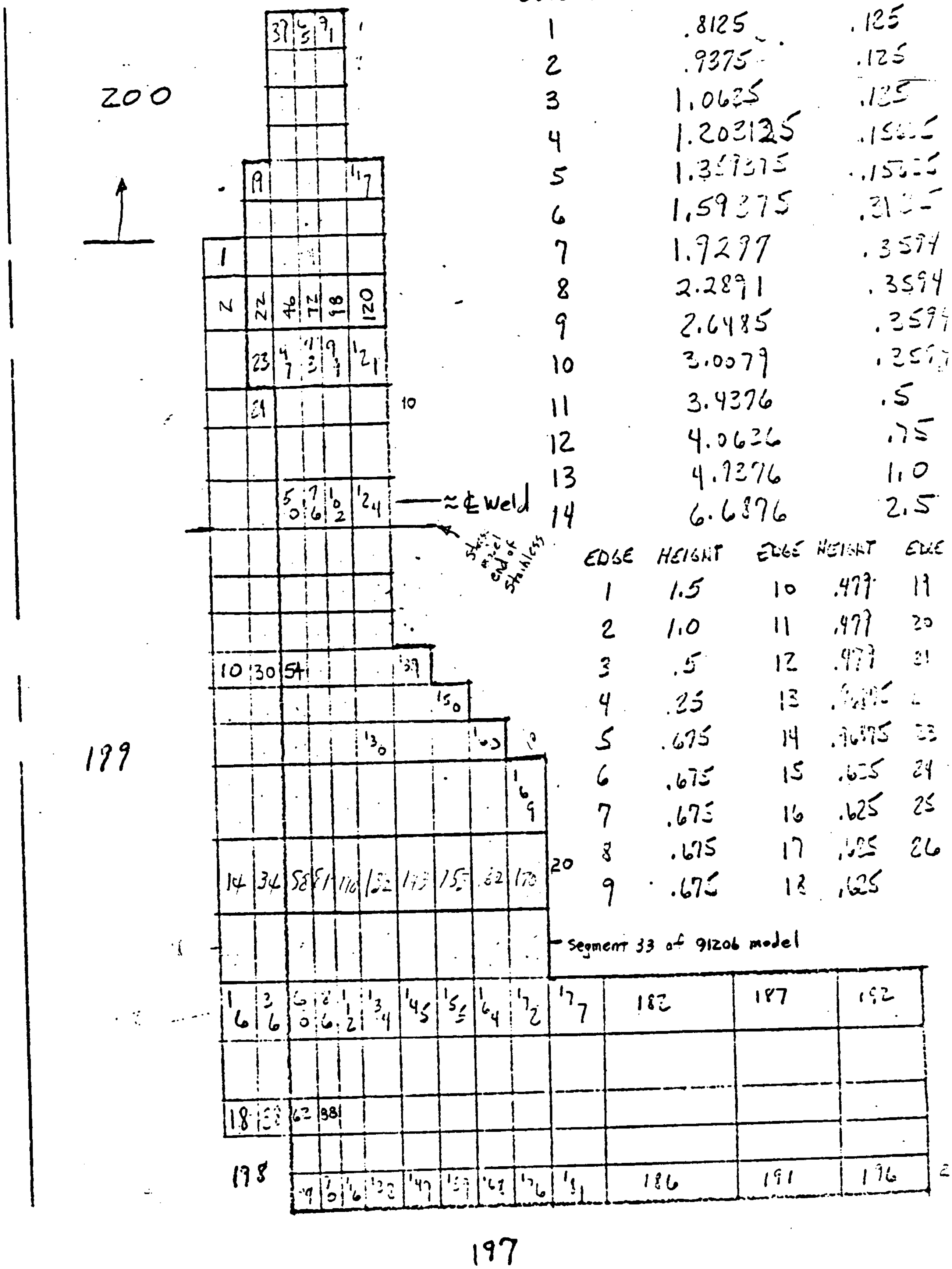
JOB NO. DD-2
MANUAL-2A35

TEMPERATURE DISTRIBUTION

The temperature distribution of the nozzle was obtained using B&W Thermal Program 91167 which performs a transient temperature distribution by solving internally generated heat balance equations as a function of time.

The grid for this program is shown on Page 2-8 and the computer output which follows depicts the input items. A heat balance equation sample is shown on pages 2-15, 2-19.

Pages 2-20, 2-22 show a graphical representation, temperatures vs. time, of selected nodes and this is finally followed by the computer print-out giving the actual temperatures at the selected critical times for stress analysis.



Column	Mean Radius	Width
1	.8125	.125
2	.9375	.125
3	1.0625	.125
4	1.203125	.15625
5	1.359375	.15625
6	1.59375	.3125
7	1.9297	.3594
8	2.2891	.3594
9	2.6485	.3594
10	3.0079	.3594
11	3.4376	.5
12	4.0626	.75
13	4.9376	1.0
14	6.6376	2.5

Edge	Height	Edge	Height	Edge
1	1.5	10	.477	19
2	1.0	11	.477	20
3	.5	12	.477	21
4	.25	13	[illegible]	[illegible]
5	.675	14	.46875	[illegible]
6	.675	15	.625	24
7	.675	16	.625	25
8	.675	17	.625	26
9	.675	18	.625	

000610301

BABCOCK & WILCOX

DEPARTMENT ______ BY ______

HPI Nozzle Thermal Grid

DATE ______

JOB NO. ______

SHEET 2-8

000619 … 0308

GENERAL [illegible]UT DATA

NO SOLID BLOCKS	NO FLUID BLOCKS	NO OF EDGES	NO OF LINES	NO OF CYCLES
196	4	26	14	8

BASE TEMP	STARTING TEMP	STARTING TIME	STARTING ITER	PUNCH CARD TIME
300.0	70.0	0.00000	0	0.00000

TIME IS IN HOURS

GEOMETRY OF THE COLUMNS

ROW NO	BLOCK NO. LOW	HI	ADJ	RADIAL DIMS	MEAN RADIUS	LOW EDGE NO	ROW NO	BLOCK NO. LOW	HI	ADJ	RADIAL DIMS	MEAN RADIUS	LOW EDGE NO
1	1	18	16	.12500	.81250	7	2	19	38	36	.12500	.93750	5
3	39	64	60	.12500	1.06250	1	4	65	90	86	.15625	1.20313	1
5	91	116	112	.15625	1.35938	1	6	117	138	134	.31250	1.59375	5
7	139	149	145	.35940	1.92970	16	8	150	159	155	.35940	2.28910	17
9	160	168	164	.35940	2.64850	18	10	169	176	172	.35940	3.00790	19
11	177	181	177	.50000	3.43760	22	12	182	186	182	.75000	4.06260	22
13	187	191	187	1.00000	4.93760	22	14	192	196	192	2.50000	6.68760	22

SERIES NO	BLOCK NO. FLUID	FIRST	LAST	SIDE NO	SERIES NO	BLOCK NO. FLUID	FIRST	LAST	SIDE NO	SERIES NO	BLOCK NO. FLUID	FIRST	LAST	SIDE
1	[illegible]	[illegible]	[illegible]	2	2	197	[illegible]	90	2	3	197	116	[illegible]	2
4	197	138	138	2	5	197	149	149	2	6	197	159	159	2
7	197	168	168	2	8	197	176	176	2	9	197	181	181	2
10	197	186	186	2	11	197	191	191	2	12	197	196	196	2
13	198	63	64	1	14	198	18	18	2	15	198	38	38	2
16	199	1	18	1	17	200	19	20	1	18	200	1	1	4
19	200	19	19	4	20	200	39	42	1					

AXIAL DIMENSION PER EDGE

EDGE	DIMENSION	EDGE	DIMENSION	EDGE	DIMENSION	EDGE	DIMENSION	EDGE	DIMENSION	EDGE	DIMENSION
1	1.50000	2	1.00000	3	.50000	4	.25000	5	.67500	6	.67500
7	.67500	8	.67500	9	.67500	10	.47900	11	.47900	12	.47900
13	.96875	14	.96875	15	.62500	16	.62500	17	.62500	18	.62500
19	1.25000	20	1.25000	21	1.25000	22	.37500	23	.37500	24	.50000
25	.50000	26	.50000								

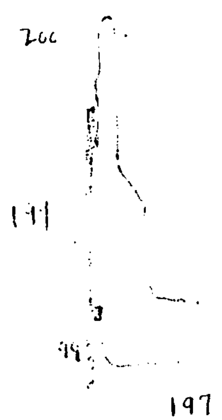
CONDUCTANCE OF TWO ADJACENT BLOCKS WITHOUT COMPLETE BOND - NO OF SUBDIVISIONS 2

FIRST BLOCK NO	LAST BLOCK NO	ADDED CONDUCT H	BLOCK SIDE	FIRST BLOCK NO	LAST BLOCK NO	ADDED CONDUCT H	BL S
38	38	100.000	3	62	62	100.000	

MATL NO	LAST BLOCK	MATL NO	LAST BLOCK	MATL NO	LAST BLOCK	MATL NO	LAST BLOCK	MATL NO	LAST BLOCK	MATL NO	LAST BLOCK	MATL NO	LAST BLOCK
4	[illegible]	10	37	4	76	1	[illegible]	4	102	1	116	4	[illegible]
1	196												

0 0 0 6 1 9 0 3 1 0

FLUID BLOCK	FILM COEF.							
197	3000.00	5900.00	5900.00	5900.00	5900.00	5900.00	3200.00	100.00
198	200.00	200.00	200.00	200.00	200.00	200.00	200.00	100.00
199	790.00	100.00	530.00	1330.00	530.00	100.00	2730.00	35.00
200	410.00	50.00	300.00	730.00	300.00	50.00	1550.00	35.00
	↑ to 3.2 based on make-up flow of 20 gpm	↑ to 4.95 based on 1.5 gpm	↑ to 10.0 based on 13. gpm	↑ to 14.0 based on 40 gpm	↑ to 16.0 based on 13 gpm	↑ to 16.2 based on 1.5 gpm	↑ to 19.15 based on 100. gpm	↑ to 22.4



3.8 4.95000 10.00000 14.00000 [illegible] [illegible] [illegible]
22.40

0 0 0 6 1 9 0 3 1 1

TIMES FOR PRINTOUT

TIME LIMIT	TIME MULTIPLE
3.50000	.50000
4.00000	.05000
5.00000	.25000
5.20000	.00833
7.50000	.46000
7.70000	.00833
10.00000	.46000
10.20000	.00278
14.00000	.38000
14.20000	.00278
16.00000	1.10000
16.40000	.00278
18.00000	.16000
19.15000	.57500
19.35000	.00278
22.40000	.31500

POINT N[illegible]97 TYPE 1

000619 [illegible] 312

TIME	0.00000	4.62000	4.95000	7.50000	7.50000	15.90000	15.90000	16.21000	16.21000
TEMP	70.00000	532.00000	575.00000	575.00000	555.00000	555.00000	590.00000	590.00000	555.00000

TIME	19.15000	22.40000	-99.99000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
TEMP	280.00000	150.00000	150.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

POINT NO. 198 TYPE 1

TIME	0.00000	4.62000	4.95000	7.50000	7.50000	15.90000	15.90000	16.21000	16.21000
TEMP	70.00000	532.00000	575.00000	575.00000	555.00000	555.00000	590.00000	590.00000	555.00000

TIME	19.15000	22.40000	-99.99000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
TEMP	280.00000	150.00000	150.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

TIME	[illegible]000	10.10000	10.10000	13.90000	13.[illegible]000	19.20000	19.20000	[illegible]	[illegible]
TEMP	9[illegible]000	95.00000	70.00000	70.00000	95[illegible]00	95.00000	280.00000	150.00000	1[illegible]

POINT NO. 200 TYPE 1

TIME	0.00000	10.10000	10.10000	13.90000	13.90000	19.20000	19.20000	22.40000	-99.99000
TEMP	95.00000	95.00000	70.00000	70.00000	95.00000	95.00000	280.00000	150.00000	150.00000

914

0	1	1.0	.143	199	.009	2	.282	21	.010	200	.557	1
0	2	[illegible]	.143	199	.009	[illegible]	.282	22	.009	1	.557	2
0	3	[illegible]	.143	199	.010	4	.282	23	.009	2	.556	3
0	4	1.0	.143	199	.018	5	.022	24	.015	3	.802	4
0	5	1.0	.143	199	.018	6	.022	25	.018	4	.799	5
0	6	1.0	.143	199	.012	7	.022	26	.018	5	.805	6
0	7	1.0	.143	199	.004	8	.022	27	.006	6	.825	7
0	8	1.0	.143	199	.005	9	.022	28	.004	7	.825	8
0	9	1.0	.143	199	.010	10	.022	29	.008	8	.816	9
0	10	1.0	.143	199	.010	11	.022	30	.010	9	.814	10
0	11	1.0	.143	199	.010	12	.022	31	.010	10	.814	11
0	12	1.0	.143	199	.007	13	.022	32	.010	11	.817	12
0	13	1.0	.143	199	.003	14	.022	33	.003	12	.829	13
0	14	1.0	.143	199	.003	15	.022	34	.003	13	.829	14
0	15	1.0	.143	199	.004	16	.022	35	.003	14	.828	15
0	16	1.0	.143	199	.029	17	.022	36	.013	15	.792	16
0	17	1.0	.143	199	.025	18	.022	37	.029	16	.781	17
0	18	1.0	.143	199	.010	198	.282	38	.019	17	.547	18
0	19	1.0	.088	200	.009	20	.279	43	.010	200	.615	19
0	20	1.0	.088	200	.009	21	.279	44	.009	19	.616	20
0	21	1.0	.244	1	.009	22	.279	45	.009	20	.459	21
0	22	1.0	.244	2	.009	23	.279	46	.009	21	.459	22
0	23	1.0	.244	3	.001	24	.279	47	.009	22	.467	23
0	24	1.0	.019	4	.001	25	.022	48	.001	23	.956	24
0	25	1.0	.019	5	.001	26	.022	49	.001	24	.957	25
0	26	1.0	.019	6	.000	27	.022	50	.001	25	.957	26
0	27	1.0	.019	7	.000	28	.022	51	.000	26	.958	27
0	28	1.0	.019	8	.000	29	.022	52	.000	27	.958	28
0	29	1.0	.019	9	.000	30	.022	53	.000	28	.958	29
0	30	1.0	.019	10	.000	31	.022	54	.000	29	.957	30
0	31	1.0	.019	11	.000	32	.022	55	.000	30	.957	31
0	32	1.0	.019	12	.000	33	.022	56	.000	31	.958	32
0	33	1.0	.019	13	.000	34	.022	57	.000	32	.958	33
0	34	1.0	.019	14	.000	35	.022	58	.000	33	.958	34
0	35	1.0	.019	15	.000	36	.022	59	.000	34	.958	35
0	36	1.0	.019	16	.001	37	.022	60	.001	35	.957	36
0	37	1.0	.019	17	.002	38	.022	61	.001	36	.955	37
0	38	1.0	.244	18	.010	198	.027	62	.002	37	.718	38
0	39	1.0	.088	200	.002	40	.246	65	.663	39		
0	40	1.0	.088	200	.005	41	.246	66	.003	39	.657	40

2-15

0	41	[illegible]	.088	200	.022	42	.246	67	.011	40	[illegible]	[illegible]
0	42	[illegible]	.088	200	.035	[illegible]	.246	68	.044	41	.587	42
0	43	[illegible]	.246	19	.009	[illegible]	.246	69	.013	42	.486	[illegible]
0	44	1.0	.246	20	.009	45	.246	70	.009	43	.490	44
0	45	1.0	.246	21	.009	46	.246	71	.009	44	.490	45
0	46	1.0	.246	22	.009	47	.246	72	.009	45	.490	46
0	47	1.0	.246	23	.010	48	.246	73	.009	46	.488	47
0	48	1.0	.019	24	.018	49	.246	74	.015	47	.702	48
0	49	1.0	.019	25	.018	50	.246	75	.018	48	.699	49
0	50	1.0	.019	26	.012	51	.246	76	.018	49	.705	50
0	51	1.0	.019	27	.004	52	.390	77	.006	50	.580	51
0	52	1.0	.019	28	.005	53	.390	78	.004	51	.581	52
0	53	1.0	.019	29	.010	54	.390	79	.008	52	.572	53
0	54	1.0	.019	30	.010	55	.390	80	.010	53	.570	54
0	55	1.0	.019	31	.010	56	.390	81	.010	54	.570	55
0	56	1.0	.019	32	.007	57	.390	82	.010	55	.573	56
0	57	1.0	.019	33	.003	58	.390	83	.003	56	.584	57
0	58	1.0	.019	34	.003	59	.390	84	.003	57	.585	58
0	59	1.0	.019	35	.004	60	.390	85	.003	58	.584	59
0	60	1.0	.019	36	.029	61	.390	86	.013	59	.548	60
0	61	1.0	.019	37	.025	62	.390	87	.029	60	.536	61
0	62	1.0	.024	38	.016	63	.390	88	.019	61	.551	62
0	63	1.0	.047	198	.016	64	.390	89	.016	62	.530	63
0	64	1.0	.047	198	.028	197	.390	90	.016	63	.518	64
0	65	1.0	.174	39	.002	66	.178	91	.646	65		
1	66	1.0	.174	40	.005	67	.178	92	.003	65	.639	66
0	67	1.0	.174	41	.022	68	.178	93	.011	66	.615	67
0	68	1.0	.174	42	.035	69	.178	94	.044	67	.569	68
0	69	1.0	.174	43	.009	70	.178	95	.013	68	.626	69
0	70	1.0	.174	44	.009	71	.178	96	.009	69	.630	70
0	71	1.0	.174	45	.009	72	.178	97	.009	70	.630	71
1	72	1.0	.174	46	.009	73	.178	98	.009	71	.630	72
0	73	1.0	.174	47	.010	74	.178	99	.009	72	.629	73
0	74	1.0	.174	48	.018	75	.178	100	.015	73	.615	74
0	75	1.0	.174	49	.018	76	.178	101	.018	74	.612	75
0	76	1.0	.174	50	.021	77	.178	102	.018	75	.609	76
0	77	1.0	.280	51	.013	78	.541	103	.011	76	.155	77
0	78	1.0	.280	52	.016	79	.541	104	.013	77	.150	78
0	79	1.0	.280	53	.032	80	.541	105	.025	78	.123	79
0	80	1.0	.280	54	.032	81	.541	106	.032	79	.116	80
0	81	1.0	.280	55	.032	82	.541	107	.032	80	.116	81

0 070 6 1 9 [illegible] 3 1 6

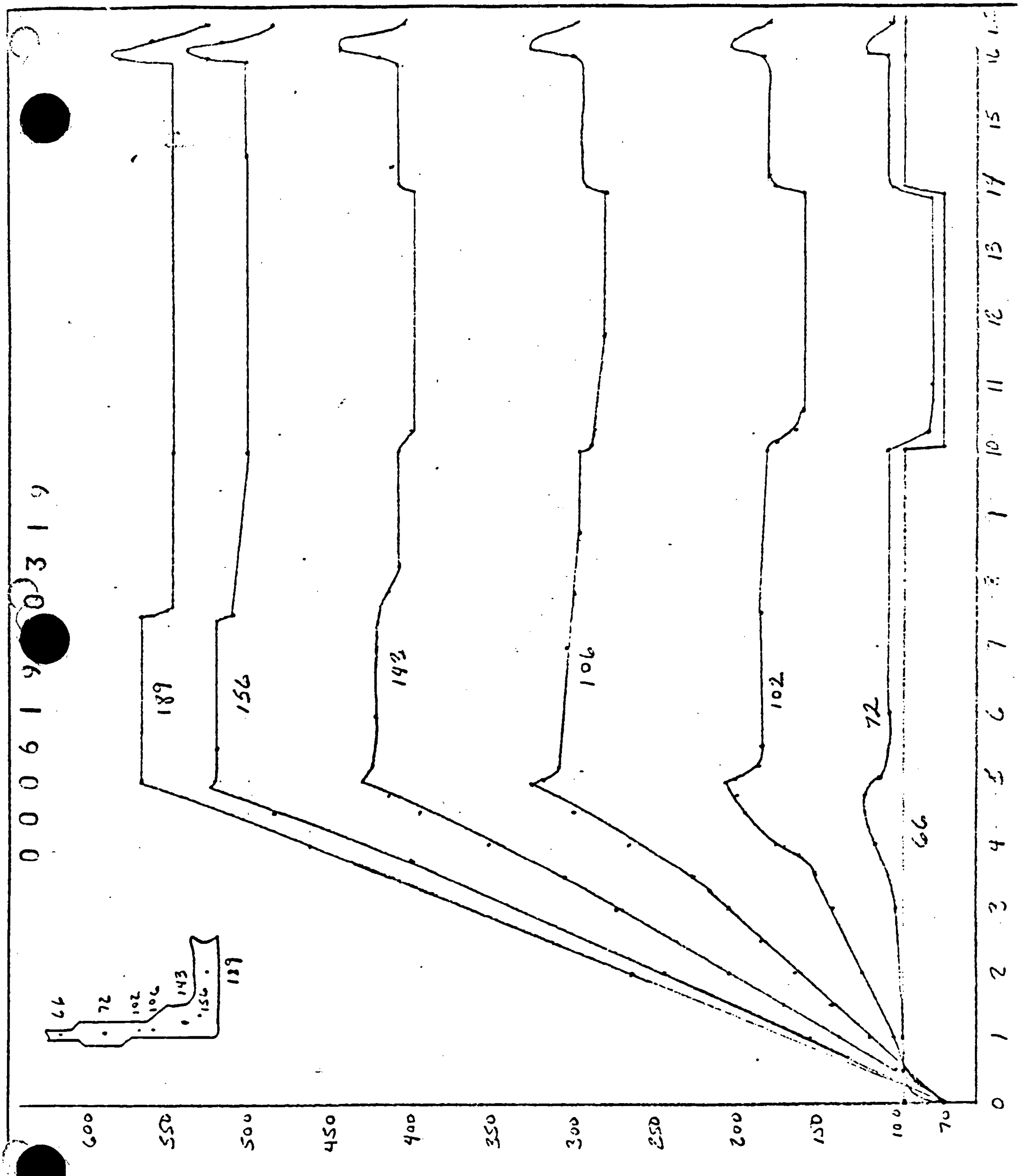
0	82	[illegible]	.280	56	.021	83	.541	108	.032	81	[illegible]	[illegible]
0	83	[illegible]	.280	57	.008	[illegible]	.541	109	.011	82	.161	[illegible]
0	84	[illegible]	.280	58	.008	[illegible]	.541	110	.008	83	.163	[illegible]
0	85	1.0	.280	59	.012	86	.541	111	.008	84	.159	85
0	86	1.0	.280	60	.088	87	.541	112	.041	85	.050	86
0	87	1.0	.280	61	.076	88	.541	113	.088	86	.015	87
0	88	1.0	.280	62	.050	89	.541	114	.057	87	.073	88
0	89	1.0	.280	63	.050	90	.541	115	.050	88	.080	89
0	90	1.0	.280	64	.068	197	.541	116	.050	89	.062	90
0	91	1.0	.158	65	.002	92	.840	91				
0	92	1.0	.158	66	.005	93	.003	91	.834	92		
0	93	1.0	.158	67	.022	94	.011	92	.810	93		
0	94	1.0	.158	68	.035	95	.044	93	.753	94		
0	95	1.0	.158	69	.009	96	.118	117	.013	94	.702	95
0	96	1.0	.158	70	.009	97	.118	118	.009	95	.706	96
0	97	1.0	.158	71	.009	98	.118	119	.009	96	.706	97
0	98	1.0	.158	72	.009	99	.118	120	.009	97	.706	98
0	99	1.0	.158	73	.010	100	.118	121	.009	98	.705	99
0	100	1.0	.158	74	.016	101	.118	122	.015	99	.692	100
0	101	1.0	.158	75	.018	102	.118	123	.018	100	.689	101
1	102	1.0	.158	76	.021	103	.118	124	.018	101	.685	102
0	103	1.0	.478	77	.013	104	.358	125	.011	102	.140	103
0	104	1.0	.478	78	.016	105	.358	126	.013	103	.134	104
0	105	1.0	.478	79	.032	106	.358	127	.025	104	.107	105
1	106	1.0	.478	80	.032	107	.358	128	.032	105	.100	106
0	107	1.0	.478	81	.032	108	.358	129	.032	106	.100	107
0	108	1.0	.478	82	.021	109	.358	130	.032	107	.111	108
0	109	1.0	.478	83	.008	110	.358	131	.011	108	.145	109
0	110	1.0	.478	84	.008	111	.358	132	.008	109	.148	110
0	111	1.0	.478	85	.012	112	.358	133	.008	110	.144	111
0	112	1.0	.478	86	.088	113	.358	134	.041	111	.035	112
0	113	1.0	.478	87	.076	114	.358	135	.088	112	-.000	113
0	114	1.0	.478	88	.050	115	.358	136	.057	113	.057	114
0	115	1.0	.478	89	.050	116	.358	137	.050	114	.065	115
0	116	1.0	.478	90	.068	197	.358	138	.050	115	.046	116
0	117	1.0	.050	95	.009	118	.941	117				
0	118	1.0	.050	95	.009	119	.009	117	.932	118		
0	119	1.0	.050	97	.009	120	.009	118	.932	119		
0	120	1.0	.050	98	.009	121	.009	119	.932	120		
0	121	1.0	.050	99	.010	122	.009	120	.930	121		
0	122	1.0	.050	100	.018	123	.015	121	.917	122		

0	123	1.0	[illegible]	101	[illegible]	[illegible]	[illegible]	[illegible]				
0	124	[illegible]	.050	102	.021	[illegible]	.018	123	.911	124		
0	125	[illegible]	.153	103	.013	[illegible]	[illegible]	124	.824	125		
0	126	1.0	.153	104	.016	127	.013	125	.818	126		
0	127	1.0	.153	105	.032	128	.025	126	.791	127		
0	128	1.0	.153	106	.032	129	.130	139	.032	127	.654	128
0	129	1.0	.153	107	.032	130	.130	140	.032	128	.654	129
0	130	1.0	.153	108	.021	131	.130	141	.032	129	.665	130
0	131	1.0	.153	109	.008	132	.130	142	.011	130	.699	131
0	132	1.0	.153	110	.008	133	.130	143	.008	131	.702	132
0	133	1.0	.153	111	.012	134	.130	144	.008	132	.698	133
0	134	1.0	.153	112	.088	135	.130	145	.041	133	.589	134
0	135	1.0	.153	113	.076	136	.130	146	.088	134	.554	135
0	136	1.0	.153	114	.050	137	.130	147	.057	135	.612	136
0	137	1.0	.153	115	.050	138	.130	148	.050	136	.619	137
0	138	1.0	.153	116	.068	197	.130	149	.050	137	.601	138
0	139	1.0	.093	128	.032	140	.875	139				
0	140	1.0	.093	129	.032	141	.105	150	.032	139	.739	140
0	141	1.0	.093	130	.021	142	.105	151	.032	140	.749	141
0	142	1.0	.093	131	.008	143	.105	152	.011	141	.784	142
1	143	1.0	.093	132	.008	144	.105	153	.008	142	.786	143
0	144	1.0	.093	133	.012	145	.105	154	.008	143	.782	144
0	145	1.0	.093	134	.088	146	.105	155	.041	144	.673	145
0	146	1.0	.093	135	.076	147	.105	156	.088	145	.638	146
0	147	1.0	.093	136	.050	148	.105	157	.057	146	.696	147
0	148	1.0	.093	137	.050	149	.105	158	.050	147	.703	148
0	149	1.0	.093	138	.068	197	.105	159	.050	148	.685	149
0	150	1.0	.088	140	.032	151	.880	150				
0	151	1.0	.088	141	.021	152	.103	160	.032	150	.755	151
0	152	1.0	.088	142	.008	153	.103	161	.011	151	.790	152
0	153	1.0	.088	143	.008	154	.103	162	.008	152	.792	153
0	154	1.0	.088	144	.012	155	.103	163	.008	153	.788	154
0	155	1.0	.088	145	.088	156	.103	164	.041	154	.679	155
1	156	1.0	.088	146	.076	157	.103	165	.088	155	.644	156
0	157	1.0	.088	147	.050	158	.103	166	.057	156	.702	157
0	158	1.0	.088	148	.050	159	.103	167	.050	157	.709	158
0	159	1.0	.088	149	.068	197	.103	168	.050	158	.691	159
0	160	1.0	.089	151	.021	161	.889	160				
0	161	1.0	.089	152	.008	162	.102	169	.011	160	.790	161
0	162	1.0	.089	153	.008	163	.102	170	.008	161	.792	162
0	163	1.0	.089	154	.012	164	.102	171	.008	162	.788	163

0 0 0 5 I 9 [illegible] 0 3

0	164	[illegible]	.089	155	.068	165	.102	172	.041	163	.679	164
0	165	[illegible]	.089	156	.076	[illegible]	.102	173	.088	164	.644	[illegible]
0	166	[illegible]	.089	157	.050	[illegible]	.102	174	.057	165	.702	[illegible]
0	167	1.0	.089	158	.050	168	.102	175	.050	166	.709	167
0	168	1.0	.089	159	.068	197	.102	176	.050	167	.691	168
0	169	1.0	.090	161	.008	170	.902	169				
0	170	1.0	.090	162	.008	171	.008	169	.894	170		
0	171	1.0	.090	163	.012	172	.008	170	.890	171		
0	172	1.0	.090	164	.088	173	.085	177	.041	171	.696	172
0	173	1.0	.090	165	.076	174	.085	178	.088	172	.661	173
0	174	1.0	.090	166	.050	175	.085	179	.057	173	.719	174
0	175	1.0	.090	167	.050	176	.085	180	.050	174	.726	175
0	176	1.0	.090	168	.068	197	.085	181	.050	175	.708	176
0	177	1.0	.053	172	.088	178	.043	182	.816	177		
0	178	1.0	.053	173	.076	179	.043	183	.088	177	.740	178
0	179	1.0	.053	174	.050	180	.043	184	.057	178	.798	179
0	180	1.0	.053	175	.050	181	.043	185	.050	179	.805	180
0	181	1.0	.053	176	.068	197	.043	186	.050	180	.787	181
0	182	1.0	.024	177	.088	183	.021	187	.867	182		
0	183	1.0	.024	178	.076	184	.021	188	.088	182	.792	183
0	184	1.0	.024	179	.050	185	.021	189	.057	183	.849	184
0	185	1.0	.024	180	.050	186	.021	190	.050	184	.856	185
0	186	1.0	.024	181	.068	197	.021	191	.050	185	.838	186
0	187	1.0	.013	182	.088	188	.008	192	.891	187		
0	188	1.0	.013	183	.076	189	.008	193	.088	187	.816	188
1	189	1.0	.013	184	.050	190	.008	194	.057	188	.873	189
0	190	1.0	.013	185	.050	191	.008	195	.050	189	.880	190
0	191	1.0	.013	186	.068	197	.008	196	.050	190	.862	191
0	192	1.0	.002	187	.088	193	.910	192				
0	193	1.0	.002	188	.076	194	.088	192	.834	193		
0	194	1.0	.002	189	.050	195	.057	193	.891	194		
0	195	1.0	.002	190	.050	196	.050	194	.899	195		
0	196	1.0	.002	191	.068	197	.050	195	.880	196		
0	197	1.0	1.000	197								
0	198	1.0	1.000	198								
0	199	1.0	1.000	199								
0	200	1.0	1.000	200								

DELTA THETA =1.738E-04HRS/ITER   BLOCK 113



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SUBJECT

JOB No.

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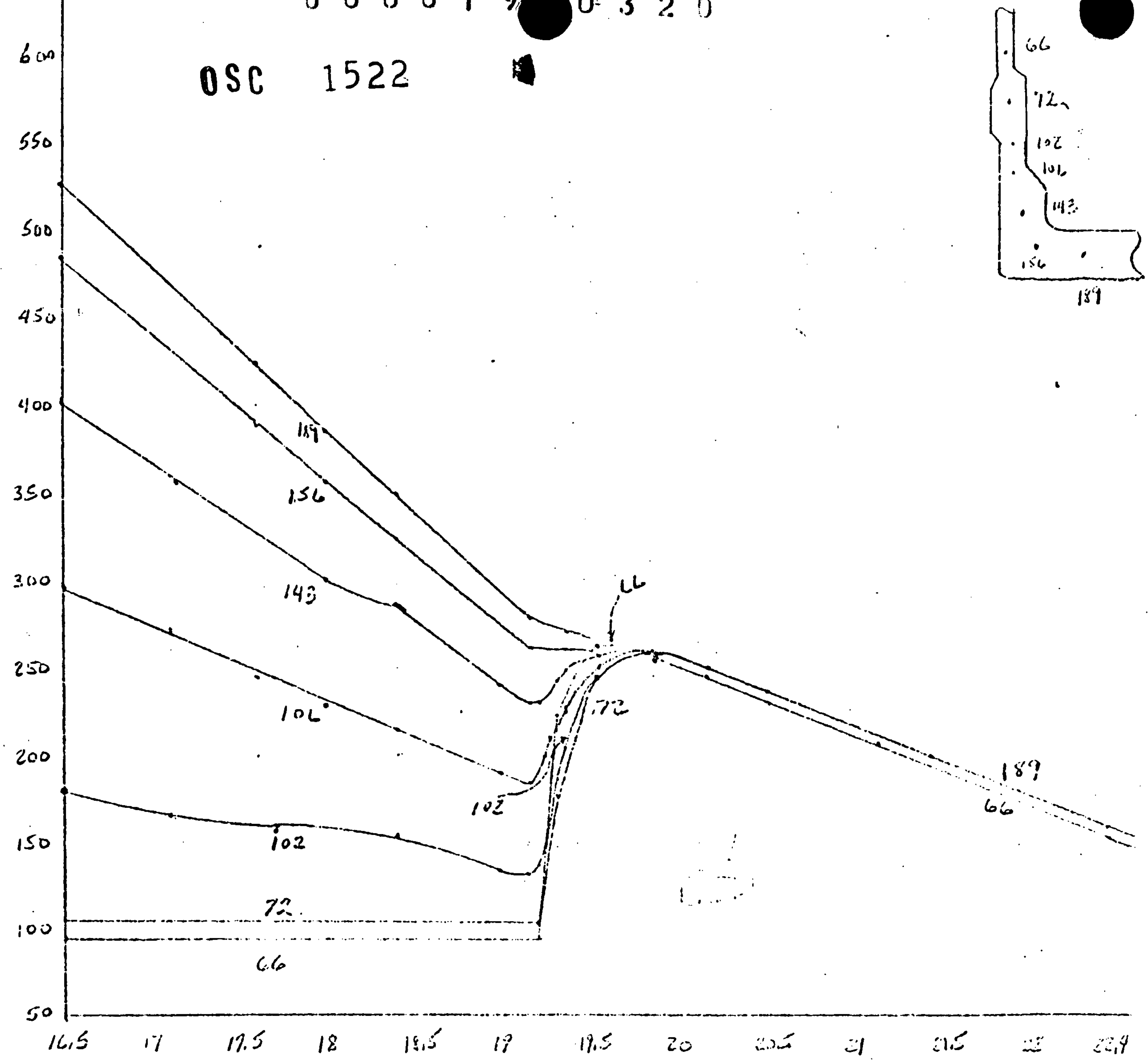

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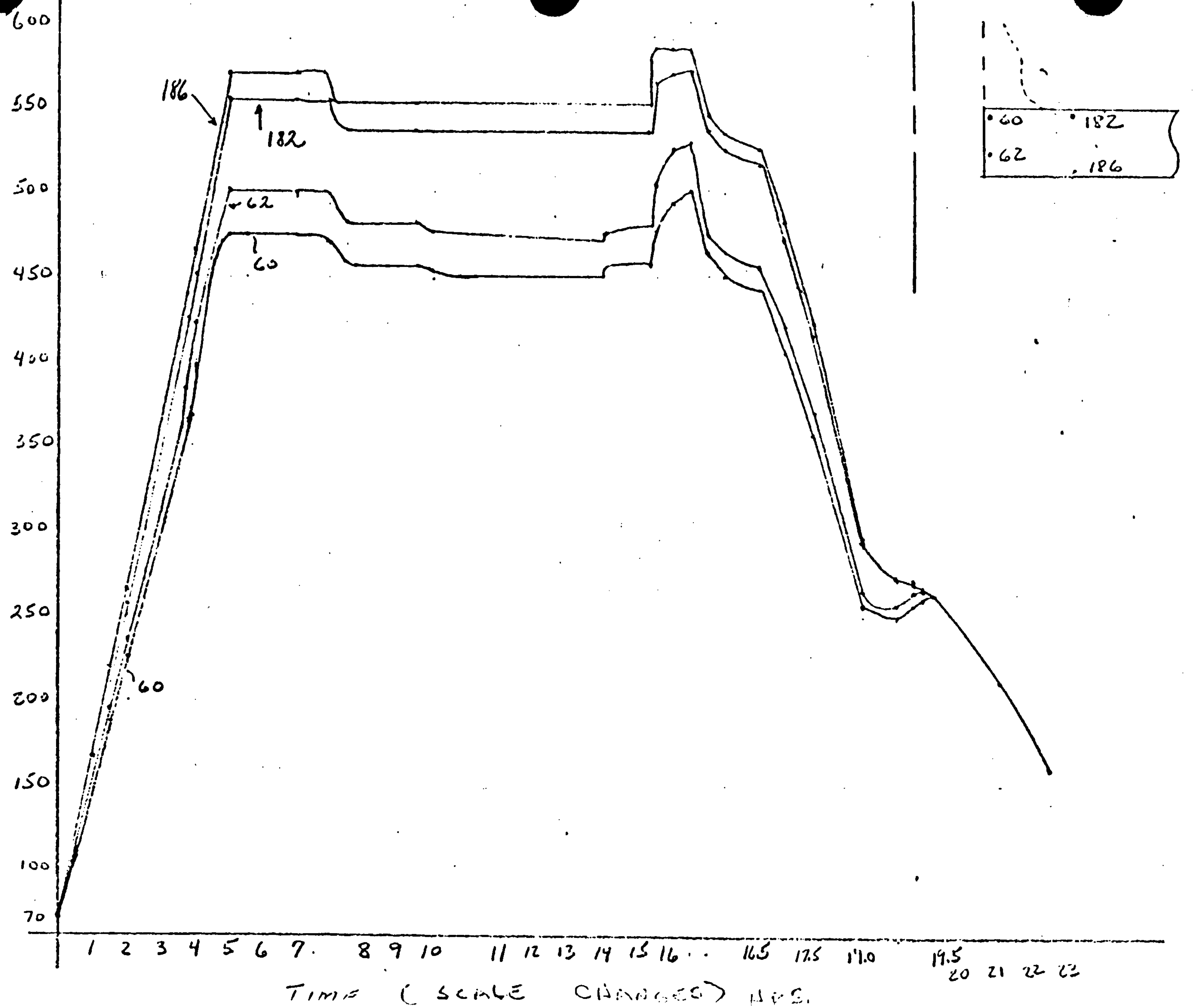

K&E

10-515

SELECTION OF CRITICAL TIMES

After a study of the preceding graphs the following times were chosen for stress analysis:

ITERATION (TIME, HRS.)	EXPLANATION
28169 (4.95)	This reflects a time near the end of heat-up to 15% power and is essentially equivalent to one of the worst axial gradient cases at 15% power.
41428 (7.5)	Steady state at 15% power. This reflects hottest cold leg temperature for a prolonged time.
52659 (9.66)	Reflects steady state distribution at 8% or 100% power.
75168 (13.9)	Reflects axial gradient at end of feed and bleed.
86960 (16.099)	Reflects maximum temperature of cold leg when trip initiates.
103154 (19.2)	Reflects short time after decay heat removal initiates and a reversal in axial gradient.

The stress analysis of these cases should define an assurance of stress levels in the nozzle and ranges in stress levels such that fatigue criteria can be justified. This will be discussed further in the stress computations portion.

28169	[illegible]	109	116	120	[illegible]	[illegible]	[illegible]	137	147	157	166	[illegible]
28169	[illegible]	174	180	189	200	214	[illegible]	266	362	103	106	4.[illegible]009
28169	21	110	118	129	139	152	167	186	206	228	247	4.95009
28169	31	263	276	293	315	343	369	389	385	96	97	4.95009
28169	41	99	101	103	107	111	120	132	157	178	201	4.95009
28169	51	229	258	290	319	341	366	384	417	456	485	4.95009
28169	61	499	514	550	566	96	97	99	101	104	107	4.95009
28169	71	112	121	135	158	180	204	232	261	293	322	4.95009
28169	81	345	364	389	422	461	491	505	521	548	565	4.95009
28169	91	96	97	99	101	104	108	113	122	137	160	4.95009
28169	101	181	207	233	261	294	325	348	366	391	424	4.95009
28169	111	464	494	508	524	547	555	105	108	114	123	4.95009
28169	121	139	161	183	208	233	252	296	328	351	370	4.95009
28169	131	394	427	468	498	512	528	548	565	335	356	4.95009
28169	141	374	398	431	472	503	517	532	549	565	362	4.95009
28169	151	379	401	434	476	508	522	536	551	566	384	4.95009
28169	161	404	436	478	514	527	540	554	567	407	437	4.95009
28169	171	480	522	534	545	557	568	540	544	551	560	4.95009
28169	181	569	552	554	558	564	570	561	562	564	567	4.95009
28169	191	572	567	568	569	571	573	575	575	95	95	

0 1230 6126 9 [illegible]0312 1

40700	1	98	100	105	100	101	103	106	109	113	116	7.36006
[illegible]	11	118	120	[illegible]	[illegible]	[illegible]	[illegible]	146	220	96	[illegible]	[illegible]
[illegible]	21	99	102	109	120	[illegible]	144	160	177	196	214	7.36006
40700	31	228	239	254	274	298	316	324	258	95	95	7.36006
40700	41	95	96	96	97	99	104	113	138	157	179	7.36006
40700	51	206	235	269	299	323	343	369	404	444	474	7.36006
40700	61	487	498	546	566	95	95	95	96	96	98	7.36006
40700	71	100	105	116	139	159	183	209	238	272	303	7.36006
40700	81	328	348	375	410	451	481	495	510	544	565	7.36006
40700	91	95	95	95	96	97	98	101	107	119	140	7.36006
40700	101	161	185	210	239	274	306	331	351	378	413	7.36006
40700	111	455	485	499	516	544	564	97	98	101	108	7.36006
40700	121	121	141	162	187	211	240	275	310	335	355	7.36006
40700	131	382	418	460	491	505	522	545	564	318	341	7.36006
40700	141	361	387	422	466	498	513	529	548	565	348	7.36006
40700	151	366	391	426	471	505	519	535	551	566	372	7.36006
40700	161	394	428	474	512	526	540	554	567	397	430	7.36006
40700	171	476	522	534	546	557	568	541	546	553	561	7.36006
40700	181	570	555	557	561	566	571	565	566	567	570	7.36006
40700	191	573	572	572	573	573	574	575	575	95	95	

41428	1	98	100	105	100	101	103	106	109	113	116	7.50007
41428	11	118	120	123	126	130	134	146	220	96	97	7.50007
41428	21	99	102	109	120	131	144	160	177	196	214	7.50007
41428	31	228	239	254	274	298	316	324	258	95	95	7.50007
41428	41	95	96	96	97	99	104	113	138	157	179	7.50007
41428	51	206	235	269	299	323	343	369	404	444	474	7.50007
41428	61	487	498	546	566	95	95	95	96	96	98	7.50007
41428	71	100	105	116	139	159	183	209	238	272	303	7.50007
41428	81	328	348	375	410	451	481	495	510	544	565	7.50007
41428	91	95	95	95	96	97	98	101	107	119	140	7.50007
41428	101	161	185	210	239	274	306	331	351	378	413	7.50007
41428	111	455	485	499	516	544	564	97	98	101	108	7.50007
41428	121	121	141	162	187	211	240	275	310	335	355	7.50007
41428	131	382	418	460	491	505	522	545	564	318	341	7.50007
41428	141	361	387	422	466	498	513	529	548	565	348	7.50007
41428	151	366	391	426	471	505	519	535	551	566	372	7.50007
41428	161	394	428	474	512	526	540	554	567	397	430	7.50007
41428	171	476	522	534	546	557	568	541	546	553	561	7.50007
41428	181	570	555	557	561	566	571	565	566	567	570	7.50007
41428	191	573	572	572	573	573	574	575	575	95	95	

0 0 0 6 1 9 [illegible] 0 3 2 5

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100	101	103	106	109	112	115	9.[illegible]19
5026[illegible]	11	117	119	121	125	[illegible]	133	143	214	96	97	[illegible]019
[illegible]	21	98	102	109	119	[illegible]	142	157	173	192	209	[illegible]20019
[illegible]	31	222	233	248	267	[illegible]	307	315	251	95	95	9.20019
50268	41	95	96	96	97	99	104	112	136	155	176	9.20019
50268	51	202	229	261	291	314	333	358	391	430	458	9.20019
50268	61	471	481	527	546	95	95	95	96	96	98	9.20019
50268	71	100	105	115	137	156	179	204	232	265	295	9.20019
50268	81	318	338	363	397	436	465	478	493	525	545	9.20019
50268	91	95	95	95	96	96	98	101	106	118	138	9.20019
50268	101	158	181	205	233	266	297	321	340	366	400	9.20019
50268	111	440	469	482	498	525	545	97	98	101	107	9.20019
50268	121	120	140	159	183	206	234	268	301	325	344	9.20019
50268	131	370	404	445	475	488	505	526	545	309	331	9.20019
50268	141	350	375	409	451	481	495	511	529	545	337	9.20019
50268	151	355	379	412	455	488	502	516	532	546	360	9.20019
50268	161	382	414	458	495	508	521	535	548	385	416	9.20019
50268	171	460	504	516	527	538	549	522	527	533	542	9.20019
50268	181	550	536	538	541	546	552	545	546	548	550	9.20019
50268	191	553	552	552	553	554	554	555	555	95	95	

52659	1	97	100	104	100	101	103	106	109	112	115	9.66003
52659	11	117	119	121	125	128	133	143	214	96	97	9.66003
52659	21	98	102	109	119	130	142	157	173	192	209	9.66003
52659	31	222	233	248	267	290	307	315	251	95	95	9.66003
52659	41	95	96	96	97	99	104	112	136	155	176	9.66003
52659	51	202	229	261	291	314	333	358	391	430	458	9.66003
52659	61	471	481	527	546	95	95	95	96	96	98	9.66003
52659	71	100	105	115	137	156	179	204	232	265	295	9.66003
52659	81	318	338	363	397	436	465	478	493	525	545	9.66003
52659	91	95	95	95	96	96	98	101	106	118	138	9.66003
52659	101	158	181	205	233	266	297	321	340	366	400	9.66003
52659	111	440	469	482	498	525	545	97	98	101	107	9.66003
52659	121	120	140	159	183	206	234	268	301	325	344	9.66003
52659	131	370	404	445	475	488	505	526	545	309	331	9.66003
62659	141	350	375	409	451	481	495	511	529	545	337	9.66003
52659	151	355	379	412	455	488	502	516	532	546	360	9.66003
52659	161	382	414	458	495	508	521	535	548	385	416	9.66003
52659	171	460	504	516	527	538	549	522	527	533	542	9.66003
52659	181	550	536	536	541	546	552	545	546	548	550	9.66003
52659	191	553	552	552	553	554	554	555	555	95	95	

2-26

0 0 0 6 1 9 [illegible] 3 2

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	76	78	80	82	13.9001[illegible]
75168	[illegible]	83	84	86	88	90	[illegible]	97	150	70	71	13[illegible]
75168	[illegible]	72	75	80	[illegible]	[illegible]	[illegible]	131	148	166	183	13[illegible]
75168	[illegible]	197	208	223	243	266	[illegible]	287	197	70	70	13.90014
75168	41	70	70	71	71	73	77	85	110	130	152	13.90014
75168	51	179	208	241	272	296	316	343	378	419	448	13.90014
75168	61	461	477	524	545	70	70	70	70	71	72	13.90014
75168	71	74	78	88	111	132	[illegible]	182	211	245	277	13.90014
75168	81	301	322	348	364	426	456	470	486	522	544	13.90014
75168	91	70	70	70	70	71	72	74	79	91	113	13.90014
75168	101	133	158	183	212	247	279	304	325	352	388	13.90014
75168	111	430	461	475	492	522	544	71	72	75	81	13.90014
75168	121	93	114	135	160	184	213	248	284	308	329	13.90014
75168	131	356	392	436	467	482	[illegible]	523	544	292	315	13.90014
75168	141	334	361	397	442	475	496	506	526	544	321	13.90014
75168	151	340	365	401	447	482	497	513	530	546	345	13.90014
75168	161	369	403	450	489	504	[illegible]	533	547	372	404	13.90014
75168	171	452	499	512	524	536	548	519	524	532	540	13.90014
75168	181	549	535	536	540	545	551	544	545	547	550	13.90014
75168	191	553	552	552	553	553	554	555	555	70	70	

75700	1	96	97	100	97	98	99	100	102	104	106	14.00017
75700	11	107	108	110	112	114	116	121	171	95	95	14.00017
75700	21	96	99	103	113	123	134	149	164	182	198	14.00017
75700	31	211	222	237	256	279	[illegible]	300	215	95	95	14.00017
75700	41	95	95	95	96	97	[illegible]	107	128	146	166	14.00017
75700	51	191	218	250	279	302	322	347	382	423	452	14.00017
75700	61	464	474	525	545	95	[illegible]	95	95	95	96	14.00017
75700	71	97	101	110	129	147	165	193	221	253	283	14.00017
75700	81	307	327	353	388	429	459	473	488	523	544	14.00017
75700	91	95	95	95	95	95	[illegible]	98	102	112	130	14.00017
75700	101	149	171	194	222	255	288	310	329	356	391	14.00017
75700	111	433	464	477	494	523	544	95	96	98	103	14.00017
75700	121	113	131	150	172	195	223	256	290	314	333	14.00017
75700	131	360	395	438	469	484	[illegible]	524	544	297	320	14.00017
75700	141	339	364	400	444	477	[illegible]	508	527	545	326	14.00017
75700	151	344	368	403	449	483	[illegible]	513	530	546	349	14.00017
75700	161	372	406	452	491	505	[illegible]	533	547	375	407	14.00017
75700	171	454	500	513	525	537	548	520	525	532	541	14.00017
75700	181	550	535	537	540	545	551	545	545	547	550	14.00017
75700	191	553	552	552	553	553	554	555	555	95	95	

86946	1	105	111	120	115	118	125	134	144	155	164	16.09634
86946	[illegible]	172	179	188	[illegible]	[illegible]	[illegible]	[illegible]	370	99	102	16.0[illegible]
86946	[illegible]	106	112	122	132	144	[illegible]	178	199	221	242	16.0[illegible]
86946	31	259	272	291	317	348	376	398	394	95	96	16.09634
86946	41	97	98	100	102	106	114	125	148	167	190	16.09634
86946	51	218	247	280	311	335	355	381	418	462	495	16.09634
86946	61	511	527	564	581	95	96	97	98	100	103	16.09634
86946	71	107	115	127	149	169	193	220	249	283	314	16.09634
86946	81	339	359	386	423	468	501	516	534	562	580	16.09634
86946	91	95	96	97	98	100	103	108	116	129	150	16.09634
86946	101	170	195	220	250	284	316	341	361	388	426	16.09634
86946	111	471	504	519	537	562	580	100	103	108	116	16.09634
86946	121	131	151	172	196	221	251	286	320	345	365	16.09634
86946	131	392	429	475	508	524	541	562	580	328	350	16.09634
86946	141	369	396	433	480	514	529	546	564	580	356	16.09634
86946	151	374	399	436	484	520	534	550	566	581	380	16.09634
86946	161	403	438	487	526	541	555	569	582	405	439	16.09634
86946	171	488	535	548	560	572	583	555	560	567	576	16.09634
86946	181	585	570	572	575	580	586	579	580	582	585	16.09634
86946	191	588	587	587	587	588	589	590	590	95	95	

86960	1	105	111	120	115	119	125	134	144	155	164	16.09898
86960	11	172	179	188	200	216	246	271	370	100	102	16.09898
86960	21	106	113	123	132	144	159	178	199	222	242	16.09898
86960	31	259	273	291	317	348	377	398	394	95	96	16.09898
86960	41	97	98	100	102	107	114	125	148	168	190	16.09898
86960	51	218	247	281	311	335	355	382	419	463	495	16.09898
86960	61	511	527	564	581	95	96	97	98	100	103	16.09898
86960	71	107	115	128	149	169	193	220	250	284	315	16.09898
86960	81	339	359	386	424	468	501	516	534	562	580	16.09898
86960	91	95	96	97	98	100	103	108	116	129	150	16.09898
86960	101	171	195	221	251	285	317	341	361	389	426	16.09898
86960	111	471	504	519	537	562	580	101	103	108	117	16.09898
86960	121	131	151	172	197	222	251	286	321	345	365	16.09898
86960	131	392	430	475	508	524	541	562	560	328	350	16.09898
86960	141	370	396	434	480	514	529	546	564	580	357	16.09898
86960	151	375	400	436	484	520	535	550	566	581	380	16.09898
86960	161	403	438	487	526	541	555	569	582	406	439	16.09898
86960	171	489	536	549	560	572	583	555	560	567	576	16.09898
86960	181	585	570	572	575	580	586	579	580	582	585	16.09898
86960	191	588	587	587	587	588	589	590	590	95	95	

[illegible]	[illegible]				[illegible]	[illegible]	116	123	130	138	145	[illegible]
[illegible]	11	150	155	161	169	[illegible]	[illegible]	199	223	96	97	[illegible]
103154	21	99	103	[illegible]	[illegible]	[illegible]	126	136	146	157	167	[illegible]
103154	31	174	181	189	199	211	221	228	228	95	95	19.20004
103154	41	95	96	96	97	99	103	108	117	125	136	19.20004
103154	51	148	161	175	187	197	204	214	227	241	250	19.20004
103154	61	254	258	266	269	95	95	95	96	96	97	19.20004
103154	71	99	103	109	117	126	137	149	161	176	188	19.20004
103154	81	196	205	216	228	242	251	255	259	265	268	19.20004
103154	91	95	95	95	96	96	97	100	103	109	118	19.20004
103154	101	126	137	149	162	176	189	198	206	216	229	19.20004
103154	111	243	252	256	260	265	268	96	97	100	103	19.20004
103154	121	109	118	127	138	149	162	176	190	200	207	19.20004
103154	131	217	230	244	253	257	261	265	268	193	201	19.20004
103154	141	209	218	231	245	255	258	262	266	268	204	19.20004
103154	151	210	210	232	246	256	250	264	267	269	212	19.20004
103154	161	220	232	247	258	262	255	268	270	221	233	19.20004
103154	171	248	261	265	267	270	271	267	268	270	271	19.20004
103154	181	273	272	273	273	274	275	276	276	276	277	19.20004
103154	191	277	280	280	280	280	280	278	278	95	95	
103163	1	109	111	115	122	126	130	137	144	152	159	19.20156
103163	11	164	169	175	182	191	202	212	232	106	105	19.20156
103163	21	104	106	111	113	120	127	137	147	158	168	19.20156
103163	31	176	182	190	200	212	222	229	233	103	104	19.20156
103163	41	104	104	101	101	101	104	110	117	126	136	19.20156
103163	51	146	161	175	167	197	204	214	227	241	250	19.20156
103163	61	[illegible]	258	266	269	99	99	99	99	98	99	19.20156
103163	71	100	104	109	117	126	137	149	162	176	188	19.20156
103163	81	198	206	216	228	242	251	255	259	265	268	19.20156
103163	91	96	96	97	97	97	98	100	103	109	118	19.20156
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103163	111	243	252	256	260	265	268	96	98	100	103	19.20156
103163	121	110	118	127	138	149	162	176	190	200	207	19.20156
103163	131	217	230	244	253	257	261	265	268	193	202	19.20156
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103163	151	211	229	232	246	256	260	264	267	269	212	19.20156
103163	161	221	232	247	258	262	265	268	270	221	233	19.20156
103163	171	248	251	265	267	270	271	267	268	270	271	19.20156
103163	181	272	272	273	273	274	274	276	276	276	277	19.20156
103163	191	277	280	280	280	280	279	278	278	280	280	

OSC 1522

SECTION III

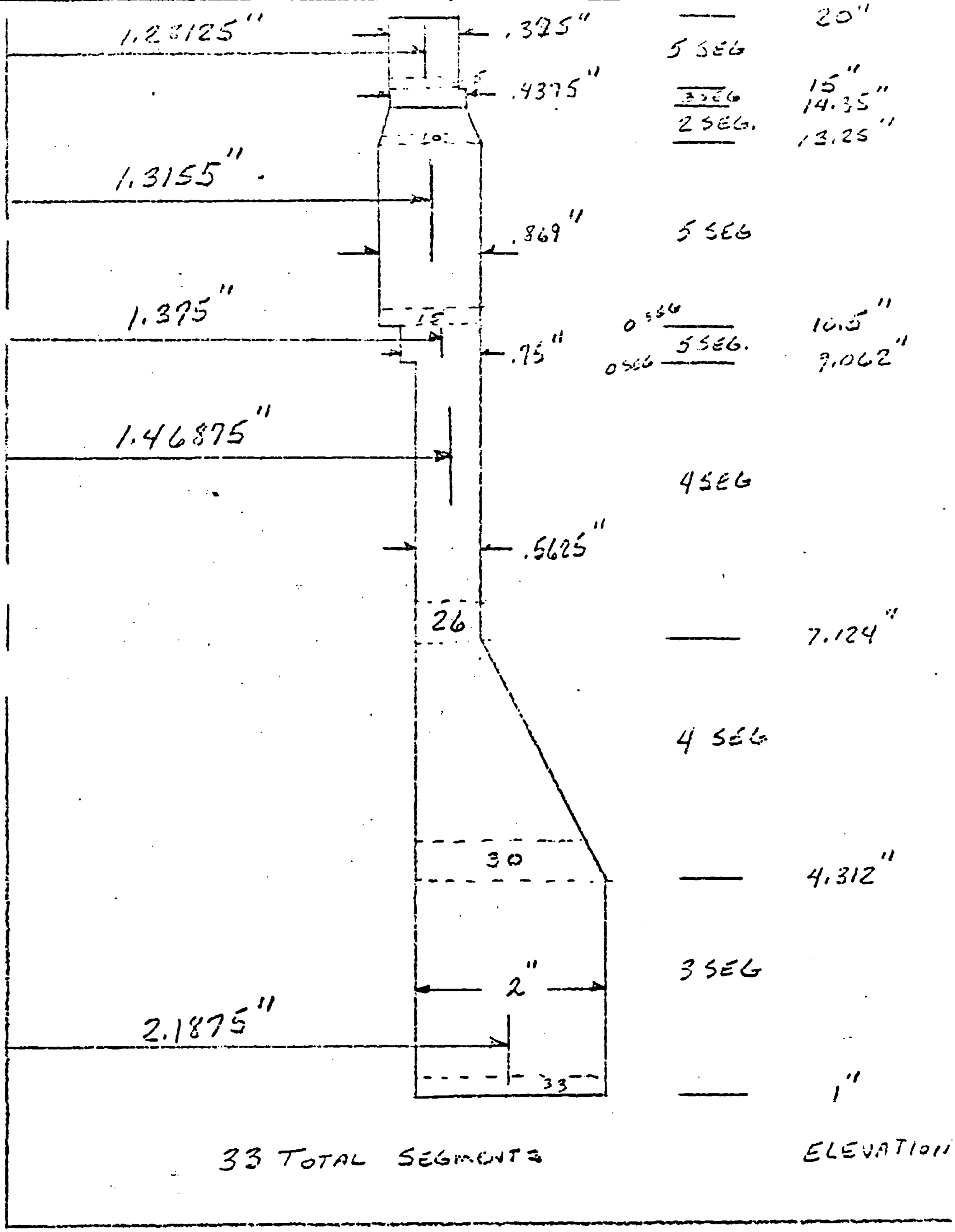
STRESS COMPUTATIONS

This section deals with the actual stress computations and comparison to allowables. The stress calculations are performed by first justifying the nozzle for pressure conditions. This was done on Page 1-7. Secondly, a combination of stress indices from B31.7 and various other literature were obtained and moment loading is defined. Thus, giving the several intensities which is associated with applied loads, i.e. dead weight, earthquake, and thermal expansion. Thirdly, the bulk of this section deals with the calculation of thermal stresses.

The thermal stress calculations are performed using B&W Computer Programs 91206 and 91032. Program 91206 uses the virtual work method to solve axisymmetric shells of revolution (See model on Page 3-1). Program 91032 is a general thermal motion and stress program solving for various shapes using appropriate classical theory. The portion which is used in this analysis is the opening in a cylinder using flat plate theory modified to account for curvature in the circumferential direction.

The stresses were generated by inputting appropriate temperatures and geometry into the programs assuming no reactions at the nozzle to shell intersection. A two element discontinuity analysis was then performed and forces and moments generated were then superimposed on the thermal stresses to give a total thermal stress picture.

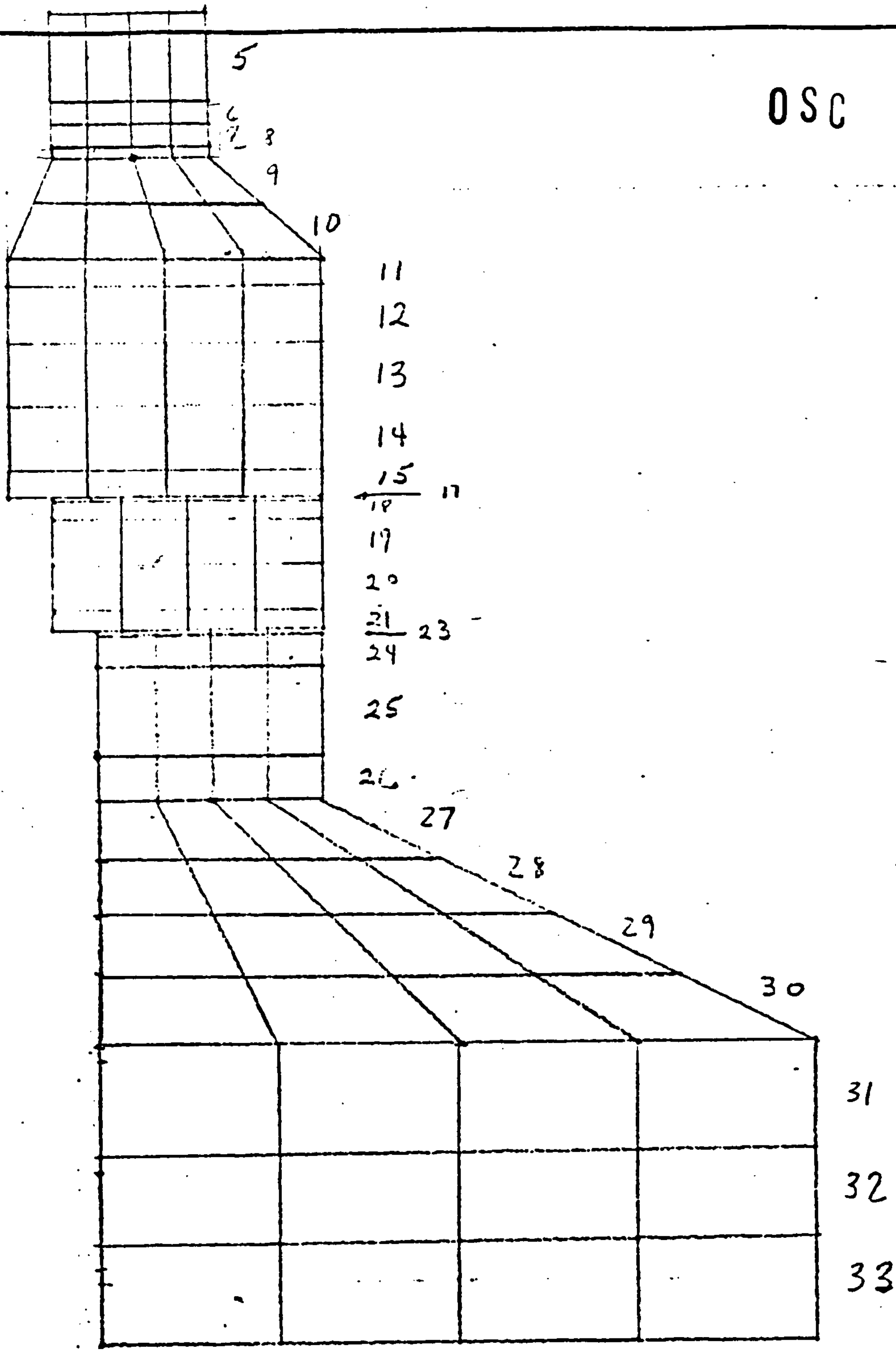
Stress concentration factors are obtained by using indices of B31.7 and other sources, and finally a fatigue analysis is performed off the branch.



0005196330

CUSTOMER	JOB No.
SUBJECT	
	BY
	DATE

OSC 1522



0006190331

CUSTOMER	JOB No.
SUBJECT 91206 GRID TO SCALE	
LONG. SCALE 4 BLOCKS = 1"	BY
RADIAL SCALE 16 BLOCKS = 1"	DATE

K&E 10-5

MID-SURFACE GEOMETRY

AT TOP BOUNDARY, MEAN RADIUS = 1.2813 Z COORDINATE = 20.0000

SEGMENTAL GEOMETRY DATA BY GROUPS

SEGMENT DATA			CENTER OF CURVATURE DATA		
BOTTOM SEG. NO.	MEAN RADIUS	Z COORD..	RADIUS TO CENTER	Z COORD.	CURVATURE IDENTIFIER
5.0	1.281	15.000	-0.000	-0.000	-0.0
6.0	1.281	14.750	-0.000	-0.000	-0.0
7.0	1.281	14.500	-0.000	-0.000	-0.0
8.0	1.281	14.350	-0.000	-0.000	-0.0
10.0	1.316	13.250	-0.000	-0.000	-0.0
11.0	1.316	13.000	-0.000	-0.000	-0.0
14.0	1.316	10.712	-0.000	-0.000	-0.0
15.0	1.316	10.500	-0.000	-0.000	-0.0
16.0	1.375	10.500	-0.000	-0.000	-0.0
17.0	1.375	10.460	-0.000	-0.000	-0.0
18.0	1.375	10.260	-0.000	-0.000	-0.0
20.0	1.375	9.302	-0.000	-0.000	-0.0
21.0	1.375	9.062	-0.000	-0.000	-0.0
22.0	1.469	9.062	-0.000	-0.000	-0.0
23.0	1.469	9.042	-0.000	-0.000	-0.0
24.0	1.469	8.553	-0.000	-0.000	-0.0
25.0	1.469	7.564	-0.000	-0.000	-0.0
26.0	1.469	7.124	-0.000	-0.000	-0.0
30.0	2.188	4.312	-0.000	-0.000	-0.0
33.0	2.188	.999	-0.000	-0.000	-0.0

SEGMENTAL GEOMETRY BY SEGMENTS (K= SEGMENT NO.)

MEAN RADIUS

K	R(K-1)	R(K)	R(K+1)	R(K+2)	R(K+3)	R(K+4)	R(K+5)	R(K+6)	R(K+7)	R(K+8)
1	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.30
11	1.32	1.32	1.32	1.32	1.32	1.32	1.38	1.38	1.38	1.38
21	1.38	1.38	1.47	1.47	1.47	1.47	1.47	1.65	1.83	2.01
31	2.19	2.19	2.19	2.19						

Z COORDINATE

K	Z(K-1)	Z(K)	Z(K+1)	Z(K+2)	Z(K+3)	Z(K+4)	Z(K+5)	Z(K+6)	Z(K+7)	Z(K+8)
1	20.00	19.00	18.00	17.00	16.00	15.00	14.75	14.50	14.35	13.80
11	13.25	13.00	12.24	11.47	10.71	10.50	10.50	10.46	10.26	9.78
21	9.30	9.06	9.06	9.04	8.55	7.58	7.12	6.42	5.72	5.01
31	4.31	3.21	2.10	1.00						

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OSC 1522

SEGMENT THICKNESS DATA BY GROUPS

TOP SEG. NO.	BOTTOM SEG. NO.	TOP THICK. OF TOP SEG.	BOTTOM THICK. OF BOTTOM SEG.
1.00	5.00	.38	.38
6.00	8.00	.44	.44
9.00	10.00	.44	.87
11.00	15.00	.87	.87
16.00	16.00	-0.00	-0.00
17.00	21.00	.75	.75
22.00	22.00	-0.00	-0.00
23.00	26.00	.56	.56
27.00	30.00	.56	2.00
31.00	33.00	2.00	2.00

MENTAL THICKNESS BY SEGMENTS

THICKNESS AT TOP OF SEGMENT (HA)

K	HA(K)	HA(K+1)	HA(K+2)	HA(K+3)	HA(K+4)	HA(K+5)	HA(K+6)	HA(K+7)	HA(K+8)	HA(K+9)
1	.38	.38	.38	.38	.38	.44	.44	.44	.44	.65
11	.87	.87	.87	.87	.87	0.00	.75	.75	.75	.75
21	.75	0.00	.56	.56	.56	.56	.55	.92	1.28	1.64
31	2.00	2.00	2.00							

THICKNESS AT BOTTOM OF SEGMENT (HB)

K	HB(K)	HB(K+1)	HB(K+2)	HB(K+3)	HB(K+4)	HB(K+5)	HB(K+6)	HB(K+7)	HB(K+8)	HB(K+9)
1	.38	.38	.38	.38	.38	.44	.44	.44	.65	.87
11	.87	.87	.87	.87	.87	0.00	.75	.75	.75	.75
21	.75	0.00	.56	.56	.56	.56	.92	1.28	1.64	2.00
31	2.00	2.00	2.00							

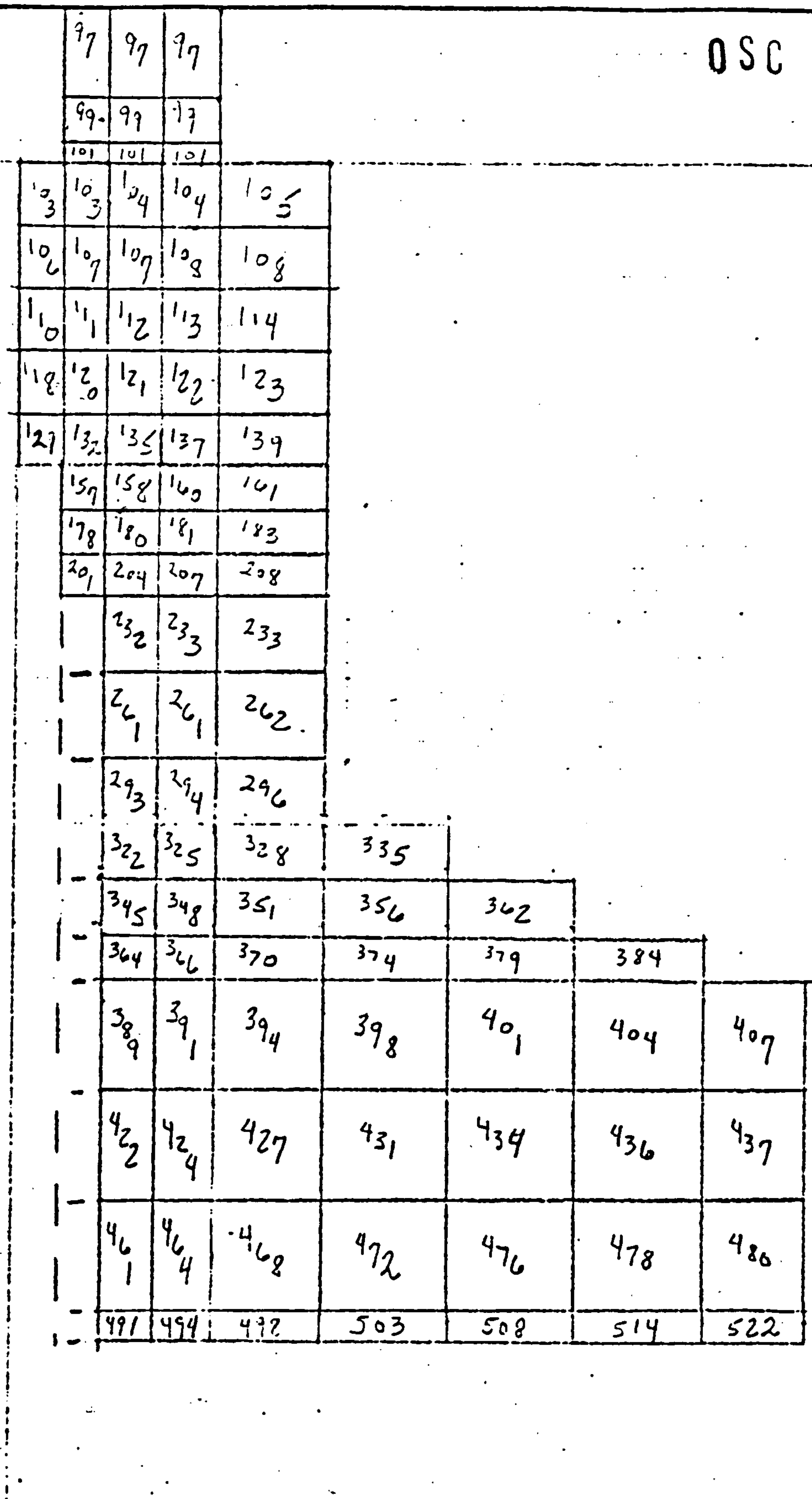
G1
G

FLEXIBILITY MATRIX OF ASSEMBLY AS IN PROGRAM 91060
(THIS MATRIX ONLY IS ON A PER RADIAN BASIS)

	M(O)	Q(O)	M(N)	Q(N)
ROTATION(O)	3.138385E-06	8.041817E-07	-4.768053E-19	1.402074E-18
DEFLECTION(O)	8.041817E-07	5.054773E-07	7.682228E-20	6.538833E-19
ROTATION(N)	-4.768053E-19	7.682228E-20	4.137258E-08	2.476880E-08
DEFLECTION(N)	1.402074E-18	6.538833E-19	2.476880E-08	5.410859E-08

NOTE: THE +1 SIGN CONVENTION IS USED IN THE MATRIX PRINTED HERE.
IF IT IS DESIRED TO USE THE -1 SIGN CONVENTION THEN THE
SIGNS MUST BE CHANGED ON ALL OF THE OFF-DIAGONAL ELEMENTS.

OSC 1522



ITER 28169 TEMPERATURE DIST.

CUSTOMER	JOB No.
SUBJECT 91167 GRID TO SCALE	
LONGITUDINAL SCALE 4 BLOCKS = 1"	BY
RADIAL SCALE 16 BLOCKS = 1"	DATE 3-7

TEMPERATURES PER SEGMENT USED IN PEAK PRINCIPLE ANALYSIS

SEGMENT	OUTSIDE T1	T2	T3	T4	INSIDE T5
1	27	27	27	27	27
2	27	27	27	27	27
3	27	27	27	27	27
4	27	27	27	27	27
5	27	27	27	27	27
6	27	27	27	27	27
7	28	28	28	27	27
8	29	29	29	28	28
9	33	33	32	29	29
10	36	36	35	31	31
11	38	38	37	34	34
12	49	48	46	36	36
13	59	57	56	45	44
14	70	67	65	53	52
15	80	77	75	62	60
16	80	77	77	72	70
				76	75
17	80	77	77	76	75
18	122	120	115	112	110
19	131	129	125	122	120
20	140	137	135	132	130
21	150	147	145	142	140
22	150	150	150	150	150
23	150	150	150	150	150
24	165	163	162	161	160
25	195	194	193	192	190
26	213	211	210	207	205
27	245	242	241	238	236
28	276	274	272	269	267
29	308	305	304	301	299
30	340	337	335	332	330
31	373	368	353	360	357
32	407	399	392	387	383
33	440	430	420	415	410

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PEAK FORCES AND MOTIONS

POSITIVE DIRECTIONS (+) ARE AS FOLLOWS

TOP OF SEGMENT NO.1		BOTTOM OF REMAINING SEGMENTS	
RADIAL------	TO THE LEFT	RADIAL------	TO THE RIGHT
ROTATIONAL--	CLOCKWISE	ROTATIONAL--	COUNTERCLOCKWISE
AXIAL-------	UPWARD	AXIAL-------	DOWNWARD

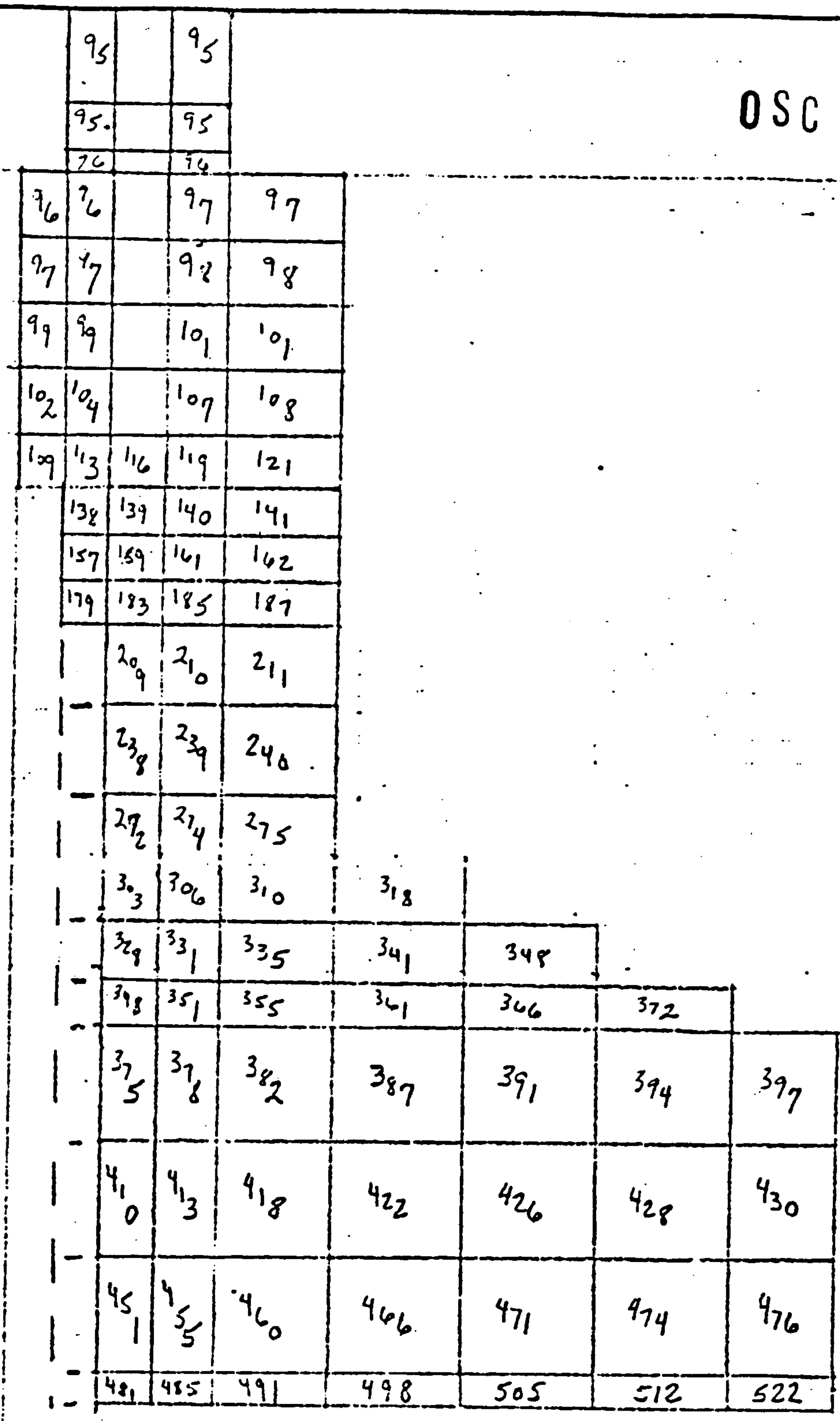
** SIGN CONVENTIONS ARE FOR A RIGHT HAND VIEW **

SEG. NO.	LOC.	RADIAL FORCE	MOMENT	AXIAL FORCE	LOC.	RADIAL MOTION	ROTATION	AXIAL MOTION
1	TOP	0.	-2.9212E-03	0.	TOP	-3.1832E-04	6.6174E-24	0.
1	BOT.	-7.4229E-03	-8.6319E-03	0.	BOT.	3.1831E-04	-5.7149E-09	2.4844E-04
2	BOT.	-2.8156E-01	1.4224E-01	0.	BOT.	3.1831E-04	3.5026E-08	4.9688E-04
3	BOT.	2.3696E+00	-4.7788E-01	0.	BOT.	3.1844E-04	6.4591E-08	7.4531E-04
4	BOT.	-9.8380E-01	-4.4384E+00	0.	BOT.	3.1767E-04	-2.3426E-06	9.9375E-04
5	BOT.	-1.2180E+02	5.6382E+01	0.	BOT.	3.1573E-04	1.2573E-05	1.2429E-03
6	BOT.	-1.3178E+02	8.9514E+01	0.	BOT.	3.1912E-04	2.3508E-05	1.3052E-03
7	BOT.	-1.5387E+02	1.2402E+02	0.	BOT.	3.2573E-04	3.9537E-05	1.3687E-03
8	BOT.	-2.1354E+02	1.5104E+02	0.	BOT.	3.3168E-04	5.2172E-05	1.4085E-03
9	BOT.	-6.6127E+02	3.9588E+02	0.	BOT.	3.6995E-04	8.7224E-05	1.5641E-03
0	BOT.	-9.0937E+02	8.8518E+02	0.	BOT.	4.2136E-04	1.0664E-04	1.7341E-03
1	BOT.	-8.4535E+02	1.1071E+03	0.	BOT.	4.4550E-04	1.1500E-04	1.8177E-03
2	BOT.	-1.7556E+03	2.0739E+03	0.	BOT.	5.3352E-04	1.6263E-04	2.1160E-03
3	BOT.	-2.6500E+03	4.0869E+03	0.	BOT.	6.6758E-04	2.7263E-04	2.4834E-03
4	BOT.	4.7045E+03	4.2631E+03	0.	BOT.	9.5034E-04	4.2818E-04	2.9026E-03
5	BOT.	9.1787E+03	2.7727E+03	0.	BOT.	1.0669E-03	4.4406E-04	3.0324E-03
6	BOT.	9.1787E+03	2.7727E+03	0.	BOT.	1.1088E-03	4.4408E-04	3.0060E-03
7	BOT.	9.7746E+03	2.3938E+03	0.	BOT.	1.1334E-03	4.5153E-04	3.0333E-03
8	BOT.	9.2970E+03	3.5340E+02	0.	BOT.	1.2588E-03	4.5547E-04	3.2142E-03
9	BOT.	2.1891E+03	-2.2878E+03	0.	BOT.	1.4962E-03	3.0934E-04	3.7668E-03
0	BOT.	-3.0965E+03	-2.1127E+03	0.	BOT.	1.5917E-03	1.1027E-04	4.3557E-03
1	BOT.	-7.7989E+03	-8.5530E+02	0.	BOT.	1.5861E-03	4.3983E-05	4.6787E-03
2	BOT.	-7.7989E+03	-8.5530E+02	0.	BOT.	1.6752E-03	4.3983E-05	4.6746E-03
3	BOT.	-7.4426E+03	-7.0288E+02	0.	BOT.	1.6728E-03	3.8979E-05	4.6928E-03
	BOT.	-1.3819E+03	1.3255E+03	0.	BOT.	1.6444E-03	6.2437E-05	5.1687E-03
	BOT.	-2.9337E+02	1.5327E+03	0.	BOT.	1.8140E-03	3.3124E-04	6.2904E-03
	BOT.	-1.2941E+03	1.9368E+03	0.	BOT.	1.9913E-03	4.7541E-04	6.9033E-03
	BOT.	-1.6020E+03	3.4759E+03	0.	BOT.	2.6266E-03	5.8482E-04	7.8586E-03
	BOT.	8.1339E+02	4.7784E+03	0.	BOT.	3.3500E-03	5.9876E-04	8.9549E-03
	BOT.	4.8234E+03	4.1337E+03	0.	BOT.	4.1241E-03	5.7607E-04	1.0208E-02

30	BOT.	3.8895E+03	2.2815E+03	0.	BOT.	4.9221E-03	5.4106E-04	1.1634E-02
31	BOT.	-1.4549E+03	3.6190E+03	0.	BOT.	5.5010E-03	4.5891E-04	1.4294E-02
32	BOT.	3.8147E+03	3.4049E+03	0.	BOT.	6.0012E-03	3.9970E-04	1.7191E-02
33	BOT.	-0.	-0.	-0.	BOT.	6.3834E-03	2.6999E-04	2.0346E-02

(FORCE AND MOTION OUTPUT IS IN GLOBAL DIRECTIONS R AND Z)

OSC 1522



0006193340

ITER 41428 TEMP. DIST.

CUSTOMER

SUBJECT 91167 GRID TO SCALE

[illegible] = 1"

[illegible] = 1"

JOB NO.

BY

DATE 3-11

TEMPERATURES PER SEGMENT USED IN PEAK PRINCIPLE ANALYSIS

	OUTSIDE			INSIDE	
SEGMENT	T1	T2	T3	T4	T5
1	25	25	25	25	25
2	25	25	25	25	25
3	25	25	25	25	25
4	25	25	25	25	25
5	25	25	25	25	25
6	25	25	25	25	25
7	25	25	25	25	25
8	26	26	26	26	26
9	26	26	26	26	26
10	27	27	27	27	27
11	28	28	28	28	28
12	36	35	34	32	30
13	45	43	39	36	33
14	53	50	45	40	35
15	63	60	55	50	45
16	63	60	60	59	58

	OUTSIDE			INSIDE	
SEGMENT	T1	T2	T3	T4	T5
17	63	60	60	59	58
18	72	71	70	68	67
19	96	93	90	88	86
20	120	115	110	107	105
21	125	120	115	112	110
22	125	120	115	115	115
23	125	120	115	115	115
24	142	141	140	139	138
25	171	171	170	169	168
26	189	188	187	186	186
27	218	217	215	213	212
28	248	246	243	240	233
29	277	276	272	268	264
30	307	305	300	295	290
31	355	350	343	337	330
32	402	395	387	378	370
33	450	440	430	420	410

PEAK FORCES AND MOTIONS
****

POSITIVE DIRECTIONS (+) ARE AS FOLLOWS

TOP OF SEGMENT NO.1		BOTTOM OF REMAINING SEGMENTS	
RADIAL------	TO THE LEFT	RADIAL------	TO THE RIGHT
ROTATIONAL--	CLOCKWISE	ROTATIONAL--	COUNTERCLOCKWISE
AXIAL-------	UPWARD	AXIAL-------	DOWNWARD

** SIGN CONVENTIONS ARE FOR A RIGHT HAND VIEW **

SEG. NO.	LOC.	RADIAL FORCE	MOMENT	AXIAL FORCE	LOC.	RADIAL MOTION	ROTATION	AXIAL MOTION
1	TOP	0.	-6.3159E-04	0.	TOP	-2.9465E-04	1.6544E-24	0.
1	BOT.	-3.0941E-03	-6.9566E-04	0.	BOT.	2.9465E-04	-7.9682E-10	2.2997E-04
2	BOT.	-3.5258E-02	2.2260E-02	0.	BOT.	2.9465E-04	6.6059E-09	4.5995E-04
3	BOT.	4.1391E-01	-1.1213E-01	0.	BOT.	2.9467E-04	-3.0283E-09	6.8992E-04
4	BOT.	-9.2703E-01	-4.3826E-01	0.	BOT.	2.9452E-04	-3.3750E-07	9.1990E-04
5	BOT.	-1.6094E+01	9.0903E+00	0.	BOT.	2.9452E-04	2.4802E-06	1.1500E-03
6	BOT.	-1.2384E+01	1.2911E+01	0.	BOT.	2.9522E-04	4.1137E-06	1.2075E-03
7	BOT.	-3.9001E+01	1.7910E+01	0.	BOT.	2.9632E-04	6.4956E-06	1.2657E-03
8	BOT.	-9.8800E+01	2.7717E+01	0.	BOT.	2.9712E-04	8.8376E-06	1.3015E-03
9	BOT.	-5.0376E+02	1.9253E+02	0.	BOT.	3.0593E-04	2.4596E-05	1.4356E-03
10	BOT.	-8.7152E+02	6.0746E+02	0.	BOT.	3.2335E-04	4.8673E-05	1.5724E-03
11	BOT.	-9.4566E+02	8.3657E+02	0.	BOT.	3.3357E-04	6.2669E-05	1.6365E-03
12	BOT.	-1.9954E+03	1.9956E+03	0.	BOT.	3.8211E-04	1.1129E-04	1.8584E-03
13	BOT.	-2.6554E+03	4.0894E+03	0.	BOT.	4.6567E-04	1.8898E-04	2.1231E-03
14	BOT.	2.9129E+03	4.7240E+03	0.	BOT.	6.5146E-04	2.8482E-04	2.4182E-03
15	BOT.	5.6630E+03	3.7838E+03	0.	BOT.	7.2738E-04	2.9142E-04	2.5128E-03
16	BOT.	5.6630E+03	3.7838E+03	0.	BOT.	7.5900E-04	2.9142E-04	2.4954E-03
17	BOT.	5.7446E+03	3.5558E+03	0.	BOT.	7.7497E-04	3.0546E-04	2.5179E-03
18	BOT.	5.8862E+03	2.3730E+03	0.	BOT.	8.6229E-04	3.5753E-04	2.6393E-03
19	BOT.	4.1295E+03	-1.9811E+02	0.	BOT.	1.0823E-03	3.5631E-04	2.9999E-03
0	BOT.	-1.1902E+03	-1.1333E+03	0.	BOT.	1.2367E-03	2.2426E-04	3.4590E-03
1	BOT.	-5.6943E+03	-3.1463E+02	0.	BOT.	1.2672E-03	1.5544E-04	3.7226E-03
2	BOT.	-5.6943E+03	-3.1463E+02	0.	BOT.	1.3358E-03	1.5544E-04	3.7080E-03
3	BOT.	-5.3533E+03	-2.0435E+02	0.	BOT.	1.3366E-03	1.4984E-04	3.7220E-03
4	BOT.	-3.1249E+02	9.7231E+02	0.	BOT.	1.3721E-03	1.4477E-04	4.1108E-03
5	BOT.	-4.0547E+02	9.3992E+02	0.	BOT.	1.5810E-03	3.0178E-04	5.0844E-03
6	BOT.	-1.9807E+03	1.4871E+03	0.	BOT.	1.7304E-03	4.0744E-04	5.6258E-03
7	BOT.	-5.3764E+03	4.4528E+03	0.	BOT.	2.2741E-03	5.4323E-04	6.4851E-03
8	BOT.	-7.6851E+03	1.0221E+04	0.	BOT.	2.9182E-03	6.1452E-04	7.4645E-03
9	BOT.	-6.1871E+03	1.7358E+04	0.	BOT.	3.6438E-03	6.4647E-04	8.5706E-03

BOT.	-2.1524E+02	2.3130E+04	0.	BOT.	4.4350E-03	6.4504E-04	9.8107E-03
BOT.	6.7521E+03	2.0795E+04	0.	BOT.	5.1583E-03	6.2906E-04	1.2237E-02
BOT.	1.3098E+04	9.8460E+03	0.	BOT.	5.8613E-03	5.4850E-04	1.5024E-02
BOT.	-0.	-0.	-0.	BOT.	6.4164E-03	3.9259E-04	1.8195E-02

(FORCE AND MOTION OUTPUT IS IN GLOBAL DIRECTIONS R AND Z)

OSC 1522

	95		95					
96				97				
97				98				
98				101				
102				107				
109	112			120				
				140				
				159				
	176	179	181	183				
		204	205	206				
		232	233	234				
		265	266	268				
		295	297	301	309			
		318	321	325	331	337		
		338	340	344	350	355	360	
		363	366	370	375	379	382	385
		397	400	404	409	412	414	416
		438	440	445	451	455	458	460
		465	469	475	481	488	495	504

↑ SAME AS ITER 41428

000619[illegible]844

ITER 52659 TEMP. DIST.

CUSTOMER

JOB NO.

SUBJECT [illegible]

BY

DATE 3-15

TEMPERATURES PER SEGMENT USED IN PEAK PRINCIPLE ANALYSIS

SEGMENT	OUTSIDE T1	T2	T3	T4	INSIDE T5
1	25	25	25	25	25
2	25	25	25	25	25
3	25	25	25	25	25
4	25	25	25	25	25
5	25	25	25	25	25
6	25	25	25	25	25
7	25	25	25	25	25
8	26	26	26	26	26
9	26	26	26	26	26
10	27	27	27	27	27
11	28	28	28	28	28
12	36	35	34	32	30
13	45	43	39	36	33
14	53	50	45	40	35
15	63	60	55	50	45
16	63	60	60	59	58

SEGMENT	OUTSIDE T1	T2	T3	T4	INSIDE T5
17	63	60	60	59	58
18	72	71	70	68	67
19	93	91	90	88	86
20	115	112	110	107	105
21	120	117	115	112	110
22	120	117	115	112	110
23	120	117	115	112	110
24	138	137	136	135	133
25	165	164	163	162	160
26	180	179	178	176	175
27	210	209	208	206	205
28	240	239	238	236	235
29	270	269	268	266	265
30	300	299	298	296	295
31	343	339	335	331	327
32	387	380	373	365	358
33	430	420	410	400	390

PEAK FORCES AND MOTIONS
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POSITIVE DIRECTIONS (+) ARE AS FOLLOWS

TOP OF SEGMENT NO.1	BOTTOM OF REMAINING SEGMENTS
RADIAL------ TO THE LEFT	RADIAL------ TO THE RIGHT
ROTATIONAL-- CLOCKWISE	ROTATIONAL-- COUNTERCLOCKWISE
AXIAL------- UPWARD	AXIAL------- DOWNWARD

** SIGN CONVENTIONS ARE FOR A RIGHT HAND VIEW **

SEG. NO.	LOC.	RADIAL FORCE	MOMENT	AXIAL FORCE	LOC.	RADIAL MOTION	ROTATION	AXIAL MOTION
1	TOP	0.	-6.1883E-04	0.	TOP	-2.9465E-04	1.6544E-24	0.
1	BOT.	-2.9868E-03	-7.1802E-04	0.	BOT.	2.9465E-04	-7.9385E-10	2.2997E-04
2	BOT.	-3.5313E-02	2.2054E-02	0.	BOT.	2.9465E-04	6.5012E-09	4.5995E-04
3	BOT.	4.0849E-01	-1.0959E-01	0.	BOT.	2.9467E-04	-2.4574E-09	6.8992E-04
4	BOT.	-8.8584E-01	-4.4503E-01	0.	BOT.	2.9453E-04	-3.3574E-07	9.1990E-04
5	BOT.	-1.6075E+01	8.9993E+00	0.	BOT.	2.9451E-04	2.4372E-06	1.1500E-03
6	BOT.	-1.2617E+01	1.2643E+01	0.	BOT.	2.9520E-04	4.0595E-06	1.2075E-03
7	BOT.	-3.9711E+01	1.7955E+01	0.	BOT.	2.9628E-04	6.4412E-06	1.2657E-03
8	BOT.	-9.9924E+01	2.7899E+01	0.	BOT.	2.9708E-04	8.7954E-06	1.3015E-03
9	BOT.	-5.0762E+02	1.9406E+02	0.	BOT.	3.0585E-04	2.4679E-05	1.4358E-03
10	BOT.	-8.7852E+02	6.1224E+02	0.	BOT.	3.2332E-04	4.6944E-05	1.5725E-03
11	BOT.	-9.5578E+02	8.4312E+02	0.	BOT.	3.3359E-04	6.3047E-05	1.6366E-03
12	BOT.	-1.9805E+03	2.0016E+03	0.	BOT.	3.8261E-04	1.1205E-04	1.8584E-03
13	BOT.	-2.5471E+03	4.0505E+03	0.	BOT.	4.6734E-04	1.8886E-04	2.1226E-03
14	BOT.	3.1773E+03	4.5282E+03	0.	BOT.	6.5331E-04	2.7800E-04	2.4173E-03
15	BOT.	5.9471E+03	3.5269E+03	0.	BOT.	7.2831E-04	2.8088E-04	2.5117E-03
16	BOT.	5.[illegible]71E+03	3.52[illegible]E+03	0.	BOT.	7.5992E-04	2.8525E-04	2.4956E-03
17	BOT.	6.22[illegible]E+03	3.2[illegible]E+03	0.	BOT.	7.75[illegible]E-04	2.9374E-04	2.5174E-03
18	BOT.	6.1471E+03	2.0511E+03	0.	BOT.	8.609[illegible]E-04	3.3925E-04	2.6388E-03
19	BOT.	4.2351E+03	-6.1622E+02	0.	BOT.	1.0710E-03	3.2947E-04	2.9975E-03
20	BOT.	-1.4235E+03	-1.5274E+03	0.	BOT.	1.2140E-03	2.0953E-04	3.4520E-03
21	BOT.	-6.1747E+03	-6.2402E+02	0.	BOT.	1.2410E-03	1.5470E-04	3.7129E-03
22	BOT.	-6.1747E+03	-6.2402E+02	0.	BOT.	1.3007E-03	1.5470E-04	3.6984E-03
23	BOT.	-5.8344E+03	-5.0392E+02	0.	BOT.	1.3102E-03	1.4784E-04	3.7119E-03
24	BOT.	-7.3729E+02	9.0174E+02	0.	BOT.	1.3343E-03	1.2211E-04	4.0891E-03
25	BOT.	-6.0431E+02	1.2203E+03	0.	BOT.	1.5174E-03	2.9581E-04	5.0260E-03
26	BOT.	-1.4772E+03	1.7309E+03	0.	BOT.	1.6703E-03	4.1981E-04	5.5397E-03
27	BOT.	-2.4678E+03	3.5065E+03	0.	BOT.	2.2242E-03	5.4265E-04	6.3469E-03
28	BOT.	-1.9796E+03	5.9797E+03	0.	BOT.	2.8746E-03	5.8579E-04	7.2842E-03
29	BOT.	4.7655E+02	7.9132E+03	0.	BOT.	3.5923E-03	5.9942E-04	8.3628E-03

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BOT.	2.0307E+03	8.7653E+03	0.	BOT.	4.3593E-03	5.9597E-04	9.5934E-03
BOT.	1.1882E+03	9.1053E+03	0.	BOT.	5.0222E-03	5.7956E-04	1.1978E-02
BOT.	6.8736E+03	5.5491E+03	0.	BOT.	5.6422E-03	4.9681E-04	1.4666E-02
BOT.	-0.	-0.	-0.	BOT.	6.1266E-03	3.4069E-04	1.7653E-02

(FORCE AND MOTION OUTPUT IS IN GLOBAL DIRECTIONS R AND Z)

OSC 1522

	70							
			70					
70				71				
71				72				
72	73	74		75				
75	77	78		81				
81	85	88		93				
	110	111		114				
	130	132		135				
	152	155		160				
		182		184				
		211		213				
		245	247	248				
		277	279	284	292			
		301	304	308	315	321		
		322	325	329	334	340	345	
		348	352	356	361	365	369	372
		384	388	392	397	401	403	404
		426	430	436	442	447	450	452
		456	461	467	475	482	489	499

000619[illegible]0348

ITER 75168 TEMP. DIST.

CUSTOMER	JOB No.
SUBJECT [illegible] GRID TO [illegible]	
[illegible] SCALE [illegible] = 1"	BY
[illegible] SCALE [illegible] = 1"	DATE 2-19

TEMPERATURES PER SEGMENT USED IN PEAK PRINCIPLE ANALYSIS

SEGMENT	OUTSIDE T1	T2	T3	T4	INSIDE T5
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	0	0	0	0	0
7	0	0	0	0	0
8	0	0	0	0	0
9	0	0	0	0	0
10	0	0	0	0	0
11	0	0	0	0	0
12	8	7	6	0	0
13	17	15	12	5	4
14	25	22	18	10	7
15	30	30	30	15	11
16	30	30	30	23	21
				30	30

SEGMENT	OUTSIDE T1	T2	T3	T4	INSIDE T5
17	30	30	30	30	30
18	45	44	42	41	40
19	70	65	64	62	60
20	95	89	87	83	80
21	103	97	95	91	88
22	103	97	95	95	95
23	103	97	95	95	95
24	115	114	113	112	112
25	145	144	143	142	142
26	165	164	163	162	162
27	195	191	187	183	180
28	225	218	211	204	198
29	256	245	235	225	216
30	287	272	259	246	234
31	335	320	308	295	283
32	332	369	356	343	331
33	430	417	405	392	380

PEAK FORCES AND MOTIONS
****

POSITIVE DIRECTIONS (+) ARE AS FOLLOWS

TOP OF SEGMENT NO.1	BOTTOM OF REMAINING SEGMENTS
RADIAL------ TO THE LEFT	RADIAL------ TO THE RIGHT
ROTATIONAL-- CLOCKWISE	ROTATIONAL-- COUNTERCLOCKWISE
AXIAL------- UPWARD	AXIAL------- DOWNWARD

** SIGN CONVENTIONS ARE FOR A RIGHT HAND VIEW **

EG. O.	LOC.	RADIAL FORCE	MOMENT	AXIAL FORCE	LOC.	RADIAL MOTION	ROTATION	AXIAL MOTION
1	TOP	0.	1.8231E-03	0.	TOP	4.5546E-11	-3.3087E-24	0.
1	BOT.	1.5596E-02	-3.4145E-03	0.	BOT.	8.0507E-10	3.4311E-10	-6.9289E-11
2	BOT.	-1.2536E-02	-2.6397E-02	0.	BOT.	-4.3707E-09	-1.4746E-08	-7.6657E-11
3	BOT.	-7.5671E-01	3.6342E-01	0.	BOT.	-1.4331E-08	8.4481E-08	4.2869E-09
4	BOT.	5.8706E+00	-1.0623E+00	0.	BOT.	3.3556E-07	2.2026E-07	-2.5249E-08
5	BOT.	7.5753E-01	-1.2426E+01	0.	BOT.	-1.5252E-06	-6.0946E-06	-5.9308E-08
6	BOT.	-3.6160E+01	-8.5334E+00	0.	BOT.	-3.3886E-06	-7.5493E-06	6.9576E-08
7	BOT.	-1.0493E+02	8.5318E+00	0.	BOT.	-5.8767E-06	-7.3474E-06	3.4582E-07
8	BOT.	-1.6400E+02	2.8604E+01	0.	BOT.	-7.5070E-06	-5.3941E-06	6.0528E-07
9	BOT.	-5.4282E+02	2.2031E+02	0.	BOT.	-1.0866E-05	1.2625E-05	2.2458E-06
0	BOT.	-9.3325E+02	6.6347E+02	0.	BOT.	-3.9967E-06	3.9281E-05	3.8895E-06
1	BOT.	-8.7300E+02	8.9713E+02	0.	BOT.	4.0180E-06	5.4004E-05	4.4731E-06
2	BOT.	-1.5294E+03	1.7703E+03	0.	BOT.	5.0521E-05	1.0655E-04	3.0592E-05
3	BOT.	-2.4617E+03	3.5502E+03	0.	BOT.	1.3560E-04	1.8730E-04	1.0325E-04
4	BOT.	2.2532E+03	4.3393E+03	0.	BOT.	3.2132E-04	2.9319E-04	2.1074E-04
5	BOT.	4.6130E+03	3.5791E+03	0.	BOT.	3.9908E-04	3.2771E-04	2.5438E-04
6	BOT.	4.6130E+03	3.5791E+03	0.	BOT.	4.1552E-04	3.2771E-04	2.3488E-04
7	BOT.	4.8301E+03	3.3904E+03	0.	BOT.	4.3225E-04	3.4266E-04	2.4593E-04
8	BOT.	5.4104E+03	2.3390E+03	0.	BOT.	5.2481E-04	3.9650E-04	3.1338E-04
9	BOT.	4.1601E+03	-1.1874E+02	0.	BOT.	7.6198E-04	3.9983E-04	5.5422E-04
0	BOT.	-3.5281E+02	-1.2485E+03	0.	BOT.	9.4381E-04	2.7950E-04	8.9748E-04
1	BOT.	-4.5520E+03	-6.7954E+02	0.	BOT.	9.9209E-04	2.1281E-04	1.1077E-03
2	BOT.	-4.5520E+03	-6.7954E+02	0.	BOT.	1.0484E-03	2.1281E-04	1.0878E-03
3	BOT.	-4.3320E+03	-5.9069E+02	0.	BOT.	1.0508E-03	2.0720E-04	1.0993E-03
4	BOT.	-6.3867E+02	5.2851E+02	0.	BOT.	1.1121E-03	1.7112E-04	1.4134E-03
5	BOT.	-6.2493E+02	6.9907E+02	0.	BOT.	1.3031E-03	2.5593E-04	2.2097E-03
6	BOT.	-3.4445E+03	1.5709E+03	0.	BOT.	1.4197E-03	3.5210E-04	2.6745E-03
7	BOT.	-1.1430E+04	7.2218E+03	0.	BOT.	1.8730E-03	5.3118E-04	3.4310E-03
8	BOT.	-1.8861E+04	1.9721E+04	0.	BOT.	2.4367E-03	6.4437E-04	4.2803E-03
9	BOT.	-1.8908E+04	3.7102E+04	0.	BOT.	3.0979E-03	6.9348E-04	5.2236E-03

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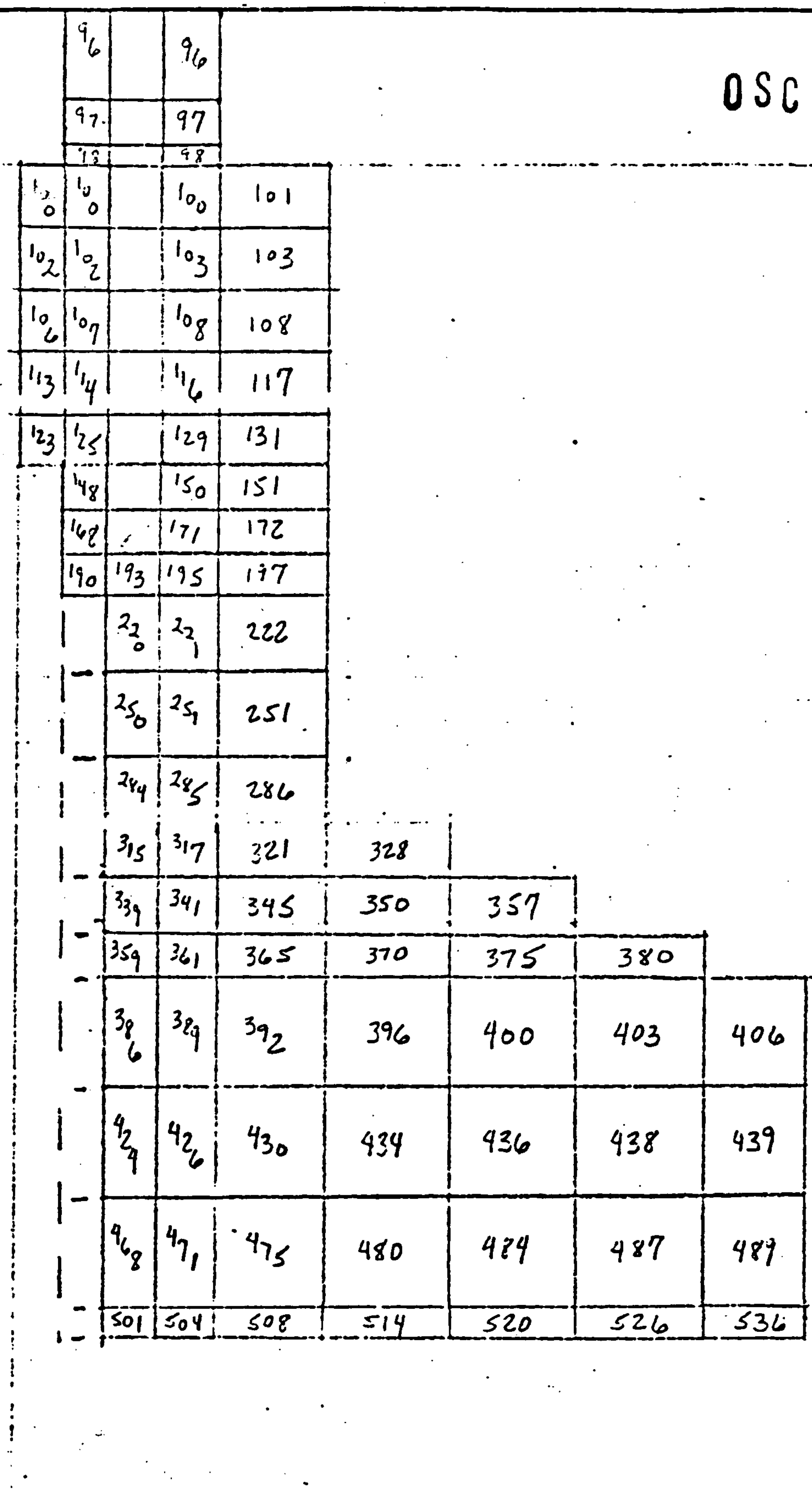
0 0 0 6 1 9 3 5 1

[illegible]	BOT.	-5.5366E+03	5.2801E+04	0.	BOT.	3.8361E-[illegible]	[illegible]E-04	6.[illegible]647E-03
[illegible]	BOT.	1.6633E+04	4.6601E+04	0.	BOT.	4.5790E-03	6.2076E-04	8.[illegible]769E-03
[illegible]	BOT.	2.6822E+04	2.0414E+04	0.	BOT.	5.3060E-03	5.0739E-04	1.0890E-02
33	BOT.	-0.	-0.	-0.	BOT.	5.8242E-03	3.1041E-04	1.3833E-02

(FORCE AND MOTION OUTPUT IS IN GLOBAL DIRECTIONS R AND Z)



ITER 86960 TEMP. DIST.

CUSTOMER

JOB No.

SUBJECT 91167

BY

DATE 2-23

TEMPERATURES PER SEGMENT USED IN PEAK PRINCIPLE ANALYSIS

SEGMENT	OUTSIDE T1	T2	T3	T4	INSIDE T5
1	26	26	26	26	26
2	26	26	26	26	26
3	26	26	26	26	26
4	26	26	26	26	26
5	26	26	26	26	26
6	26	26	26	26	26
7	28	28	28	28	28
8	30	30	30	30	28
9	30	30	30	30	30
10	30	30	30	30	30
11	33	32	32	30	30
12	43	41	40	31	31
13	53	51	49	39	37
14	63	60	57	46	44
15	73	70	67	54	50
16	73	70	67	63	60

SEGMENT	OUTSIDE T1	T2	T3	T4	INSIDE T5
17	73	70	67	65	65
18	85	83	82	81	80
19	107	104	102	99	98
20	130	126	122	118	115
21	135	131	127	123	120
22	135	131	127	123	120
23	135	131	127	123	120
24	155	154	153	151	150
25	180	180	180	180	180
26	199	198	197	197	196
27	229	228	225	223	221
28	260	258	253	248	245
29	290	288	282	274	270
30	321	318	310	300	295
31	365	360	350	340	333
32	410	403	390	380	372
33	455	445	430	420	410

3-7

PEAK FORCES AND MOTIONS

POSITIVE DIRECTIONS (+) ARE AS FOLLOWS

TOP OF SEGMENT NO.1		BOTTOM OF REMAINING SEGMENTS	
RADIAL------	TO THE LEFT	RADIAL------	TO THE RIGHT
ROTATIONAL--	CLOCKWISE	ROTATIONAL--	COUNTERCLOCKWISE
AXIAL-------	UPWARD	AXIAL-------	DOWNWARD

** SIGN CONVENTIONS ARE FOR A RIGHT HAND VIEW **

SEG. NO.	LOC.	RADIAL FORCE	MOMENT	AXIAL FORCE	LOC.	RADIAL MOTION	ROTATION	AXIAL MOTION
1	TOP	0.	-5.2727E-03	0.	TOP	-3.0648E-04	1.3235E-23	0.
1	BOT.	-4.3647E-02	8.6891E-03	0.	BOT.	3.0648E-04	-1.4223E-09	2.3921E-04
2	BOT.	1.1257E-02	8.4621E-02	0.	BOT.	3.0649E-04	4.3678E-08	4.7841E-04
3	BOT.	2.2843E+00	-1.0423E+00	0.	BOT.	3.0653E-04	-2.2825E-07	7.1761E-04
4	BOT.	-1.6280E+01	2.5633E+00	0.	BOT.	3.0550E-04	-8.0318E-07	9.5689E-04
5	BOT.	-1.2211E+01	3.6956E+01	0.	BOT.	3.1049E-04	1.7895E-05	1.1963E-03
6	BOT.	8.8652E+01	3.0963E+01	0.	BOT.	3.1592E-04	2.2823E-05	1.2557E-03
7	BOT.	1.0476E+02	1.2414E+00	0.	BOT.	3.2277E-04	2.5184E-05	1.3178E-03
8	BOT.	-4.9294E+01	-5.1441E+00	0.	BOT.	3.2672E-04	2.5770E-05	1.3584E-03
9	BOT.	-8.8815E+02	2.7157E+02	0.	BOT.	3.4271E-04	4.2174E-05	1.5130E-03
0	BOT.	-1.0805E+03	9.0504E+02	0.	BOT.	3.7030E-04	7.7311E-05	1.6660E-03
11	BOT.	-8.1200E+02	1.1437E+03	0.	BOT.	3.8785E-04	9.2725E-05	1.7372E-03
2	BOT.	-1.2676E+03	1.8820E+03	0.	BOT.	4.6386E-04	1.4109E-04	1.9938E-03
3	BOT.	-2.0833E+03	3.3883E+03	0.	BOT.	5.7789E-04	2.1837E-04	2.3134E-03
4	BOT.	2.4276E+03	3.9115E+03	0.	BOT.	7.8813E-04	3.2253E-04	2.6846E-03
5	BOT.	4.8652E+03	3.1143E+03	0.	BOT.	8.7059E-04	3.3533E-04	2.8030E-03
6	BOT.	4.8652E+03	3.1143E+03	0.	BOT.	9.0748E-04	3.3533E-04	2.7831E-03
7	BOT.	5.1338E+03	2.9144E+03	0.	BOT.	9.2455E-04	3.4204E-04	2.8079E-03
8	BOT.	5.6653E+03	1.7949E+03	0.	BOT.	1.0150E-03	3.7136E-04	2.9469E-03
9	BOT.	3.6421E+03	-5.8395E+02	0.	BOT.	1.2337E-03	3.5019E-04	3.3619E-03
0	BOT.	-1.7682E+03	-1.2550E+03	0.	BOT.	1.3777E-03	2.0749E-04	3.8721E-03
1	BOT.	-6.4033E+03	-2.8373E+02	0.	BOT.	1.4013E-03	1.3894E-04	4.1611E-03
2	BOT.	-6.4033E+03	-2.8373E+02	0.	BOT.	1.4775E-03	1.3894E-04	4.1481E-03
3	BOT.	-5.9933E+03	-1.5976E+02	0.	BOT.	1.4777E-03	1.3173E-04	4.1631E-03
4	BOT.	-1.0447E+02	1.0587E+03	0.	BOT.	1.4966E-03	1.1070E-04	4.5859E-03
5	BOT.	-4.5793E+02	9.0046E+02	0.	BOT.	1.6783E-03	2.8366E-04	5.6352E-03
6	BOT.	-2.3818E+03	1.5438E+03	0.	BOT.	1.8213E-03	4.0614E-04	6.2103E-03
7	BOT.	-6.7335E+03	5.1616E+03	0.	BOT.	2.3757E-03	5.5920E-04	7.1226E-03
8	BOT.	-9.8523E+03	1.2389E+04	0.	BOT.	3.0355E-03	6.3430E-04	8.1528E-03
9	BOT.	-8.3848E+03	2.1563E+04	0.	BOT.	3.7760E-03	6.5776E-04	9.3084E-03

30	BOT.	-1.6853E+03	2.9474E+04	0.	BOT.	4.5757E-03	6.3727E-04	1.0599E-02
31	BOT.	8.0562E+03	2.7328E+04	0.	BOT.	5.2713E-03	5.8938E-04	1.3092E-02
32	BOT.	1.6715E+04	1.3090E+04	0.	BOT.	5.9250E-03	4.7736E-04	1.5926E-02
33	BOT.	-0.	-0.	-0.	BOT.	6.3695E-03	2.6523E-04	1.9127E-02

(FORCE AND MOTION OUTPUT IS IN GLOBAL DIRECTIONS R AND Z)

OSC 1522

	95		95				
	[illegible]		96				
96			96	96			
97				97			
99	99		100	100			
103			103	103			
107	108		109	109			
	117		118	118			
	125		126	127			
	136		137	138			
		149	149	149			
		161	162	162			
		176	176	176			
		188	189	190	193		
		198	198	200	201	204	
		205	206	207	209	210	212
		216	216	217	218	219	220	221
		228	229	230	231	232	232	233
		242	243	244	245	246	247	248
		251	252	253	255	256	258	261

00061935

10 3154 TEMP. DIST. 3-27

CUSTOMER

SUBJECT

JOB No.

BY

DATE

TEMPERATURES PER SEGMENT USED IN PEAK PRINCIPLE ANALYSIS

SEGMENT	OUTSIDE T1	T2	T3	T4	INSIDE T5
1	25	25	25	25	25
2	25	25	25	25	25
3	25	25	25	25	25
4	25	25	25	25	25
5	25	25	25	25	25
6	25	25	25	25	25
7	25	25	25	25	25
8	25	25	25	25	25
9	25	25	25	25	25
10	26	26	26	26	26
11	27	27	27	27	27
12	31	31	31	31	31
13	34	34	34	34	34
14	38	38	38	38	38
15	43	43	43	43	43
16	43	43	43	43	43

SEGMENT	OUTSIDE T1	T2	T3	T4	INSIDE T5
17	43	43	43	43	43
18	43	48	48	48	48
19	58	58	58	58	58
20	68	68	68	66	68
21	73	73	73	73	73
22	73	73	73	73	73
23	73	73	73	73	73
24	80	80	80	80	80
25	90	90	90	90	90
26	97	97	97	97	97
27	108	107	107	107	106
28	118	117	117	116	116
29	129	128	127	126	125
30	140	138	137	136	135
31	157	154	153	151	150
32	173	171	169	167	165
33	190	187	185	182	180

PEAK FORCES AND MOTIONS

POSITIVE DIRECTIONS (+) ARE AS FOLLOWS

TOP OF SEGMENT NO.1		BOTTOM OF REMAINING SEGMENTS	
RADIAL------	TO THE LEFT	RADIAL------	TO THE RIGHT
ROTATIONAL--	CLOCKWISE	ROTATIONAL--	COUNTERCLOCKWISE
AXIAL-------	UPWARD	AXIAL-------	DOWNWARD

** SIGN CONVENTIONS ARE FOR A RIGHT HAND VIEW **

SEG. NO.	LOC.	RADIAL FORCE	MOMENT	AXIAL FORCE	LOC.	RADIAL MOTION	ROTATION	AXIAL MOTION
1	TOP	0.	7.0211E-04	0.	TOP	-2.9465E-04	-3.3087E-24	0.
1	BOT.	9.8449E-03	-4.4392E-03	0.	BOT.	2.9465E-04	-9.9498E-10	2.2997E-04
2	BOT.	-7.0700E-02	1.1654E-02	0.	BOT.	2.9465E-04	-3.2160E-09	4.5995E-04
3	BOT.	-3.8875E-02	1.6283E-01	0.	BOT.	2.9467E-04	7.6341E-08	6.8992E-04
4	BOT.	4.1011E+00	-1.7502E+00	0.	BOT.	2.9476E-04	-3.4924E-07	9.1987E-04
5	BOT.	-2.6034E+01	3.1766E+00	0.	BOT.	2.9297E-04	-1.7450E-06	1.1500E-03
6	BOT.	-5.5360E+01	1.3273E+01	0.	BOT.	2.9233E-04	-4.2915E-07	1.2076E-03
7	BOT.	-9.1150E+01	3.1703E+01	0.	BOT.	2.9201E-04	3.0378E-06	1.2653E-03
8	BOT.	-1.1205E+02	4.7033E+01	0.	BOT.	2.9223E-04	6.6725E-06	1.2999E-03
9	BOT.	-2.2515E+02	1.4254E+02	0.	BOT.	3.0179E-04	2.1855E-05	1.4281E-03
0	BOT.	-1.4311E+02	2.7309E+02	0.	BOT.	3.1971E-04	3.4593E-05	1.5583E-03
1	BOT.	-1.8517E+01	2.9152E+02	0.	BOT.	3.2866E-04	3.9668E-05	1.6192E-03
2	BOT.	-2.7930E+02	3.6209E+02	0.	BOT.	3.6390E-04	5.8442E-05	1.8230E-03
3	BOT.	-7.2318E+02	8.2201E+02	0.	BOT.	4.1382E-04	9.2482E-05	2.0537E-03
4	BOT.	1.0901E+03	9.6386E+02	0.	BOT.	5.0695E-04	1.4568E-04	2.3067E-03
5	BOT.	2.0218E+03	6.1958E+02	0.	BOT.	5.4432E-04	1.5605E-04	2.3847E-03
6	BOT.	2.0218E+03	6.1958E+02	0.	BOT.	5.6791E-04	1.5605E-04	2.3754E-03
7	BOT.	2.1327E+03	5.3657E+02	0.	BOT.	5.7567E-04	1.5829E-04	2.3911E-03
8	BOT.	2.5149E+03	6.1080E+01	0.	BOT.	6.1622E-04	1.6390E-04	2.4743E-03
9	BOT.	2.0222E+03	-1.1323E+03	0.	BOT.	7.0937E-04	1.3559E-04	2.7089E-03
0	BOT.	-1.0098E+03	-1.5244E+03	0.	BOT.	7.6266E-04	6.7378E-05	2.9928E-03
1	BOT.	-4.1973E+03	-9.2257E+02	0.	BOT.	7.6447E-04	4.3047E-05	3.1560E-03
2	BOT.	-4.1973E+03	-9.2257E+02	0.	BOT.	8.0745E-04	4.3047E-05	3.1520E-03
3	BOT.	-4.0093E+03	-8.4050E+02	0.	BOT.	8.0658E-04	3.8284E-05	3.1605E-03
	BOT.	-6.7363E+02	2.7369E+02	0.	BOT.	7.8832E-04	8.8333E-06	3.3861E-03
	BOT.	1.2108E+02	3.8477E+02	0.	BOT.	8.2861E-04	9.4462E-05	3.9041E-03
	BOT.	-3.2613E+02	4.1673E+02	0.	BOT.	8.8034E-04	1.3676E-04	4.1782E-03
	BOT.	-1.4507E+03	1.1312E+03	0.	BOT.	1.1020E-03	1.7756E-04	4.6094E-03
	BOT.	-2.1806E+03	2.7202E+03	0.	BOT.	1.3527E-03	1.9849E-04	5.0813E-03
	BOT.	-1.7324E+03	4.7157E+03	0.	BOT.	1.6223E-03	2.0837E-04	5.5952E-03

30	BOT.	1.2423E+02	6.2660E+03	0.	BOT.	1.9247E-03	2.0852E-04	6.1528E-03
31	BOT.	1.8142E+03	5.3611E+03	0.	BOT.	2.1591E-03	2.0618E-04	7.1846E-03
32	BOT.	3.1971E+03	2.4920E+03	0.	BOT.	2.3893E-03	1.8782E-04	8.3342E-03
33	BOT.	-0.	-0.	-0.	BOT.	2.5846E-03	1.5159E-04	9.6060E-03

(FORCE AND MOTION OUTPUT IS IN GLOBAL DIRECTIONS R AND Z)

0 0 0 8 1 9 3 6 0

MASS [illegible] NOZZLE [illegible] MODEL THERMAL MOTIONS ELEMENT 1

PLATE THICKNESS = 2.1[illegible] MATERIAL CODE ------- 1

OUTSIDE RADIUS -- 7.930 INSIDE RADIUS --- 1.000

AXIAL INCREMENT = .546 RADIAL INCREMENT .693

NO. OF ROWS -------- 5 NO. OF COLUMNS ------ 11

POISSONS VALUE -- .306

E AND ALPHA ARE CALCULATED IN PROGRAM

OSC 1522

THE O.D. IS FIXED - DEFLECTION IS CALCULATED IN PROGRAM

```
       :      I-----------------------------------COLUMNS-----------------------------------I
       :
       :      1                                  6                                         11
 C :   -    -I-----------------------------------I-----------------------------------------I-
 E :   A   5 I                                                                             I   5
 N :   I     I                                                                             I
 T :   I     I                                                                             I
 E :   I     I                                                                             I
 R :   I     I                                                                             I
       I     I                                                                             I
 L :   I     I                                                                             I
 I :   F     I                                                                             I
 N :   O    -I-----------------------------------------------------------------------------I-
 E :   G   3 I                                                                             I   3
       R     I                                                                             I
 O :   S     I                                                                             I
 P :   I     I                                                                             I
 E :   I     I                                                                             I
 N :   I     I                                                                             I
 I :   V     I                                                                             I
 N :   -   1-I-----------------------------------------------------------------------------I-1
 G :
       :
...:...............................CENTER LINE OF THE VESSEL.......................................
       :
```

-----NOTE:EDGE ONE IS ON THE BOTTOM OF THE PLATE OR INSIDE OF THE VESSEL FOR TEMPERATURES, MOTIONS AND STRESSES-----

DEFLECTION ON OD = 2.57[illegible]E-02 BASED ON TEMP. OF 573

HEAT PIPE NODE THERMAL ... ELEMENT 1

TEMPERATURE OF NODES PER EDGE FOR ITERATION 28169

OSC 1522

3-32

COLUMNS

	1	2	3	4	5	6	7	8	9	10	11
5	475	492	502	518	549	557	562	566	567	568	570
4	495	513	523	535	550	560	563	567	568	570	572
3	516	533	540	548	555	562	566	568	569	571	573
2	552	553	556	561	564	567	569	570	571	573	574
1	568	571	572	572	572	573	575	575	574	574	573

[illegible] MODEL INTEGRAL MOTIONS ELEMENT 1

0 0 0 5 1 9 0 3 6 2

DEFLECTION ON OD = 2.476045E-02 BASED ON TEMP. OF 573

ITERATION = 24157 STRESSES MOTIONS

EDGE	COL	SIGMA R	SIGMA Z	AXIAL DEF	RADIAL DEF	ROTATION
1	1	178.8	2824.	-1.03[illegible]	3.67[illegible]	-7.95[illegible]-05
3	1	207.64242	14577.24514	-1.08480E-03	3.77423E-03	-7.95332E-05
5	1	-1915.03717	24199.53704	-1.08460E-03	3.86108E-03	-7.95332E-05
3	2	27[illegible].1[illegible]	[illegible]7.17392	-1.05708E-03	6.02671E-03	1.16875E-04
3	3	35[illegible]	[illegible].39240	-9.51059E-04	8.40595E-03	2.16251E-04
3	4	[illegible]21.30060	2[illegible].09162	-7.80457E-04	1.08414E-02	2.61209E-04
3	5	[illegible]	2100.96594	-5.92621E-04	1.33479E-02	2.80066E-04
3	6	[illegible]	1577.[illegible]	-4.11195E-04	1.58977E-02	2.60359E-04
3	7	[illegible]	1220.57507	-2.52751E-04	1.84649E-02	1.93033E-04
3	8	[illegible]	1104.75570	-1.48572E-04	2.10418E-02	1.42011E-04
3	9	33[illegible].23437	1134.80070	-6.55700E-05	2.36194E-02	9.35333E-05
3	10	[illegible]	1052.07150	-1.[illegible]E-05	2.61971E-02	4.76086E-05
1	11	561.[illegible]	35.49090	7.21045E-16	2.87804E-02	1.26635E-16
3	11	2372.45242	9[illegible].25143	7.21045E-16	2.87804E-02	1.26635E-16
5	11	58[illegible]	2247.[illegible]	7.21045E-16	2.87804E-02	1.26635E-16

DEFLECTION ON OD = 2.900943E-02 BASED ON TEMP. OF 576

315

NAME [illegible] HEAT PIPE MODEL THERMAL [illegible] 0 0 0 6 1 9 0 3 6 3 ELEMENT 1

TEMPERATURE OF NODES PER EDGE FOR ITERATION 1424

COLUMNS

ROWS	1	2	3	4	5	6	7	8	9	10	11
5	463	465	500	519	550	561	566	571	572	575	578
4	463	507	520	535	553	562	568	571	572	574	576
3	499	520	539	549	559	565	569	571	573	575	577
2	[illegible]	551	550	561	566	569	571	573	573	574	575
1	565	570	571	572	574	573	574	575	575	575	575

[illegible] NOZZLE [illegible] PIPE MODEL THERMAL MOTIONS 0 0 0 6 1 9 [illegible] 0 3 6 4 ELEMENT 1

DEFLECTION ON OD = 2.90094 3E-02 BASED ON T[illegible] OF 576

ITERATION = [illegible] STRESSES MOTIONS

EDGE	COL	SIGMA R	SIGMA θ	AXIAL DEF	RADIAL DEF	ROTATION
1	1	-13.30036	4506.07455	-1.29571E-03	3.74939E-03	-6.67773E-05
3	1	-2937.21934	19526.73551	-1.29571E-03	3.62231E-03	-6.67773E-05
5	1	-3937.23969	26507.76917	-1.29571E-03	3.59523E-03	-6.67773E-05
3	2	[illegible]11.91311	7750.79755	-1.25237E-03	6.03788E-03	1.55590E-04
3	3	[illegible]	4720.79500	-1.12866E-03	8.41873E-03	2.64206E-04
3	4	[illegible].21327	3009.01754	-9.13389E-04	1.10694E-02	3.29179E-04
[illegible]	5	[illegible]11.13603	2010.41955	-6.99291E-04	1.34005E-02	3.25065E-04
3	6	[illegible].17370	1376.50955	-4.94287E-04	1.59806E-02	2.79588E-04
3	7	[illegible]	1262.73071	-3.10955E-04	1.85780E-02	2.25599E-04
3	8	[illegible]	1140.47561	-1.74095E-04	2.11868E-02	1.67687E-04
3	9	3571.[illegible]	1061.04634	-7.64956E-05	2.37947E-02	1.11508E-04
3	10	3223.[illegible]	916.48[illegible]	-1.95237E-05	2.63991E-02	5.71165E-05
1	11	[illegible].76776	542.99675	-8.00423E-16	2.90094E-02	3.26128E-16
3	11	2941.[illegible]	574.07190	-8.00423E-16	2.90094E-02	3.26128E-16
5	11	5193.37030	1245.13912	-8.00423E-16	2.90094E-02	3.26128E-16

DEFLECTION ON OD = 2.76974 1E-02 BASED ON TEMP. OF 556

TEMPERATURE OF NODES PER EDGE FOR ITERATI[illegible] 56659

COLUMNS

		1	2	3	4	5	6	7	8	9	10	11
	5	446	464	477	500	530	541	547	551	552	555	558
	4	457	482	497	517	534	543	547	551	552	554	556
E D	3	482	503	516	530	538	545	550	552	553	555	557
G E	2	536	531	535	542	546	549	551	553	554	555	556
S	1	545	551	551	553	553	555	554	554	554	554	553

...OZZLE ... MODEL ... MOTIONS 0006190365 ELEMENT: 1

DEFLECTION ON OD = 2.76976E-02 BASED ON TEMP. OF 556

ITERATION = 52659 STRESSES MOTIONS

EDGE	COL	SIGMA R	SIGMA H	AXIAL DEF	RADIAL DEF	ROTATION
1	1	231.[illegible]7327	4570.9[illegible]509	-1.31220E-03	3.57785E-03	-6.95026E-05
3	1	2152.9[illegible]413	14045.21250	-1.31298E-03	3.65375E-03	-6.95026E-05
5	1	-3205.61198	20156.50444	-1.31298E-03	3.72964E-03	-6.95026E-05
3	2	623[illegible].6[illegible]502	4759.04070	-1.26975E-03	5.75092E-03	1.61186E-04
3	3	4[illegible]2.[illegible]7594	5217.86607	-1.13084E-03	8.00655E-03	2.76439E-04
3	4	4632.30457	2453.10539	-9.11264E-04	1.03509E-02	3.36450E-04
3	5	52[illegible].[illegible]	2114.74909	-6.87493E-04	1.27741E-02	3.26667E-04
3	6	4707.10271	1375.72323	-4.75944E-04	1.52426E-02	2.78504E-04
3	7	41[illegible].[illegible]430	1003.49107	-3.04065E-04	1.77268E-02	2.23025E-04
3	8	3777.[illegible]60	884.97063	-1.70458E-04	2.02191E-02	1.64535E-04
3	9	35[illegible].[illegible]1063	1020.47497	-7.62334E-05	2.27108E-02	1.08699E-04
3	10	334[illegible].71755	1005.15346	-1.89035E-05	2.52017E-02	5.53594E-05
1	11	1564.47375	1112.94109	1.36778E-16	2.76976E-02	3.13985E-16
3	11	3172.[illegible]0904	886.29065	1.36778E-16	2.76976E-02	3.13985E-16
5	11	5441.60237	1317.74773	1.36778E-16	2.76976E-02	3.13985E-16

DEFLECTION ON OD = 2.70936E-02 BASED ON TEMP. OF 556

0008193 67 ELEMENT 1

TEMPERATURE OF NODES PER EDGE FOR ITERATI[illegible] 75168

OSC 1522

3-38

COLUMNS

	1	2	3	4	5	6	7	8	9	10	11
5	436	462	476	495	530	542	545	550	552	555	558
4	457	484	498	513	531	541	547	550	552	554	557
3	471	505	518	527	538	544	549	552	553	555	557
2	534	529	535	540	545	549	552	553	553	554	555
1	543	551	552	552	553	554	554	555	555	555	555

ZERO LINE

0 0 0 0 6 1 9 3 6 8

[illegible] PIPE [illegible] THERMAL MOTIONS [illegible] ELEMENT 1

DEFLECTION ON OD = 2.770916E-02 BASED ON TEMP. OF 556

ITERATION = 75150 STRESSES MOTIONS

EDGE	COL	SIGMA R	SIGMA θ	AXIAL DEF	RADIAL DEF	ROTATION
1	1	390.67093	5227.93003	-1.36457E-03	3.59006E-03	-7.01372E-05
3	1	2383.10[illegible]	21596.14253	-1.36457E-03	3.66665E-03	-7.01372E-05
5	1	-4370.54[illegible]	24112.44315	-1.36457E-03	3.74324E-03	-7.01372E-05
3	2	3435.57[illegible]	4531.32[illegible]	-1.32018E-03	5.75280E-03	1.63556E-04
3	3	[illegible]	5100.41102	-1.19703E-03	8.01603E-03	2.77116E-04
3	4	4703.9[illegible]	3372.76425	-9.64937E-04	1.03499E-02	3.47289E-04
3	5	5152.[illegible]	2120.[illegible]	-7.33309E-04	1.27053E-02	3.42205E-04
3	6	4975.70[illegible]	1359.57[illegible]	-5.13816E-04	1.52332E-02	2.91816E-04
3	7	[illegible]	1260.37120	-3.32612E-04	1.77201E-02	2.36057E-04
3	8	4121.97117	1003.20673	-1.65702E-04	2.02171E-02	1.76618E-04
3	9	3754.[illegible]	1132.67750	-8.55550E-05	2.27134E-02	1.20766E-04
3	10	[illegible]	1026.60132	-2.13583E-05	2.52005E-02	6.24511E-05
1	11	[illegible]	547.71[illegible]	4.44089E-16	2.77094E-02	2.23779E-16
3	11	[illegible]	827.[illegible]	4.44089E-16	2.77094E-02	2.23779E-16
5	11	[illegible]	1310.10[illegible]	4.44089E-16	2.77094E-02	2.23779E-16

DEFLECTION ON OD = 2.[illegible]E-02 BASED ON TEMP. OF 591

OSC 15[illegible]

MAKE [illegible] ZZLE MOD. PIPE MODEL INTERNAL [illegible] 0 0106 1 9 [illegible] 0 3 6 9 ELEMENT 1

TEMPERATURE OF NODES PER FOSR FOR ITERAT[illegible] 86960

3140

COLUMNS

	1	2	3	4	5	6	7	8	9	10	11
5	483	501	513	531	564	576	581	585	587	590	593
4	508	525	536	550	567	577	581	585	587	589	592
3	530	540	554	563	573	579	584	586	587	589	590
2	572	567	571	576	580	584	587	588	588	589	590
1	581	586	580	587	584	589	584	589	589	589	590

.....ZERO LI..............

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PIPE MODEL INTERNAL MOTIONS 0 0 0 6 1 9 0 3 7 0 ELEMENT 1

DEFLECTION ON OD = 2.99871YE-02 BASED ON . OF 591

ITERATION = [illegible] STRESSES MOTIONS

EDGE	COL	SIGMA R	SIGMA θ	AXIAL DEF	RADIAL DEF	ROTATION
1	1	135.16996	4154.29707	-1.26872E-03	3.86929E-03	-6.86047E-05
3	1	[illegible]	15904.44315	-1.26872E-03	3.94420E-03	-6.86047E-05
5	1	-1592.[illegible]	26157.05071	-1.26872E-03	4.01912E-03	-6.86047E-05
3	2	[illegible]	7331.16275	-1.22665E-03	6.26705E-03	1.43232E-04
3	3	[illegible]	4966.55241	-1.10917E-03	8.73221E-03	2.52190E-04
3	4	[illegible]	3350.07600	-9.02900E-04	1.12520E-02	3.20501E-04
3	5	2017.74452	2261.46220	-6.57233E-04	1.35730E-02	3.19136E-04
3	6	[illegible]	1565.55615	-4.82319E-04	1.65349E-02	2.72896E-04
3	7	[illegible]	1164.74516	-3.12743E-04	1.92161E-02	2.20986E-04
3	8	[illegible]	1097.66352	-1.77093E-04	2.19080E-02	1.67736E-04
3	9	[illegible]	1257.91660	-8.97163E-05	2.45597E-02	1.13739E-04
3	10	[illegible]	1260.42032	-2.01563E-05	2.72906E-02	5.89579E-05
1	11	[illegible]	577.22005	2.08167E-16	2.99872E-02	3.19189E-16
3	11	[illegible]	1150.36727	2.08167E-16	2.99872E-02	3.19189E-16
5	11	[illegible]	1600.67010	2.08167E-16	2.99872E-02	3.19189E-16

DEFLECTION ON OD = 1.10994 3E-02 BASED ON TEMP. OF 283

3-42

TEMPERATURE OF NODES PER EDGE FOR ITERA[illegible] 103154

COLUMNS

ROW	1	2	3	4	5	6	7	8	9	10	11
5	247	251	254	259	270	274	277	279	280	281	283
4	253	257	260	265	271	275	277	278	280	281	283
3	259	262	265	268	272	275	277	278	280	281	283
2	266	266	268	271	273	276	276	279	280	281	282
1	269	269	270	271	275	276	277	276	280	281	282

......ZERO LEF..............

NAME [illegible] NOZZLE AND PIPE MODEL THERMAL MOTIONS RF [illegible] ELEMENT 1

0 0 0 6 1 9 [illegible] 0 3 7 2

DEFLECTION ON OD = 1.10990E-02 BASED O[illegible]P. OF 283

ITERATION = 10315 STRESSES MOTIONS

EDGE	COL	SIGMA R	SIGMA θ	AXIAL DEF	RADIAL DEF	ROTATION
1	1	498.96572	4645.23582	-2.64524E-04	1.46801E-03	-1.22271E-05
3	1	-94.05759	6700.70621	-2.64524E-04	1.48136E-03	-1.22271E-05
5	1	-341.16905	[illegible]	-2.64524E-04	1.49471E-03	-1.22271E-05
3	2	1000.16900	3611.12947	-2.55027E-04	2.33803E-03	3.01739E-05
3	3	2047.10419	2716.47704	-2.22904E-04	3.24502E-03	5.20101E-05
3	4	2365.80990	2221.00420	-1.65270E-04	4.17592E-03	6.26734E-05
3	5	2424.70301	1612.95170	-1.39924E-04	5.13403E-03	6.06275E-05
3	6	2474.40290	1350.05823	-9.64913E-05	6.11168E-03	5.64332E-05
3	7	2240.96272	1110.69545	-6.10011E-05	7.09942E-03	4.49430E-05
3	8	2137.50930	934.77930	-3.45035E-05	8.09353E-03	3.32368E-05
3	9	1900.64932	615.67003	-1.54547E-05	9.09161E-03	2.20189E-05
3	10	1940.90909	657.61311	-3.64117E-06	1.00930E-02	1.12263E-05
1	11	1257.43521	436.92209	2.42861E-17	1.10990E-02	3.29597E-17
3	11	1725.97909	475.94519	2.42861E-17	1.10990E-02	3.29597E-17
5	11	2271.90343	625.47590	2.42861E-17	1.10990E-02	3.29597E-17

DEFLECTION ON OD = 2.729203E-02 BASED ON TEMP. OF 550

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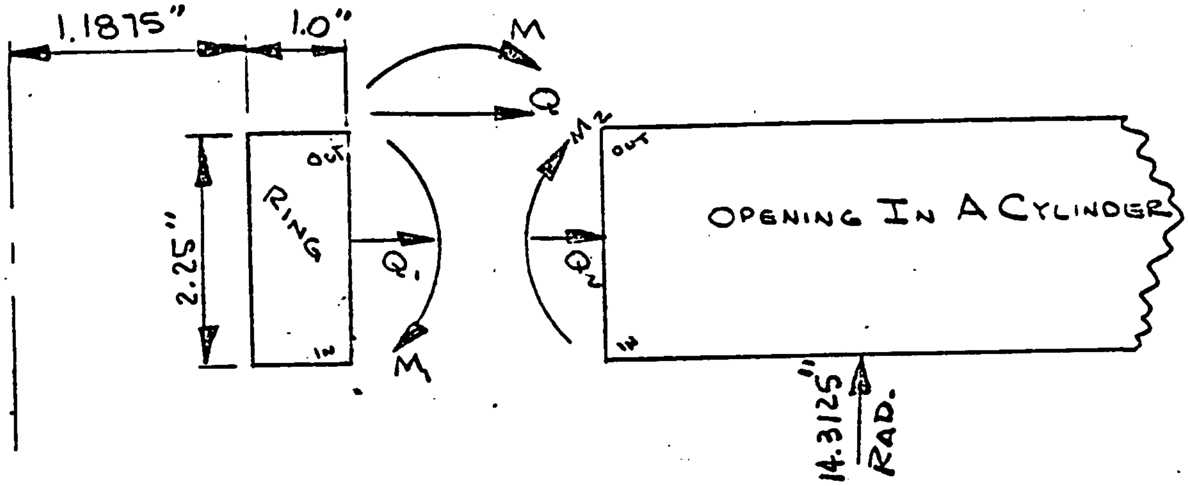
OSC 1522

E @ 550°

OSC 1522



INFLUENCE COEFFICIENTS

*** RING**

$$\theta/M_1 = \frac{12}{t^3 E \ln \frac{R_o}{R_i}} = .065 \times 10^{-6}$$

$$\delta/Q_1 = \frac{R_m}{Et(R_o - R_i)} = .02827 \times 10^{-6}$$

$$\theta/Q_1 = \delta/M_1 = 0.0$$

*** OPENING IN A CYLINDER**

$$\theta/M_2 = \frac{15.6}{Et^3} = .0516 \times 10^{-6}$$

$$\delta/Q_2 = \frac{1.3}{Et^2} = .00968 \times 10^{-6}$$

$$\theta/Q_2 = \delta/M_2 = 0.0$$

* THESE VALUES BASED ON E @ 550°F

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SHEET 3-44

$\theta_{RING} = \theta_{CYL}$

$$M_1\left(\frac{\theta}{M_1}\right)_1 = M_2\left(\frac{\theta}{M_2}\right)$$

$$M_1 = \frac{M_2\left(\frac{\theta}{M_2}\right)}{\frac{\theta}{M_1}}$$

$$\text{say: } \frac{\theta/M_2}{\theta/M_1} = K$$

$$M_1 = M_2 K$$

$$M = M_1 + M_2$$

$$M_2 = M - M_1$$

$$M_1 = (M - M_1)K$$

$$M_1 = \frac{MK}{1+K}$$

$$\theta = M_1\left(\frac{\theta}{M_1}\right) = \frac{MK}{1+K}\left(\frac{\theta}{M_1}\right) \sim \frac{\theta}{M} = \frac{K}{1+K}\left(\frac{\theta}{M_1}\right)$$

WHERE: $E = E$ FOR CARBON STEEL @ 550° = 26.53×10^6

$t = 2.25''$

$R_o = 2.1875''$

$R_1 = 1.1875''$

$\therefore \theta/M = .0288 \times 10^{-6}$

$$\delta_{RING} = \delta_{CYL}$$

$$Q_1\left(\frac{\delta}{Q_1}\right) = Q_2'\left(\delta/Q_2\right)$$

$$Q_1 = (Q_2)\left(\frac{\delta/Q_2}{\delta/Q_1}\right) \qquad \text{SAY } \frac{\delta/Q_2}{\delta/Q_1} = N.$$

$$Q_1 = Q_2(N)$$

$$Q = Q_1 + Q_2$$

$$Q_2 = Q - Q_1$$

$$Q_1 = (Q - Q_1)N.$$

$$Q_1 = \frac{QN}{1+N}$$

$$\delta_{\gamma} = Q_1\left(\frac{\delta}{Q_1}\right) = \frac{QN}{1+N}\left(\delta/Q_1\right)$$

$$\delta/Q = \frac{N}{1+N}\left(\delta/Q_1\right)$$

WHERE: $R_M = 1.6875''$
$R_o = 2.1875$
$t = 2.25''$
$E = 26.53 \times 10^{-6}$ psi

$$\therefore \delta^s/Q = .0072 \times 10^{-6}$$

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OSC 1522

$\delta = r\theta \qquad t/2 = r$

$\frac{\delta}{M} = \left(\frac{t}{2}\right)\left(\frac{\theta}{M}\right)$

$\frac{\delta_s}{M} = \left(\frac{2.25}{2}\right)(.0288 \times 10^{-6}) = .0324 \times 10^{-6}$

$\frac{\theta_s}{Q} = \left(\frac{\theta}{m}\right)\frac{t}{2} = .0324 \times 10^{-6}$

ADDITIONAL $\frac{\delta}{Q} = \left(\frac{\theta}{Q}\right)(t/2) = .03645 \times 10^{-6}$

TOTAL $\delta_s/Q = .0072 \times 10^{-6} + .03645 \times 10^{-6} = .04365 \times 10^{-6}$

0006193375

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Influence Coefficients For Nozzle (91206)

$\theta_N/M = +4.137258 \times 10^{-8}$

$\theta_N/Q = -2.47688 \times 10^{-8}$

$\delta_N/M = +2.47688 \times 10^{-8}$

$\delta_N/Q = -5.410859 \times 10^{-8}$

Influence Coefficients For Shell

$\theta_s/M = -2.88 \times 10^{-8}$

$\theta_s/Q = -3.24 \times 10^{-8}$

$\delta_s/M = +3.24 \times 10^{-8}$

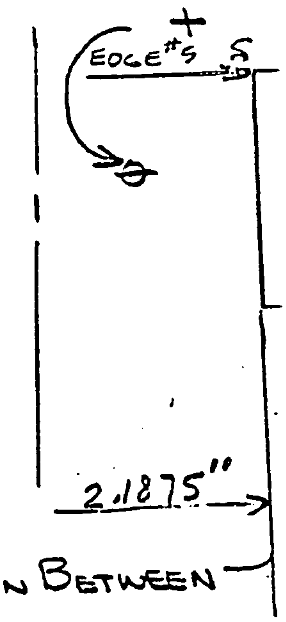
$\delta_s/Q = +4.365 \times 10^{-8}$

0006103771

Motions @ Nozzle To Shell Juncture At The Shell (Secondary)

+Radial δ	+ Rotation	Iteration
7.5128×10^{-3}	1.8779×10^{-4}	28169
7.4745×10^{-3}	2.3309×10^{-4}	41428
7.0866×10^{-3}	2.4343×10^{-4}	52659
7.0926×10^{-3}	2.4459×10^{-4}	75168
7.7775×10^{-3}	2.2098×10^{-4}	86960
2.9333×10^{-3}	4.6183×10^{-5}	103154

Sign Convention



Motion Ratio Procedure (Program 91032)

$$\text{Motion @ Juncture} = \left(\frac{2.1875-1.693}{2.386-1.693}\right) \times \left(\text{Motions @ } 2.386 - \text{Motions @ } 1.693"\right) + \text{Motions @ } 1.69$$

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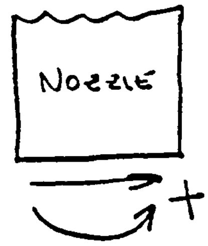
DATE ________

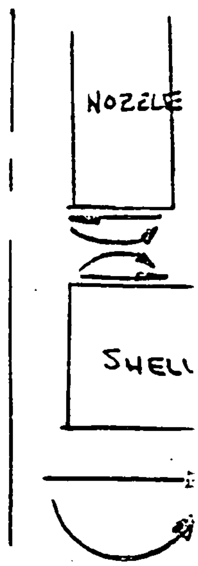
JOB NO. ________

SHEET 3-49

MOTIONS @ NOZZLE TO SHELL JUNCTURE
AT THE NOZZLE (SECONDARY)

ITERATION	+ RADIAL δ	+ ROTATION
28169	6.3834×10^{-3}	2.6999×10^{-4}
41428	6.4164×10^{-3}	3.9259×10^{-4}
52659	6.1266×10^{-3}	3.4069×10^{-4}
75168	5.8242×10^{-3}	3.1041×10^{-4}
86960	6.3896×10^{-3}	2.8523×10^{-4}
103154	2.5848×10^{-3}	1.5159×10^{-4}





COMPATIBILITY EQUATIONS

$$\theta^{S}_{TOT} = -2.88\times10^{-8}M - 3.24\times10^{-8}Q + \theta^{S}_{T}$$

$$\theta^{N}_{TOT} = 4.137258\times10^{-8}M - 2.47688\times10^{-8}Q + \theta^{N}_{T}$$

$$\theta^{S}_{TOT} = \theta^{N}_{TOT}$$

$$(-2.88 - 4.137258)(10^{-8})(M) + (-3.24 + 2.47688)(10^{-8})(Q) = \theta^{N}_{T} - \ldots$$

$$1)\quad -(7.017)(M) - .763Q = (\theta^{N}_{T} - \theta^{S}_{T})(10^{8})$$

$$\delta^{S}_{TOT} = 3.24\times10^{-8}M + 4.365\times10^{-8}Q + \delta^{S}_{T}$$

$$\delta^{N}_{TOT} = 2.47688\times10^{-8}M - 5.410859\times10^{-8}Q + \delta^{N}_{T}$$

$$\delta^{S}_{TOT} = \delta^{N}_{TOT}$$

$$(3.24 - 2.47688)(10^{-8})(M) + (4.365 + 5.410859)(10^{-8})(Q) = \delta^{N}_{T} - \delta^{S}_{T}$$

$$2)\quad (.763)(M) + (9.776)(Q) = (\delta^{N}_{T} - \delta^{S}_{T})(10^{8})$$

SOLVING SIMO

$$1)\quad -7.017M - .763Q = (\theta_T^N - \theta_T^S)(10^8)$$
$$2)\quad .763M + 9.776Q = (\delta_T^N - \delta_T^S)(10^8)$$

$$1)\quad -7.017M - .763Q = (\theta_T^N - \theta_T^S)(10^8)$$
$$2 \times 9.1966)\quad 7.017M + 89.906Q = 9.1966(10^8)(\delta_T^N - \delta_T^S)$$
$$-90.669Q = (\theta_T^N - \theta_T^S)(10^8) - (9.1966)(10^8)(\delta_T^N - \delta_T^S$$

ITERATION 28169

$$-90.669Q = (2.6999 - 1.8774)(10^{+4}) - (9.1966)(-6.3834 - 7.51$$
$$-90.669Q = 1046613$$
$$Q = -11534 \ \#/RAD$$

$$1)\quad M = \frac{(2.6999 - 1.8774)10^4 + .763(-11534)}{-7.017} = +82 \frac{IN-L}{RA}$$

ITERATION 41428

$$-90.669Q = (3.9259 - 2.3309)(10^4) - 9.1966(6.4164 - 7.4745)$$
$$= 939042$$
$$Q = -10908 \ \#/RAD$$

$$1)\quad M = \frac{(3.9259 - 2.3309)(10^4) + .763(-10908)}{-7.017}$$

$$M = -1087 \ \frac{IN-LBS.}{RAD}$$

OSC 1522

ITERATION 52659

$-90.669 Q = (3.4069-2.4343)(10^4)-(9.1966)(6.1266-7.08$

$= 892599.6$

$Q = -9845$ #/RAD.

1) $M = \frac{(3.4069-2.4343)(10^4) + .763(-9845)}{-7.017}$

$M = -316 \frac{\text{IN-LBS}}{\text{RAD.}}$

ITERATION 75168

$-90.669 Q = (3.1041-2.4459)(10^4)-(9.1966)(5.8242-7.092$

$= 1173078$

$Q = -12,938$ #/RAD

1) $M = \frac{(3.1041-2.4459)(10^4) + (.763)(-12938)}{-7.017}$

$M = +469 \frac{\text{IN.LBS.}}{\text{RAD}}$

ITERATION 86960

$-90.669 Q = (2.8523-2.2098)(10^4)-9.1966(6.3896-7.7775)($

$= 1282821$

$Q = -14148$ #/RAD

1) $M = \frac{(2.8523-2.2098)(10^4) + (.763)(-14148)}{-7.017}$

$M = 622 \frac{\text{IN-LBS}}{\text{RAD}}$

ITERATION 10315 4

$$-90.669Q = (1.5159 - .46183)(10^4) - (9.1966)(2.5848 - 2.933)$$

10 540

$$= 331042$$

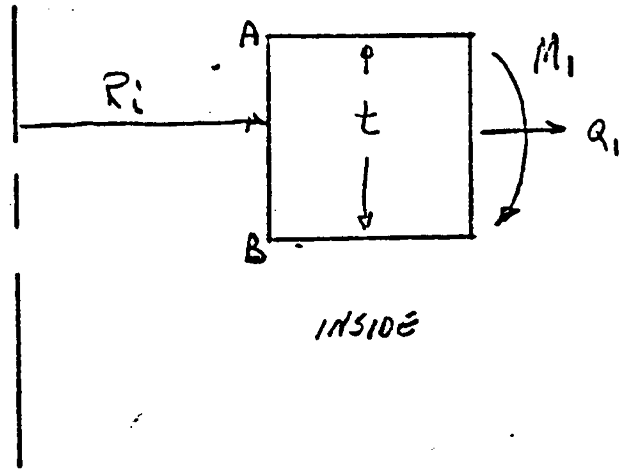
$$Q = -3651 \text{ \#/RAD}$$

1) $$M = \frac{(1.5159 - .46183)(10^4) + (.763)(-3651)}{-7.017}$$

$$M = -1105 \frac{\text{IN. LBS.}}{\text{RAD}}$$

0 0 0 6 1 9 3 8 3

CALCULATE DISCONTINUITY HOOP STRESS IN RING



$M_1 = .49265 \left[M + \frac{Qt}{2} \right.$

$Q_1 = .25506\ Q$

$S_A = Q_1 \left[S/Q_1 \right] + M_1 \left[S/M_1 \right]$ WHERE: $S/Q_1 = .02827 \times 10^{-6}$

$S_B = Q_1 \left[S/Q_1 \right] - M_1 \left[S/M_1 \right]$ $S/M_1 = \left(\frac{9}{M_1}\right) t/12$

$= .065 \times 10^{-6} [1.125]$

$= .07313 \times 10^{-6}$ "/IN.

$\sigma_H^A = \frac{E S_A}{R_i}$ $\sigma_H^B = \frac{E S_B}{R_i}$ $R_i = 1.1875''$

ITER	Q_1	M_1	S_A x10⁻⁶	S_B x10⁻⁶	E x10⁶	σ_H^A (PSI)	σ_H^B (
28169	-2942	-5707	-500.5	+334.2	27.	-11380	759[illegible]
41428	-1272	-5913	-468.4	396.5	27.	-10649	901[illegible]
52659	-1148	-5043	-401.2	336.3	27.	-9122	764[illegible]
75168	-1509	-6235	-498.6	413.3	27.2	-11421	946[illegible]
86960	-1650	-6770	-591.7	448.4	26.7	-12180	1008[illegible]
103154	-426	-2307	-180.8	156.7	28.7	-4370	379[illegible]

TABULATION OF THERMAL STRESSES FROM PROGRAM 91032.

OSC 1522

PSI

ITER	σ_H IN	σ_H OUT	σ_R IN	σ_R OUT
28169	2830	24200	180	-1905
41428	4566	26508	-13	-3887
52659	4576	26167	231	-3267
75168	5222	28113	369	-4371
86960	4184	26137	135	-1698
103154	4695	9236	499	-341

TOTAL THERMAL STRESS INTENSITY

COMBINING FREE THERMAL STRESSES WITH DISCONTINUITY STRESS

STRESS INTENSITY IN KSI

ITER	IN $S_1 = \sigma_H - \sigma_R$	IN $S_2 = \sigma_H$	OUT $S_1 = \sigma_H - \sigma_R$	$S_2 = \sigma_H$
28169	10.2	10.4	14.7	12.8
41428	13.6	13.6	19.7	15.9
52659	12.0	12.2	20.3	19.1
75168	14.4	14.7	21.1	16.7
86960	14.2	14.3	15.9	14.0
103154	7.9	8.4	5.2	4.9

$S_{max} = 21.1$ KSI $< 1.5\, S_m = 1.5(17.8) = 26.7$ KSI

NOTE: THE FREE BODY THERMAL STRESSES CALCULATED BY PROGRAM 9103 ARE THE RESULT OF NON-LINEAR THERMAL RADIAL GRADIENTS. THE B31.7 PIPING CODE REQUIRES THAT THE PRIMARY + SECONDARY STRESS VALUE BE DETERMINED USING THE LINEAR PORT OF THE THERMAL RADIAL GRADIENT. THE NON-LINEAR GRADIENT WAS USED IN THIS ANALYSIS, AND SINCE IT IS LARGER MAGNITUDE THAN THE LINEAR PORTION, THE RESULTS ARE CONSERVATIVE.

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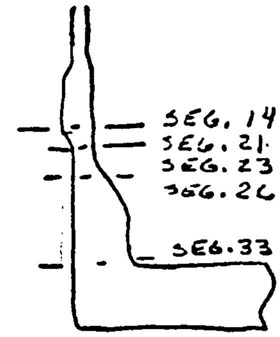
	JOB NO.
	SHEET 3-56

0005190385

THERMAL SECONDARY STRESS SUMMARY OF CRITICAL JUNCTURES

$S_1 = \sigma_L - \sigma_H$ $S_2 = \sigma_H - \sigma_R$ $S_3 = \sigma_R - \sigma_L$

INTENSITIES IN KSI



SEGMENT 14 (STAINLESS)

ITER	time	INSIDE S_1	INSIDE S_2	INSIDE S_3	OUTSIDE S_1	OUTSIDE S_2	OUTSIDE S_3
28169	4.95	-3.6	8.7	-5.1	-4.1	0	4.1
41428	7.50	-3.2	8.9	-5.8	-2.8	-1.1	3.9
52659	9.66	-3.3	8.9	-5.6	-2.7	-1.0	3.7
75168	13.90	-2.4	7.7	-5.3	-2.9	-.9	3.8
86960	16.099	-2.3	7.2	-4.9	-2.7	-.8	3.5
103154	17.2	-.8	2.0	-1.2	-.4	.4	.9

SEGMENT 21 (STAINLESS)

ITER	S_1	S_2	S_3	S_1	S_2	S_3
28169	5.4	-6.5	1.2	5.4	-4.7	-.8
41428	3.5	-4.5	1.0	5.0	-5.0	0
52659	4.3	-5.2	.9	4.6	-4.2	-.4
75168	3.4	-4.4	1.0	4.9	-4.9	0
86960	3.7	-4.3	.5	4.9	-4.8	0
103154	3.9	-5.1	1.2	3.0	-2.1	-.9

SEGMENT 23 (CARBON)

ITER	S_1	S_2	S_3	S_1	S_2	S_3
28169	-7.7	5.9	1.7	-2.8	4.4	-1.6
41428	-7.7	6.4	1.4	-2.4	2.5	0
52659	-8.1	6.7	1.4	-2.0	3.2	-1.1
75168 13.70	-5.6	3.7	1.9	-1.0	1.4	-.4
86960	-9.4	8.6	.7	-2.8	3.3	-.5
103154	-4.8	2.8	2.0	-.8	2.6	-1.7

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DEPARTMENT ______ BY ______ DATE ______
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SHEET 3-57 OF

STRESS SUMMARY (CONTINUED)

OSC 1522

SEGMENT 26 (CARBON)

ITER	INSIDE S_1	INSIDE S_2	INSIDE S_3	OUTSIDE S_1	OUTSIDE S_2	OUTSIDE S_3
28169	2.4	1.8	-4.2	-1.6	-1.9	3.5
41428	3.1	-.1	-2.9	-.8	-1.9	2.7
52659	2.3	1.3	-3.6	-1.6	-1.5	3.1
75168	4.7	-1.7	-3.0	.1	-2.9	2.8
86960	3.5	-.3	-3.2	-.7	-2.1	2.8
103154	1.1	.2	-.9	-.2	-.5	+.8

SEGMENT 33 (CARBON)

	S_1	S_2	S_3	S_1	S_2	S_3
28169	-14.3	14.0	.3	-1.0	.6	.4
41428	-12.2	11.7	.5	1.4	-.6	-.8
52659	-12.6	12.8	-.2	.8	-.5	-.4
75168	-11.8	12.7	-.8	1.6	-1.8	.2
86960	-15.5	16.1	-.6	.2	0	-.1
103159	-3.8	2.9	1.0	.6	0	-.6

MAX. THERMAL STRESS RANGE FOR STAINLESS OCCURS AT JUNCTURE 14 ON INSIDE

$$S_{MAX.} = 8.9 \text{ KSI} < 1.5 S_m = 1.5(17.1) = 25.7$$

MAX. THERMAL STRESS RANGE FOR CARBON IN THE NOZZLE OCCURS AT JUNCTURE 33

$$S_{MAX} = 15.5 \text{ KSI} < 1.5 S_m = 26.7 \text{ KSI}$$

000619 387

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DEPARTMENT ____ BY ____

DATE ____

JOB NO. ____

SHEET 3-58 OF ____

PEAK PRINCIPAL STRESSES

SEG. NO.	OUTSIDE LONG	OUTSIDE HOOP	OUTSIDE RAD.	MIDPLANE LONG	MIDPLANE HOOP	MIDPLANE RAD.	INSIDE LONG	INSIDE HOOP	INSIDE RAD.
1	.0	-.0	-.0	-.0	-.0	-.0	-.1	-.1	-.0
2	-.6	-.2	.0	.0	-.0	.0	.7	.2	.0
3	1.1	2.1	.0	-.1	2.2	.1	-1.3	2.2	.0
4	24.3	-4.9	-.1	-1.4	-14.5	-.6	-27.5	-26.2	-.1
5	-227.9	-91.4	.3	13.7	-17.6	1.6	258.7	59.8	.3
6	-329.8	-65.9	2.0	21.6	38.9	13.7	371.9	163.4	2.0
7	-459.7	-190.1	2.9	31.6	-65.9	19.4	517.6	73.8	2.9
8	-563.4	-322.3	3.1	38.2	-192.0	20.1	633.3	-49.2	3.1
9	-524.8	-396.3	5.4	54.8	-161.1	54.0	634.4	161.2	5.4
10	-584.2	-314.7	15.4	108.8	109.7	170.4	796.8	813.9	15.4
11	-778.2	-373.2	23.2	174.0	102.6	252.6	1045.6	768.8	23.2
12	-1710.9	-1173.6	33.4	225.7	-252.6	294.4	2107.4	1007.2	33.4
13	-3572.5	-1546.8	72.0	404.1	393.2	505.3	4386.7	3239.9	72.0
14	-4101.3	34.2	157.8	500.5	3499.2	1059.5	5080.2	8694.2	157.8
15	-2333.0	491.7	199.5	477.0	3460.4	1350.9	2884.3	7479.4	199.5
17	-3067.4	646.7	117.5	299.3	3246.9	686.5	3164.0	6153.4	117.5
18	-301.2	-4758.3	53.3	547.4	-4209.4	373.3	291.3	-5019.2	53.3
19	2910.8	-2290.7	-16.1	-168.9	-2520.2	-9.5	-3702.1	-3405.9	-16.1
20	2403.8	-2420.7	-21.8	-393.9	-2817.1	-134.6	-3220.4	-3534.9	-21.8
21	646.7	-4727.2	-38.1	-266.3	-5364.4	-318.6	-1164.4	-6511.7	-38.1
23	1560.9	-4402.2	25.2	-59.8	5052.0	208.9	-1743.5	5925.7	25.2
24	-3083.3	604.1	43.2	272.0	2630.1	308.6	3318.6	4781.2	43.2
25	-2921.4	-1498.2	41.5	247.0	-328.2	261.2	3590.6	1230.5	41.5
26	-3544.9	-1928.0	40.5	48.7	-505.2	255.4	4149.0	1769.7	40.5
27	-1995.5	-2019.2	85.7	9.4	16.5	558.6	2441.2	3478.6	85.7
28	-1544.6	-2014.9	130.1	113.9	264.5	819.3	2099.8	4383.4	130.1
29	-1154.8	-2391.5	166.3	183.1	-49.7	1001.0	1711.9	4191.7	166.3
30	-1184.6	-3013.4	172.5	190.7	-1051.5	964.9	1632.9	2718.0	172.5
31	-2812.8	-1604.8	98.3	541.9	886.6	569.3	3358.7	4845.7	98.3
32	-4031.8	-1557.7	268.7	1239.4	3437.5	1693.6	4832.6	9919.6	268.7
33	-405.8	550.2	441.0	1213.0	6896.0	2875.0	-306.1	13998.7	441.0

(LONGITUDINAL DIRECTION IS ALONG SHELL MIDSURFACE. RADIAL DIRECTION IS NORMAL TO SHELL MIDSURFACE.)

PEAK PRINCIPAL STRESSES

SEG. NO.	OUTSIDE LONG	OUTSIDE HOOP	OUTSIDE RAD.	MIDPLANE LONG	MIDPLANE HOOP	MIDPLANE RAD.	INSIDE LONG	INSIDE HOOP	INSIDE RAD.
1	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
2	-.1	-.0	.0	.0	.0	.0	.1	.0	.0
3	.3	.3	.0	-.0	.3	.0	-.4	.2	.0
4	2.9	-1.4	-.0	-.2	-2.7	-.1	-3.3	-4.3	-.0
5	-39.9	-9.3	.1	2.3	2.5	.4	44.1	16.9	.1
6	-47.6	-2.0	.4	3.2	15.0	2.4	53.8	35.3	.4
7	-67.1	-89.7	.2	4.7	-86.2	1.1	74.9	-86.2	.2
8	-107.2	-198.2	-.2	6.1	-194.6	-2.5	118.9	-207.4	-.2
9	-325.7	-218.0	.2	23.9	-166.6	-.9	378.4	-101.0	.2
10	-554.5	-146.1	4.4	59.5	27.6	26.4	692.2	308.0	4.4
	-740.4	-234.6	8.9	99.8	-26.9	56.4	933.0	252.3	8.9
.2	-1565.3	-1140.4	30.7	192.3	-205.4	208.5	2228.7	1455.0	30.7
13	-3244.8	-1792.4	90.8	462.4	403.6	629.7	4655.3	4171.1	90.8
14	-3847.9	-1059.6	184.6	665.5	2648.2	1295.2	5782.9	8921.4	184.6
15	-2739.4	-1464.4	219.1	726.0	1751.7	1554.1	4368.6	6618.7	219.1
17	-4576.2	-1744.8	91.3	398.5	466.3	474.2	4915.5	2759.6	91.3
18	-2626.0	-1632.0	73.1	229.3	-561.6	435.1	3285.1	1060.6	73.1
19	111.7	-2473.2	38.4	187.4	-1535.8	285.8	-645.3	-1449.2	38.4
20	1014.2	-4369.6	10.0	299.7	-3271.6	90.7	-2361.6	-4292.3	10.0
21	-129.1	-5011.0	-2.2	359.8	-3762.0	-5.3	-992.3	-4444.7	-2.2
23	26.5	2669.4	57.1	732.3	5546.0	443.9	-1336.0	6339.2	57.1
24	-2165.7	144.2	49.9	254.2	1508.8	370.7	2524.0	3011.4	49.9
25	-1562.8	-997.4	24.0	140.0	-465.2	174.8	1975.6	378.2	24.0
26	-2739.6	-1899.4	18.1	228.8	-941.2	138.9	2895.0	-120.4	18.1
27	-2755.6	-2562.9	60.9	145.1	-630.1	428.2	3114.0	2264.4	60.9
28	-3021.9	-2772.8	125.0	290.2	-126.2	846.1	3993.0	4595.8	125.0
29	-2845.3	-2798.8	209.2	463.3	341.2	1367.5	4447.9	6780.2	209.2
30	-2351.2	-2828.0	297.4	616.2	605.4	1880.8	4513.3	8408.7	297.4
31	-3642.6	-2052.4	225.9	853.7	1231.1	1471.9	5889.2	7537.6	225.9
32	-3457.2	-1958.4	340.6	969.6	2597.1	2147.7	5508.3	10498.3	340.6
33	815.9	-565.0	440.3	469.3	4257.4	2769.5	-494.8	11679.9	440.3

(LONGITUDINAL DIRECTION IS ALONG SHELL MIDSURFACE. RADIAL DIRECTION IS NORMAL TO SHELL MIDSURFACE.)

PEAK PRINCIPAL STRESSES

SEG. NO.	OUTSIDE LONG	OUTSIDE HOOP	OUTSIDE RAD.	MIDPLANE LONG	MIDPLANE HOOP	MIDPLANE RAD.	INSIDE LONG	INSIDE HOOP	INSIDE RAD.
1	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
2	-.1	-.0	.0	.0	.0	.0	.1	.0	.0
3	.3	.3	.0	-.0	.3	.0	-.4	.2	.0
4	2.9	-1.3	-.0	-.2	-2.6	-.1	-3.3	-4.2	-.0
5	-39.4	-9.4	.1	2.3	2.2	.4	43.6	16.4	.1
6	-47.4	-2.3	.3	3.2	14.5	2.4	53.5	34.6	.3
7	-67.3	-90.5	.2	4.7	-87.1	1.1	75.1	-87.2	.2
8	-107.9	-189.3	-.2	6.2	-195.7	-2.6	119.7	-208.5	-.2
9	-328.3	-219.7	.2	24.1	-167.9	-.9	381.4	-101.6	.2
10	-558.8	-147.4	4.4	59.9	27.6	26.6	697.6	310.0	4.4
[illegible]	-746.2	-275.6	9.0	100.6	-25.9	56.9	940.3	256.2	9.0
[illegible]	-1571.5	-1135.3	30.9	193.2	-195.1	210.1	2236.9	1473.9	30.9
13	-3215.7	-1767.2	91.2	459.5	428.8	632.5	4617.0	4196.1	91.2
14	-3660.9	-1019.9	183.9	647.0	2652.9	1291.6	5572.4	8853.4	183.9
15	-2513.6	-1402.1	216.3	696.0	1746.9	1536.4	4104.9	6520.5	216.3
17	-4271.5	-1660.9	87.4	362.8	459.4	448.5	4545.9	2638.4	87.4
18	-2260.1	-1565.1	68.3	187.4	-619.6	403.3	2840.3	.840.2	68.3
19	703.4	-1963.8	26.3	-128.4	-1897.6	186.5	-961.6	-1935.9	26.3
20	1689.8	-3458.8	-15.0	-303.7	-3958.8	-131.2	-2383.9	-4980.2	-15.0
21	433.5	-4177.0	-32.8	-258.7	-4530.7	-283.4	-886.1	-5169.7	-32.8
23	1104.4	3174.5	52.7	-88.7	4762.3	391.9	-1378.4	6706.4	52.7
24	-1997.1	236.0	49.1	213.4	1546.9	343.2	2562.0	3286.3	49.1
25	-2227.0	-1231.4	31.9	179.5	-279.4	193.2	2795.9	1073.0	31.9
26	-3122.4	-1533.0	32.5	136.5	-366.8	214.9	3629.1	1319.1	32.5
27	-2006.7	-1847.9	67.8	65.4	-182.3	469.0	2428.6	2630.0	67.8
28	-1811.3	-1864.0	106.7	137.6	49.8	702.4	2437.7	3697.4	106.7
29	-1565.7	-1491.5	148.5	202.7	29.6	930.1	2358.6	4265.0	148.5
30	-1436.5	-2298.7	178.0	233.1	-372.6	1051.9	2330.1	4087.8	178.0
31	-2686.4	-1593.3	107.3	362.7	758.7	657.0	3914.4	5372.9	107.3
32	-3172.7	-1605.8	277.0	718.8	2550.8	1709.2	4797.0	9982.8	277.0
33	359.5	-470.2	434.2	475.7	4591.8	2718.4	152.0	12755.9	434.2

(LONGITUDINAL DIRECTION IS ALONG SHELL MIDSURFACE. RADIAL DIRECTION IS NORMAL TO SHELL MIDSURFACE.)

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PEAK PRINCIPAL STRES

SEG. NO.	OUTSIDE LONG	OUTSIDE HOOP	OUTSIDE RAD.	MIDPLANE LONG	MIDPLANE HOOP	MIDPLANE RAD.	INSIDE LONG	INSIDE HOOP	INSIDE RAD.
1	.0	.0	.0	-.0	.0	.0	-.0	.0	.0
2	.1	-.0	-.0	-.0	-.1	-.0	-.2	-.2	-.0
3	-1.5	-.5	.0	.1	-.1	.0	1.7	.4	.0
4	2.1	5.4	.0	-.1	5.7	.1	-2.5	6.2	.0
5	65.9	-10.0	-.2	-3.9	-35.3	-1.6	-74.5	-66.3	-.2
6	31.8	-48.8	-.6	-2.9	-72.7	-4.8	-36.6	-101.8	-.6
7	-30.8	-105.0	-.6	.6	-120.0	-5.0	33.4	-138.9	-.6
8	-109.1	-154.1	-.4	5.4	-152.5	-3.3	121.2	-152.4	-.4
9	-377.4	-228.6	.6	28.8	-163.0	1.9	439.4	-80.4	.6
10	-694.7	-151.0	4.8	65.6	24.2	28.9	754.3	319.1	4.8
11	-760.4	-109.7	12.1	105.4	175.9	78.8	991.3	594.9	12.1
12	-1500.1	-1045.3	28.6	241.6	-163.4	182.2	1993.7	1061.5	28.6
13	-2945.4	-1626.4	73.3	504.0	370.1	472.1	4021.4	3224.4	73.3
14	-3826.7	-903.6	155.3	749.7	2608.6	1030.1	5279.0	7713.1	155.3
15	-2557.1	-126.0	177.7	186.4	983.5	1038.1	5759.2	5695.0	177.7
17	-3691.5	-224.7	69.7	483.9	1299.3	477.0	4646.3	3227.8	69.7
18	-2615.9	-1514.1	63.6	537.7	-29.3	455.0	3156.0	1293.6	63.6
19	-163.5	-2350.6	44.0	45.8	-1416.6	286.7	-288.6	-959.5	44.0
20	812.4	-4059.2	21.6	-348.2	-3448.6	21.0	-1961.0	-3495.8	21.6
21	-37.0	-4526.3	6.6	-333.4	-4371.0	-151.3	-955.7	-4375.8	6.6
23	353.2	1369.9	36.4	401.0	3512.3	184.5	-1894.1	3752.9	36.4
24	-1254.3	418.3	33.5	153.9	1473.0	215.1	1245.2	2445.8	33.5
25	-1239.4	-1213.4	16.9	143.4	-610.0	138.8	1192.1	-257.8	16.9
26	-2811.2	-2414.1	9.8	223.7	-2211.3	77.3	2963.8	-1733.6	9.8
27	-4977.9	-4765.2	72.5	166.2	-1683.9	475.5	5041.3	2243.5	72.5
28	-6473.8	-5775.6	200.9	521.8	-596.2	1266.6	7164.2	6789.9	200.9
29	-6842.3	-6327.1	382.6	964.2	757.9	2348.4	8257.2	11633.3	382.6
30	-6143.8	-6556.8	594.2	1400.8	2089.4	3556.5	8213.8	15977.6	594.2
31	-7462.7	-5317.1	550.4	1922.7	2045.0	3283.1	10227.0	12532.1	550.4
32	-6113.3	-4375.5	573.2	1716.1	2762.8	3448.0	8631.5	13237.5	573.2
33	-238.8	-1805.8	579.9	805.9	4135.2	3564.2	839.6	12674.6	579.9

(LONGITUDINAL DIRECTION IS ALONG SHELL MIDSURFACE. RADIAL DIRECTION IS NORMAL TO SHELL MIDSURFACE.)

0 0 0 6 1 9 [illegible] 3 9 2

PEAK PRINCIPAL STRESSES

SEG. NO.	OUTSIDE LONG	OUTSIDE HOOP	OUTSIDE RAD.	MIDPLANE LONG	MIDPLANE HOOP	MIDPLANE RAD.	INSIDE LONG	INSIDE HOOP	INSIDE RAD.
1	-.0	-.0	-.0	.0	-.0	-.0	.0	-.0	-.0
2	-.5	.1	.0	.0	.3	.0	.5	.5	.0
3	4.2	1.5	-.0	-.3	.4	-.0	-4.8	-1.0	-.0
4	-3.9	-15.2	-.1	.3	-16.9	-.4	4.5	-19.2	-.1
5	-200.8	21.0	.7	11.8	95.9	4.6	227.1	187.8	.7
6	-115.1	129.3	2.0	9.7	203.9	14.3	131.8	294.5	2.0
7	-10.1	-137.2	.6	4.2	-162.7	4.3	10.5	-207.3	.6
8	4.2	-469.3	-2.4	-2.1	-584.0	-18.5	-10.2	-736.7	-2.4
9	-471.2	-316.9	-1.7	27.3	-247.8	-15.5	545.0	-142.4	-1.7
10	-824.6	-49.6	9.4	88.4	290.9	60.3	1041.0	865.5	9.4
[illegible]	-1117.5	-487.6	25.3	17.2	97.0	162.1	1140.8	918.1	25.3
[illegible]	-1711.8	-1257.8	42.2	140.0	-261.0	252.2	2093.3	1214.0	42.2
13	-2931.8	-1654.4	78.3	349.5	210.7	467.9	3897.3	3116.3	78.3
14	-3526.2	-797.5	149.2	536.0	2310.3	934.9	4925.9	7228.3	149.2
15	-3517.7	-1124.6	176.6	451.4	1497.0	1170.8	3420.6	5265.5	176.6
17	-3454.4	-1145.4	102.9	737.3	1856.0	802.2	3259.7	4021.5	102.9
18	-2326.2	-1418.7	74.7	418.5	-488.1	531.9	2492.7	362.4	74.7
19	545.7	-2297.0	31.8	18.1	-1657.3	177.2	-996.5	-1507.9	31.8
20	1454.7	-3496.4	6.9	-98.7	-3651.6	35.2	-2125.3	-3961.9	6.9
21	135.3	-4790.0	-3.9	-10.1	-4284.5	-38.7	-534.4	-4268.8	-3.9
23	539.7	3330.5	77.9	114.8	5871.5	597.1	-736.6	8649.5	77.9
24	-2299.7	61.2	62.6	190.7	1454.1	473.2	2735.7	3228.8	62.6
25	-1530.0	-916.4	20.9	160.5	-552.1	151.9	1756.6	-240.1	20.9
26	-2528.6	-2097.8	13.4	306.2	-1138.4	72.0	3173.9	-336.1	13.4
27	-3175.5	-3009.2	65.5	155.9	-866.7	437.3	3653.4	2416.5	65.5
28	-3566.9	-3351.2	142.5	283.9	-343.8	1006.3	4680.7	5201.3	142.5
29	-3439.8	-3542.1	243.7	457.7	134.7	1725.8	5181.9	7796.4	243.7
30	-2904.0	-3714.2	349.2	614.4	349.9	2447.4	5212.2	9679.7	349.2
31	-4842.5	-2665.0	296.4	1334.4	1557.9	2212.4	7599.3	9472.7	296.4
32	-5093.4	-2519.0	432.1	1815.0	3682.4	3033.3	7816.9	13333.5	432.1
33	117.7	-76.5	567.9	1480.7	6845.8	3914.2	577.9	16082.1	567.9

(GITUDINAL DIRECTION IS ALONG SHELL MIDSURFACE. RADIAL DIRECTION IS NORMAL TO SHELL MIDSURFACE.)

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PEAK PRINCIPAL STRESSES

SEG. NO.	OUTSIDE LONG	OUTSIDE HOOP	OUTSIDE RAD.	MIDPLANE LONG	MIDPLANE HOOP	MIDPLANE RAD.	INSIDE LONG	INSIDE HOOP	INSIDE RAD.
1	.0	.0	-.0	-.0	.0	-.0	-.0	-.0	-.0
2	-.0	-.1	-.0	.0	-.1	-.0	.0	-.1	-.0
3	-.8	.1	.0	.0	.4	.0	1.0	.8	.0
4	6.9	2.9	-.0	-.4	1.0	-.0	-7.8	-1.2	-.0
5	-1.3	-25.2	-.1	.2	-29.8	-.0	1.7	-35.7	-.1
6	-48.6	-50.3	-.0	2.6	-45.0	-.5	54.3	-39.2	-.0
7	-116.5	-71.9	.3	7.0	-47.0	1.8	130.8	-18.0	.3
8	-174.7	-94.8	.8	11.2	-41.4	5.3	196.4	8.5	.8
9	-233.2	-88.2	1.6	20.3	-23.6	10.2	274.7	61.3	1.6
10	-235.7	18.8	4.5	29.4	139.9	30.0	305.8	339.6	4.5
11	-254.7	-34.2	6.1	41.6	66.0	41.3	324.7	192.7	6.1
12	-314.2	-167.6	3.0	44.1	-111.1	17.8	392.8	-56.6	3.0
13	-708.2	-156.4	5.5	82.7	64.2	33.3	896.0	415.0	5.5
14	-907.9	401.6	24.2	122.7	969.0	164.7	1183.3	1957.1	24.2
15	-521.0	161.0	29.8	128.2	515.1	207.9	684.3	915.0	29.8
17	-579.0	286.2	17.7	84.9	652.5	125.6	713.3	1136.3	17.7
18	-70.5	29.6	10.8	38.9	97.3	77.4	92.9	113.5	10.8
19	1263.7	-196.7	-11.6	-117.5	-780.7	-80.0	-1570.5	-1674.2	-11.6
20	1767.7	-1029.6	-42.3	-215.7	-2176.6	-299.1	-2197.0	-3830.2	-42.3
21	917.4	-2062.0	-62.8	-188.4	-3324.8	-455.7	-1205.6	-5078.2	-62.8
23	1747.6	2595.6	5.2	-105.8	2665.8	55.3	-1965.5	2814.2	5.2
24	-704.6	747.8	11.2	66.7	1230.5	89.6	824.3	1824.9	11.2
25	-831.9	-268.1	9.0	75.4	-16.2	63.4	955.3	252.7	9.0
26	-763.6	-526.5	4.1	58.5	-380.9	26.0	869.3	-229.0	4.1
27	-762.4	-790.7	15.8	32.6	-236.9	96.1	793.1	507.1	15.8
28	-972.0	-922.4	36.5	83.7	-53.6	214.4	1063.6	1227.4	36.5
29	-1015.5	-1029.3	64.6	144.9	109.5	368.1	1174.2	1882.9	64.6
30	-945.0	-1123.8	94.8	200.2	215.4	522.2	1148.5	2373.4	94.8
31	-1189.0	-744.0	65.7	209.6	305.9	354.3	1445.2	1804.7	65.7
32	-944.5	-560.1	93.5	178.7	693.5	543.1	1180.2	2648.0	93.5
33	625.2	42.4	117.5	-49.5	1162.9	720.3	-906.4	2922.0	117.5

GITUDINAL DIRECTION IS ALONG SHELL MIDSURFACE. RADIAL DIRECTION IS NORMAL TO SHELL MIDSURFACE.)

FATIGUE ANALYSIS

IT CAN BE SEEN THAT THE HIGHEST STRESSED LOCATION IS AT THE INSIDE OF THE NOZZLE NEAR THE NOZZLE TO RUN PIPE INTERSECTION. THIS IS CARBON STEEL WHICH HAS THE WORST FATIGUE PROPERTIES. THEREFORE, JUSTIFICATION OF THIS POINT WILL JUSTIFY THE ENTIRE VICINITY OF THE BRANCH.

S_{MAX} THERMAL STRESS RANGE = 21.1 KSI (PAGE 3-56)

S_{MAX} PRESSURE STRESS INTENSITY $= \frac{3.3 P R_r}{t_r} = 24.55 P$

WHERE: $R_r = 14.3125 + \frac{2.0625}{2} = 15.344''$ $t_r = 2.0625''$

$S_{PEAK} = 21.1 + 2.500(24.55) = 82.5$ KSI

$S_{ALT} = 41.3$ KSI FOR 240 CYCLES [HEAT-UP & COOL-DOWN]

$N_{ALLOW} = 6000$ CYCLES

$U_1 = \frac{240}{6000} = 0.04$

BABCOCK & WILCOX			REVISION
DEPARTMENT	DATE 8-72	BY JML	
	CHECKED DATE	BY	
	JOB NO.		SHEET 3-65 OF

-2471

CASE 3

MAX. FLUCTUATION OF THERMAL STRESS EXCLUDING HEAT-UP AND COOL-DOWN VALUES
= 21.1 - 14.7 = 6.4 KSI (SEE PAGE 3-56)

MAX. FLUCTUATION OF PRESSURE EXCLUDING HEAT-UP AND COOL-DOWN = 2500 - 1700 (REACTOR TRIP 8B) = 800 PSI

S_{PEAK} = 6.4 + .8(24.55) = 26.0 KSI

S_{ALT} = 13.0 KSI N_{ALLOW} = 30,000 CYCLES

ACTUAL CYCLES = 160 (TRIP 8B) $U_3 = \frac{160}{30000} = 0.005$

CASE 4

NEXT MAX. PRESSURE RANGE IS LESS THAN 300 PSI FOR ALL OTHER TRANSIENT CONDITIONS

∴ NEXT LARGEST S_{PEAK} = 6.4 + .3(24.55) = 13.8 KSI

S_{ALT} = 6.9 KSI $N_{ALLOW} = \infty$ ∴ U = 0.0

CUMULATIVE NOZZLE USAGE FACTOR, $U_{TOT} = U_1 + U_3$
= 0.04 + 0.005 = 0.045

0.045 < 1.0

(O.K.)

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DEPARTMENT	DATE 8-72	BY [initials]	REVISION
	CHECKED DATE	BY ✓	
	JOB NO.		SHEET 3-66 OF

0005197039 5

SECTION 4

Temperature Distribution of High Pressure Injection Nozzle

The high pressure injection nozzle only has flow through it for two conditions. One is a test condition when 60°F water is injected at 100 gallons per minute for 10 seconds. The second condition is during rapid depressurization when the reactor pressure goes below 1500 psi. This condition is defined as 60°F water injection for 45 sec. with a continuation for 15 minutes at 40°F water. The flow rate is 425 gpm. All other times the nozzle essentially follows the cold leg fluid temperature.

The same thermal model and B&W Program 91167 were used in the analysis of the RPI (See Section 2). The figures showing the transients run are on Pages 43,44 These pages are followed by time-temperatures plots of selected nodes and a discussion of selection of critical times. Finally the actual temperature distribution is shown for the selected times for stress calculation.

Film Coefficients

The cold leg fluid coefficients are the same as identified in Section 2. The high pressure injection fluid film coefficients are calculated in the same manner for turbulent flow. A film coefficient of 35 BTU/°F-HR-FT² is used for the no flow condition.

Film Coefficient for Test Condition

$$hD^{.2} = .023\left(G/\mu\right)^{.8}\left(C_p\mu/K\right)^{.4}$$

WHERE: FOR 60°F WATER AT 100 gpm

$C_p = 1$ $\quad \mu = 2.71$ $\quad K = .344$ $\quad$ 62.34 lbs = 1 cu.ft. of wat

In Branch

$D_i = 2.125'' = .177'$ $\quad$ AREA $= .0246\ FT^2$ $\quad D^{.2} = .707$

$$G = \text{lb}/FT^2\text{-HR} = 100\ \text{gal/min} \cdot \frac{60\ \text{min}}{\text{HR}} \cdot \frac{1\ \text{cu.ft.}}{7.481\ \text{gal}} \times \frac{62.34\ \text{lb}}{1\ \text{cu ft}} \times \frac{1}{.02}$$

$$= 2032466\ \text{lb}/FT^2\text{-HR}$$

$$hD^{.2} = .023(.344)(50124)(2.289) = 906$$

$$h = 906/.707 = 1281 \quad \text{USE } \underline{1300}\ BTU/HR\text{-}°F\text{-}FT^2$$

Inside Sleeve

$D_i = 1.5'' = .125'$ $\quad$ AREA $= .01227$ $\quad D^{.2} = .66$

$G = 4074871$

$$hD^{.2} = .023(.344)(87441)(2.289) = 1580$$

$$h = 1580/.66 = 2394 \quad \text{USE } \underline{2400}\ BTU/HR\text{-}°F\text{-}FT^2$$

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FILM COEFFICIENTS (CONTINUED)

RAPID DEPRESSURIZATION

FOR 60°F WATER: $C_p = 1$ $\rho = 62.34$ lb/cu ft $\mu = 2.71$

$K = .344$

IN BRANCH

$G = 2032466\left(\frac{425}{100}\right) = 8637981$

$h D^{.2} = .01807\,[3187447]^{.8} = 2882$

$h = 2882/.707 = 4076$ USE 4100 BTU/HR-°F-FT^2

INSIDE SLEEVE

$G = 4074871(4.25) = 17318201$

$h D^{.2} = .01807\,[6390780]^{.8} = 5028$

$h = 5028/.66 = 7618$ USE 8000 BTU/HR-°F-FT^2

FOR 40°F WATER: $C_p = 1.005$ $\rho = 62.42$ $\mu = 3.75$ $K = .332$

IN BRANCH

$G = 8637981\left[\frac{62.42}{62.34}\right] = 8649066$

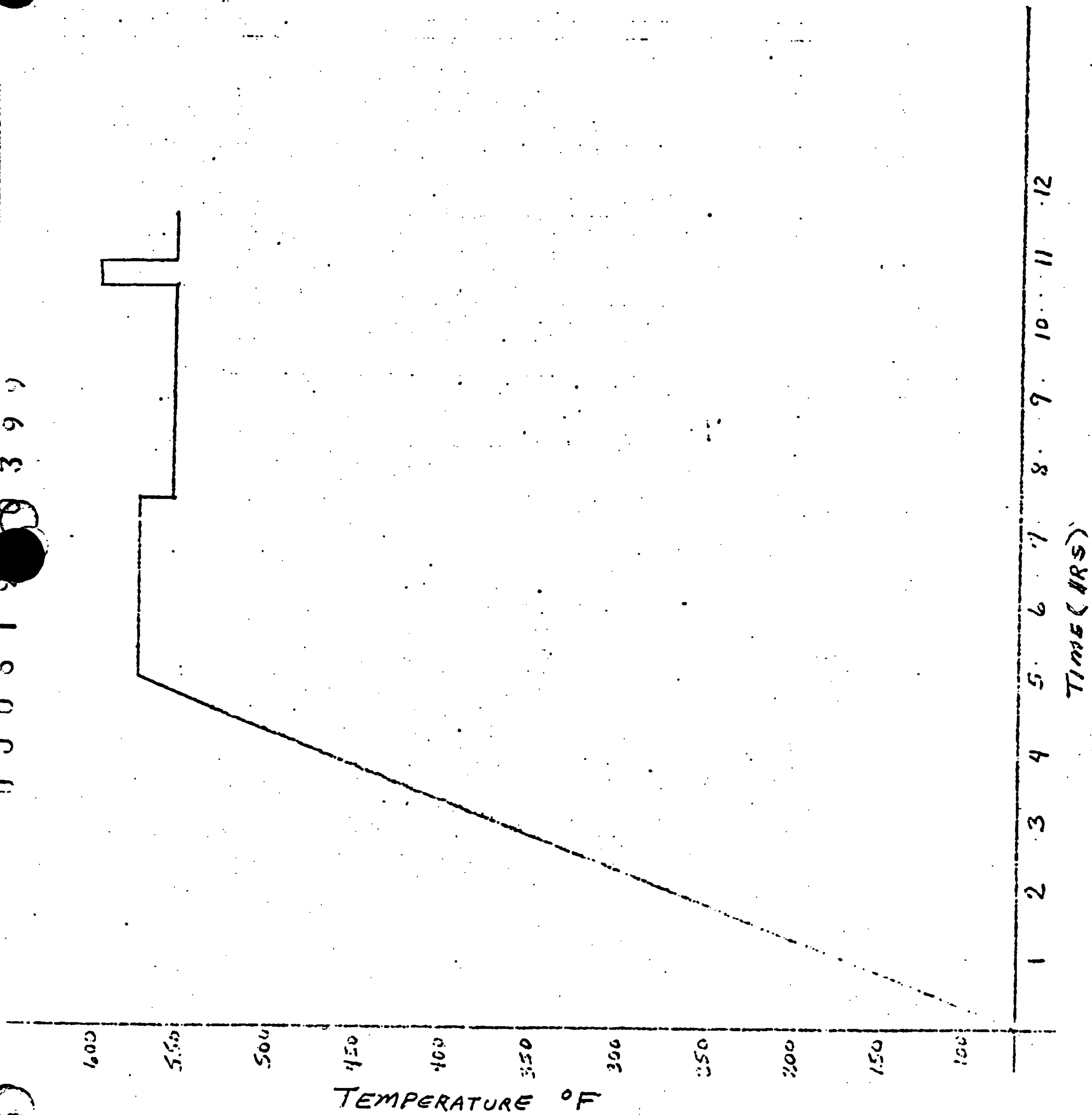
$h D^{.2} = .023(.332)\,[2306418]^{.8}\,[2.64] = 2482$

$h = 2482/.707 = 3510$ USE 3600 BTU/HR-°F-FT^2

INSIDE SLEEVE

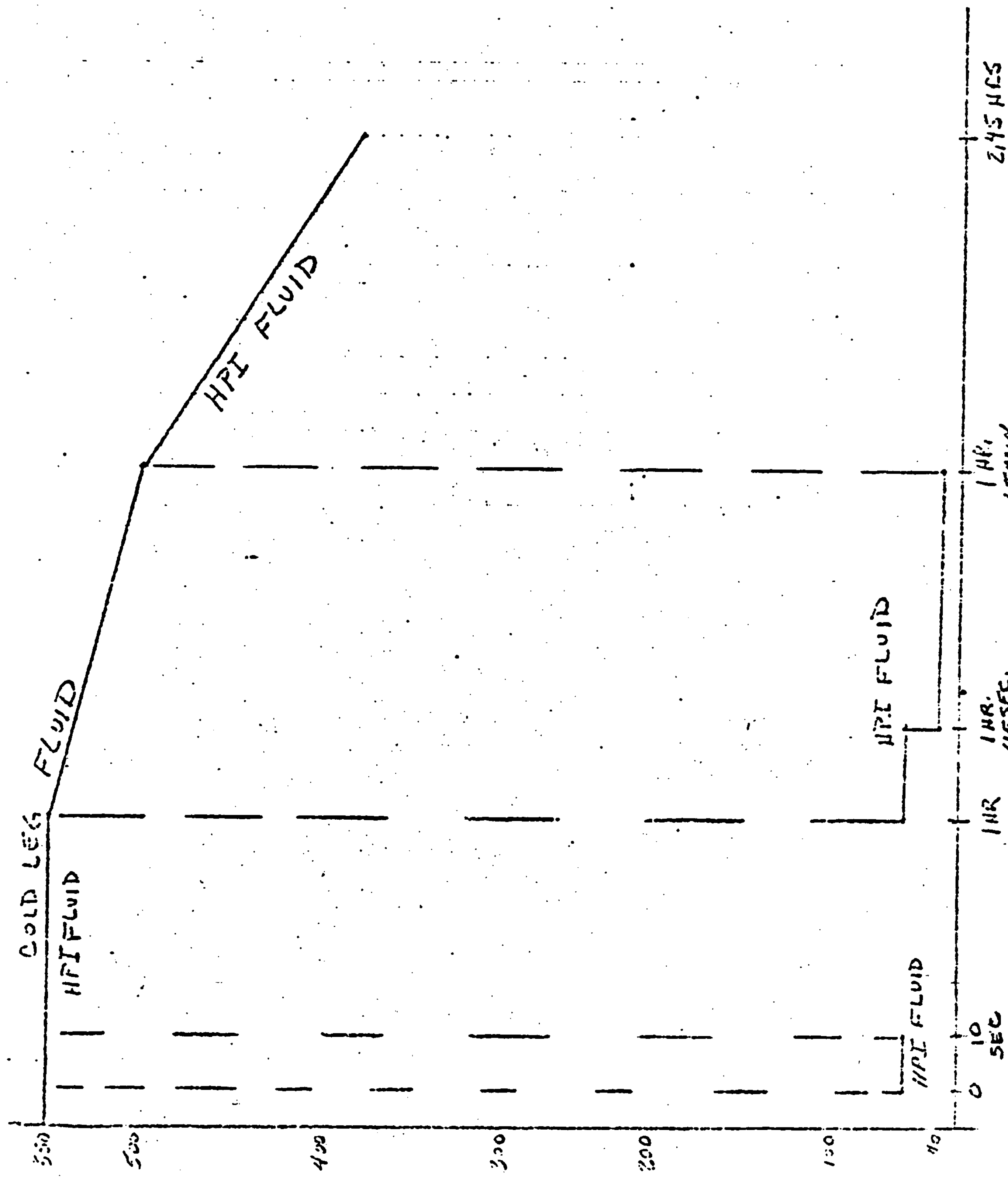
$h = 4330/.66 = 6561$ USE 6600 BTU/HR-°F-FT^2

OSC 1522



OMER	JOB No.
JECT FLUID TRANSIENT FOR NO FLOW IN HIGH PRESSURE INJECTION NOZZLE	
	BY
	DATE 4-3

000519 400



CUSTOMER	JOB No.
SUBJECT TEMPERATURE TRANSIENT FOR TEST TRANSIENT AND RAPID DEPRES-SURIZATION	BY
	DATE 4-4

0006190401

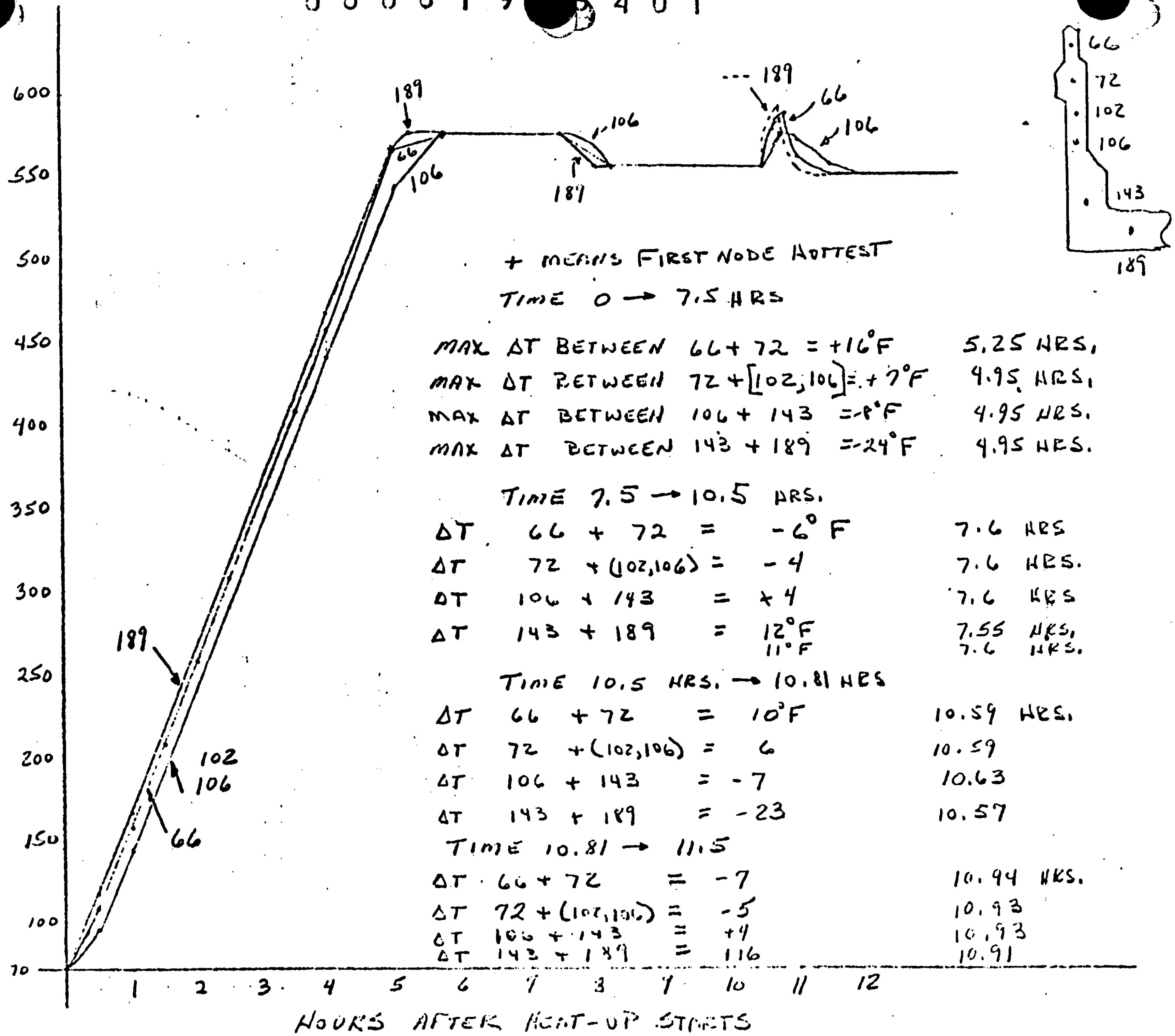
CUSTOMER

SUBJECT

JOB No.

BY

DATE



+ MEANS FIRST NODE HOTTEST

TIME 0 → 7.5 HRS

MAX ΔT BETWEEN 66 + 72	= +16°F	5.25 HRS.
MAX ΔT BETWEEN 72 + [102, 106]	= +7°F	4.95 HRS.
MAX ΔT BETWEEN 106 + 143	= -8°F	4.95 HRS.
MAX ΔT BETWEEN 143 + 189	= -24°F	4.95 HRS.

TIME 7.5 → 10.5 HRS.

ΔT 66 + 72	= -6°F	7.6 HRS
ΔT 72 + (102, 106)	= -4	7.6 HRS.
ΔT 106 + 143	= +4	7.6 HRS
ΔT 143 + 189	= 12°F 11°F	7.55 HRS. 7.6 HRS.

TIME 10.5 HRS. → 10.81 HRS

ΔT 66 + 72	= 10°F	10.59 HRS.
ΔT 72 + (102, 106)	= 6	10.59
ΔT 106 + 143	= -7	10.63
ΔT 143 + 189	= -23	10.57

TIME 10.81 → 11.5

ΔT 66 + 72	= -7	10.94 HRS.
ΔT 72 + (102, 106)	= -5	10.93
ΔT 106 + 143	= +4	10.93
ΔT 143 + 189	= 16	10.91

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CUSTOMER

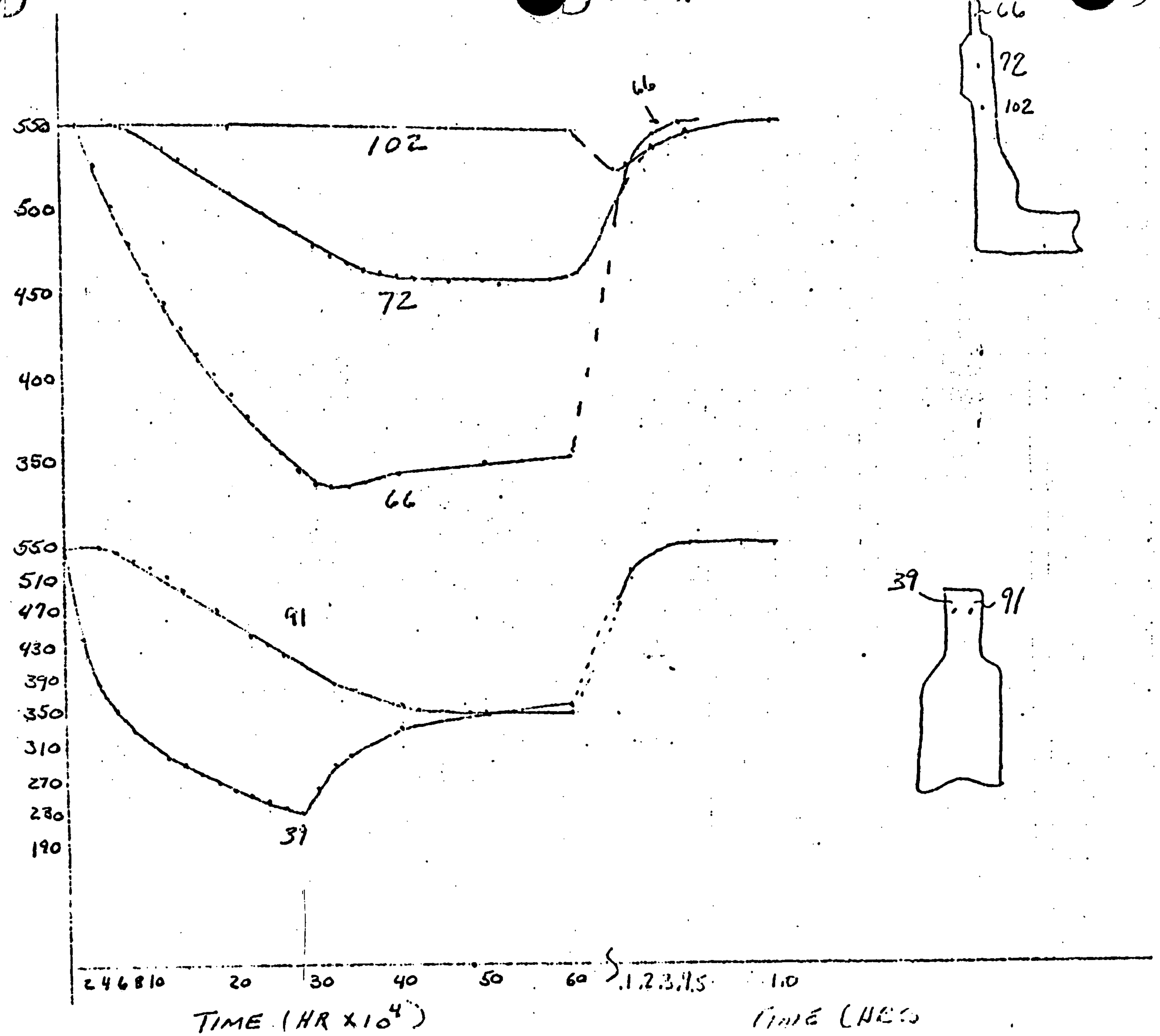
SUBJECT TEST TRANSIENT

TIME-TEMPERATURE PLOT

JOB NO.

BY

DATE 4-6



0006197 0403

CUSTOMER

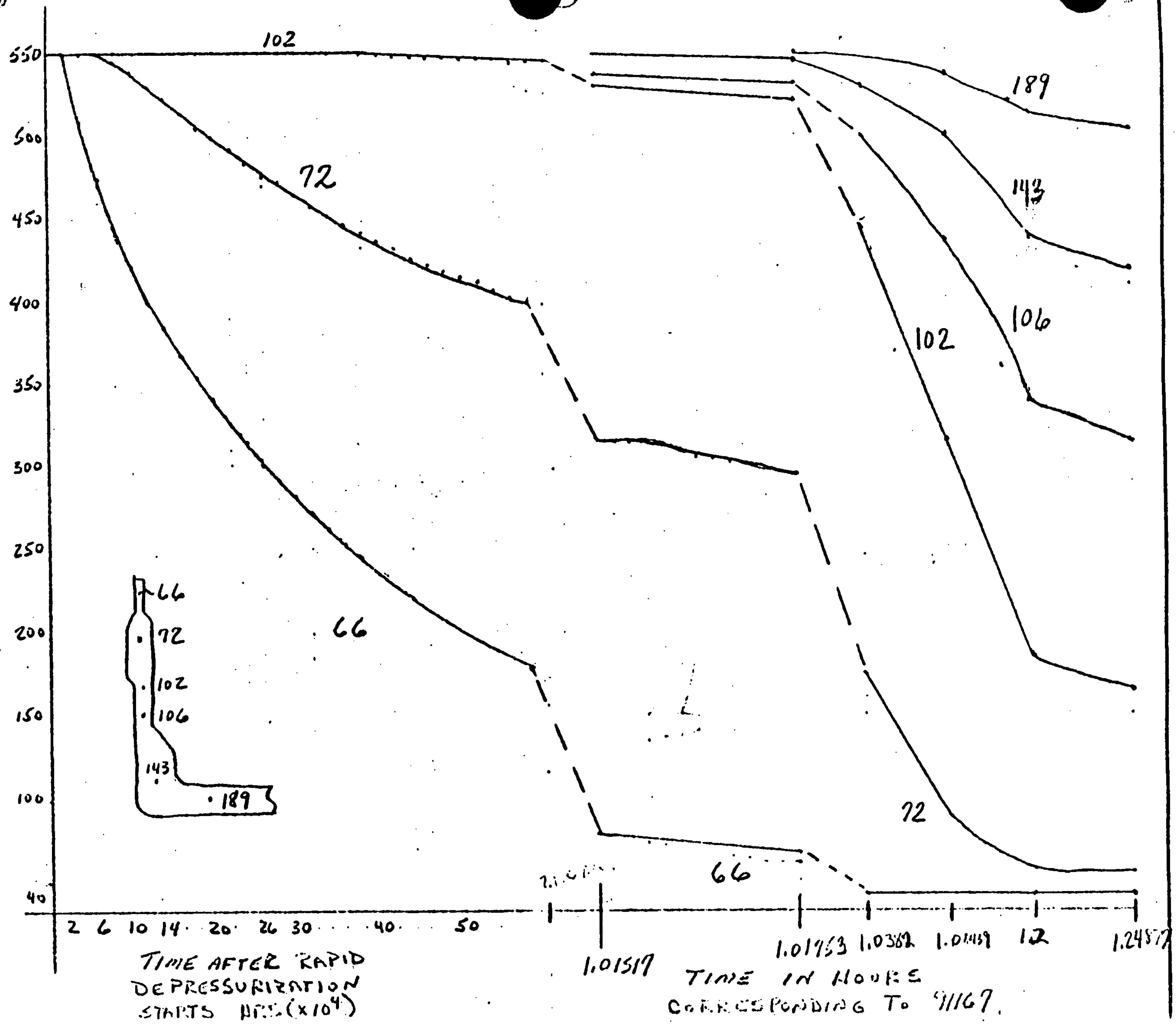
SUBJECT Fluid Pressure Retention

Time-Temperature Plot

JOB NO.

BY

DATE 4-7



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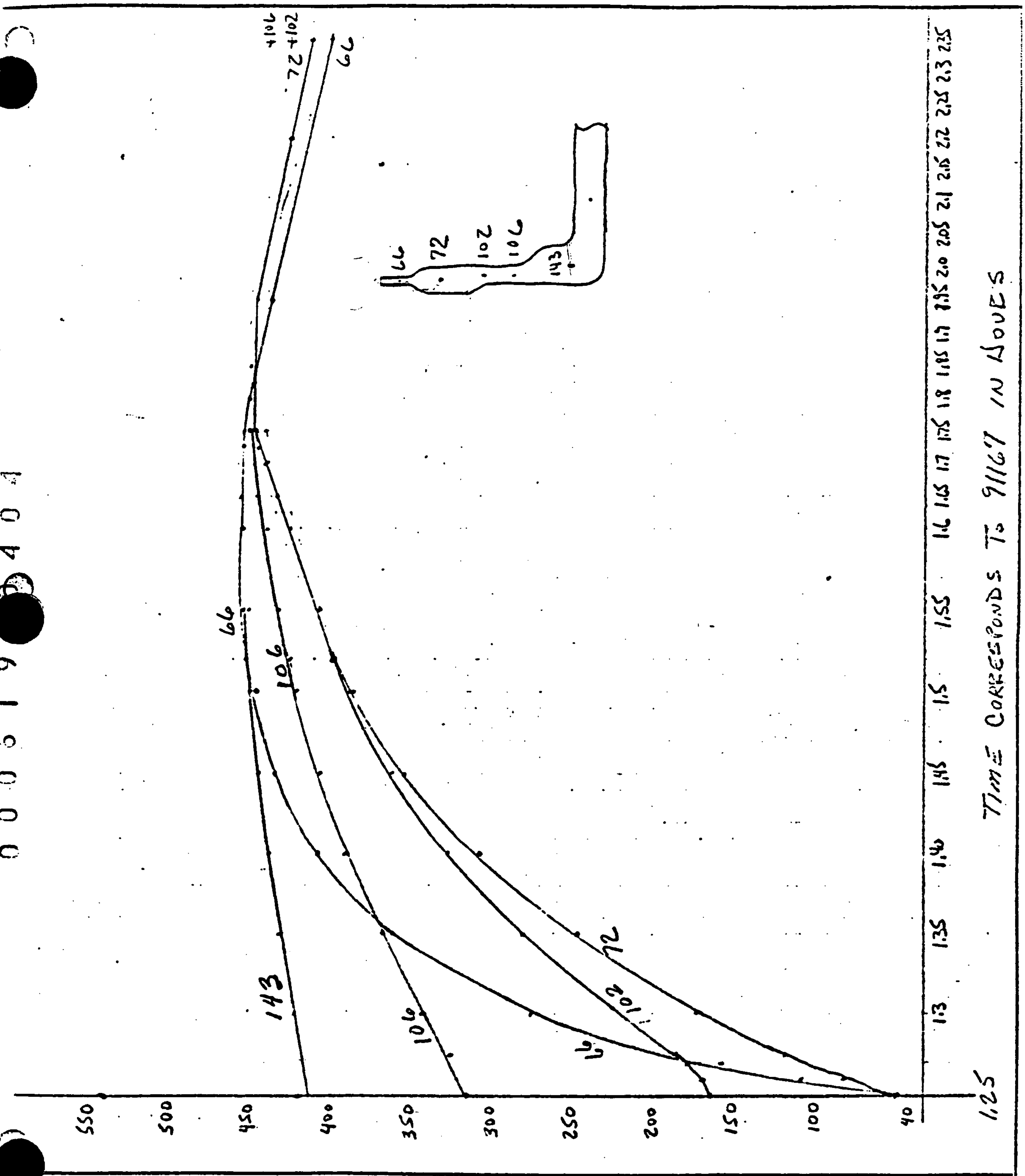

STOMER	JOB No.
SUBJECT INITIATION OF COOL-DOWN	
AFTER HIGH PRESSURE INJECTION	BY
	DATE 4-4

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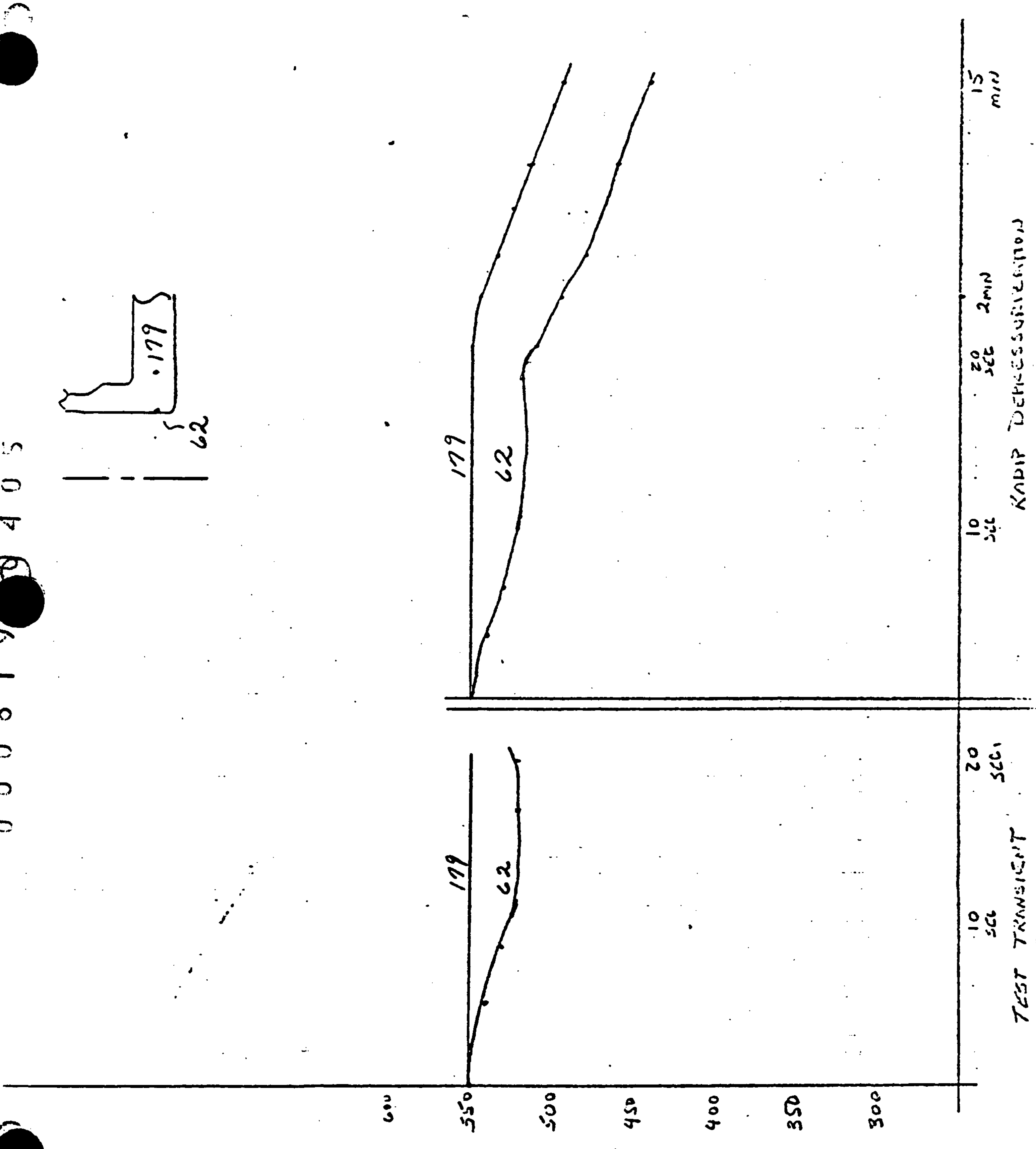


CUSTOMER	JOB No.
SUBJECT [illegible] OF SHELL TEMPERATURE CHANGES	
FOR [illegible] TEST AND RAPID DEPRESSURIZATION	BY [illegible]
	DATE 4-7

908 2027 K&E 10-5154

HPI STRESS CASES

ITERATION	TIME	EXPLANATION
27967	4.95 Hrs.	End of Heat-Up - No flow condition See Page 4-5
41491	7.5 Hrs.	Steady State Temperature at 575 Hottest temperature in vicinity of Bi-metal weld.
42021	7.6 Hrs.	Reversal in Axial gradient from 27967. See Page 4-5
3, 6, 8	0 - 10 Secs.	Maximum radial gradient stress during test transient. See Page 8-6
15	10.7 Sec. from start of test	Maximum axial gradient in upper part of nozzle
30	21.4 Sec. after test	Reversal of radial gradient
1211	14.8 min. after test	Reversal of axial gradient in upper part of nozzle
5060, 5063, 5072	0-10 Secs. after start of rapid depressurization	Maximum radial gradient stress in radid depressurization. See Page 4-7
5124	1.015 Hrs. .9 min. after start of rapid depressurization	One location of possible maximum axial gradient stress. See Page 4-7.
5237	1.0384 Hrs.	Possible maximum axial gradient stress
6059	1.2 hrs.	Possible maximum axial gradient stress.
6307	1.248 hrs.	End of 40°F water injection
6338	1.254 hrs.	Reversal of radial gradient and reversal of axial gradient. See Page 4-8
6850	1.35 hrs.	Reversal of axial gradient.

0006190407

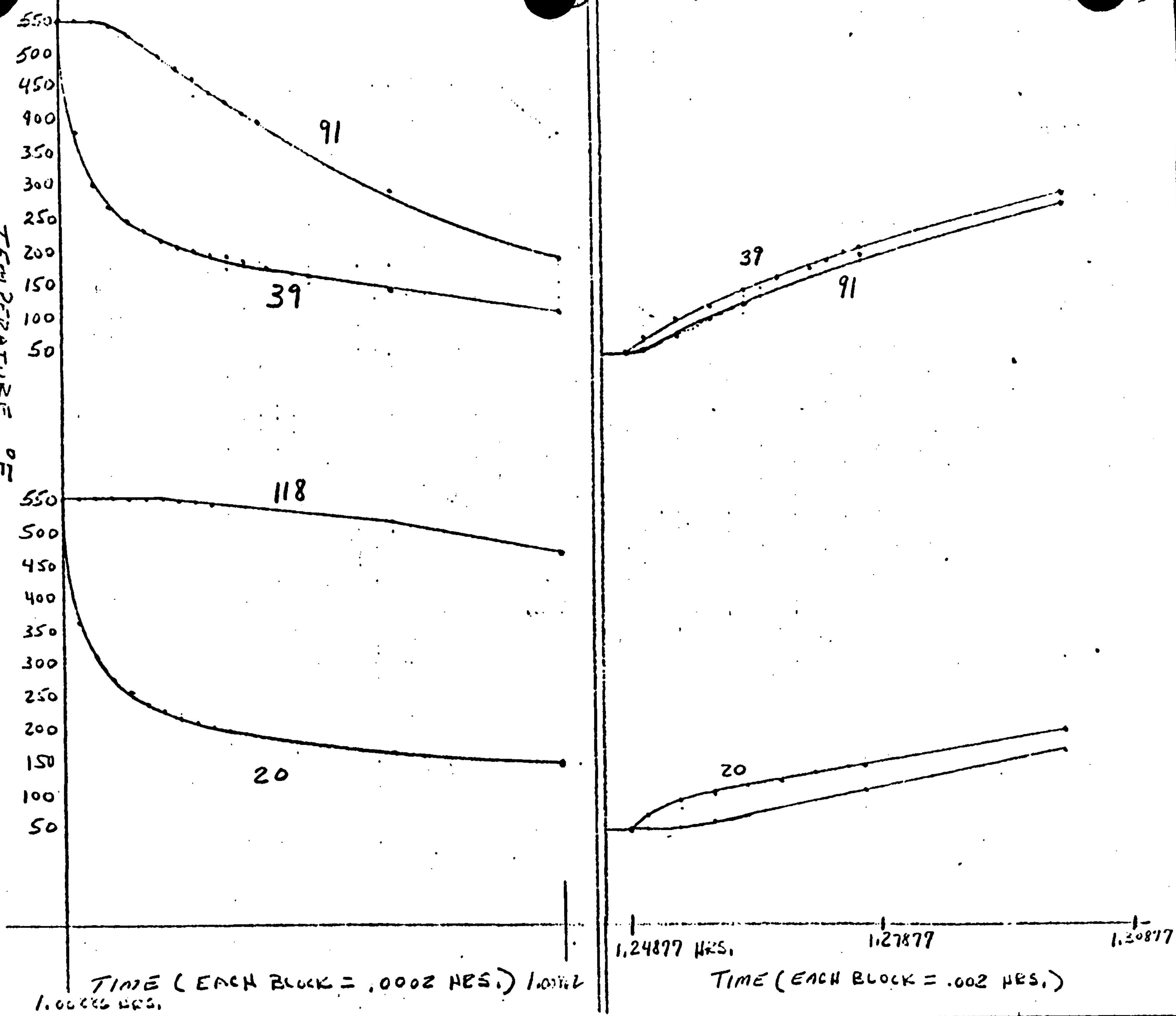
CUSTOMER

SUBJECT

JOB No.

BY

DATE 4-10



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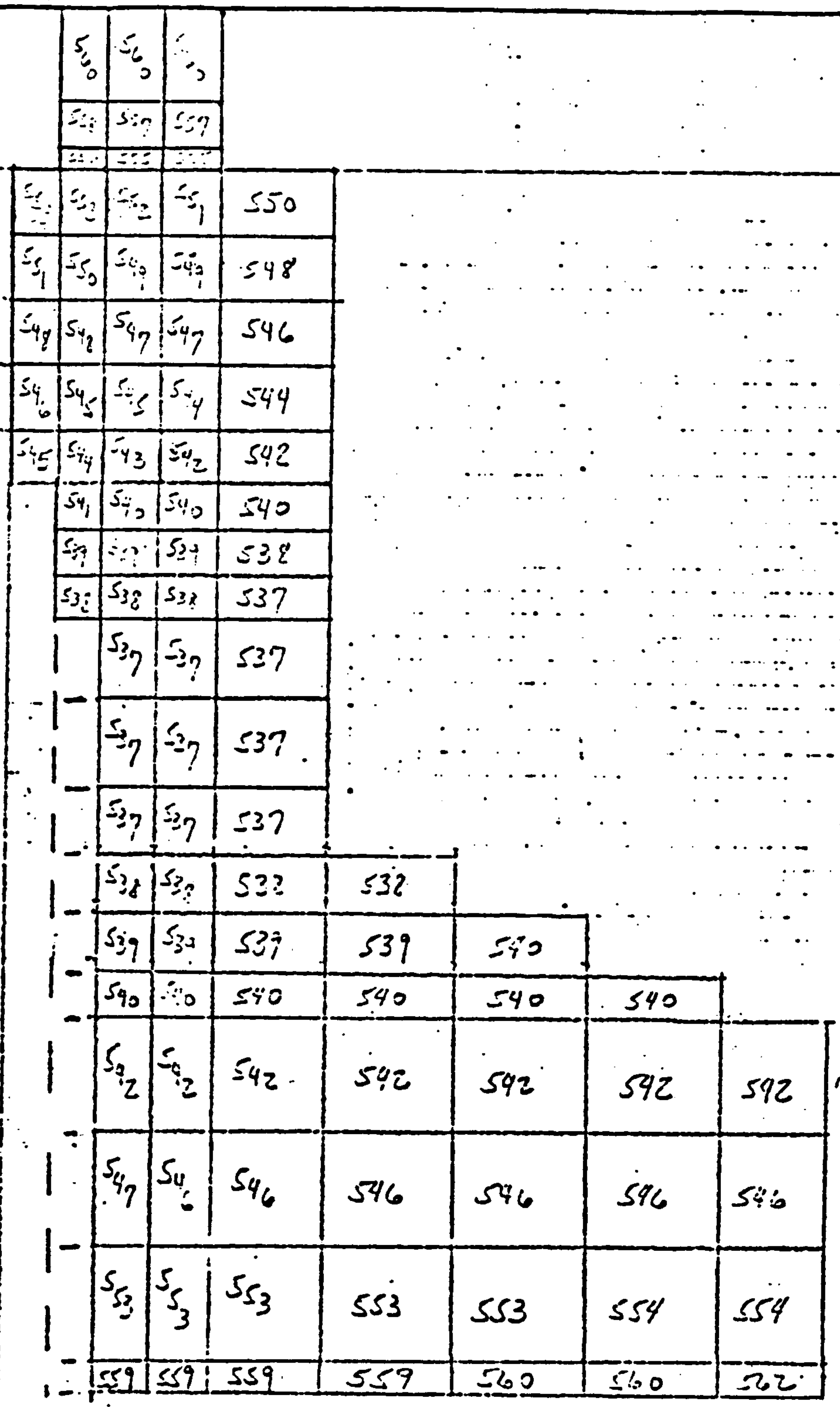
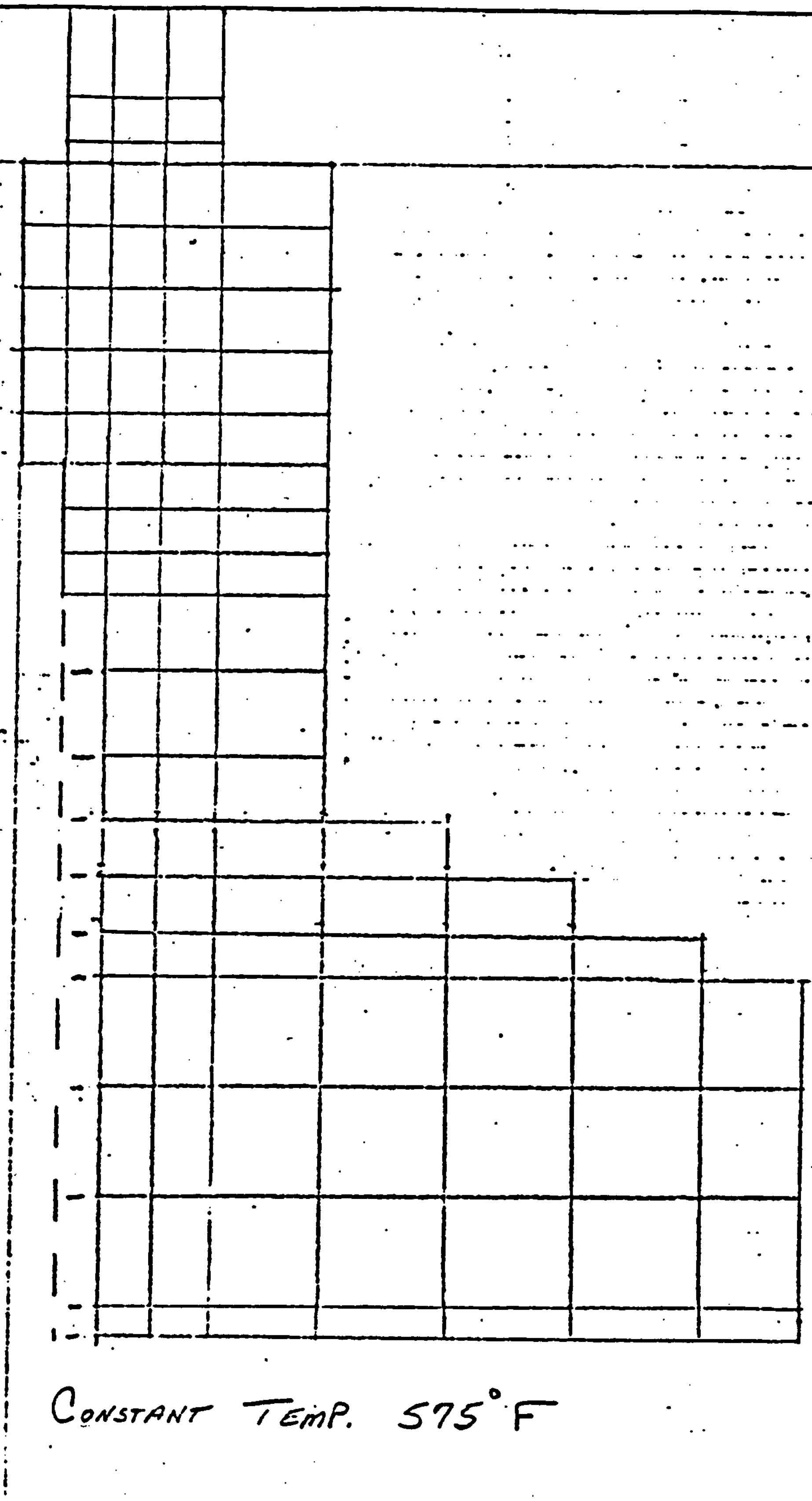


TEMP. FOR ITER 27967

CUSTOMER	JOB NO.
SUBJECT 9116? GRID TO SCALE	
LONGITUDINAL SCALE 4 BLOCKS = 1"	BY
RADIAL SCALE 16 BLOCKS = 1"	DATE 4-12

00051940

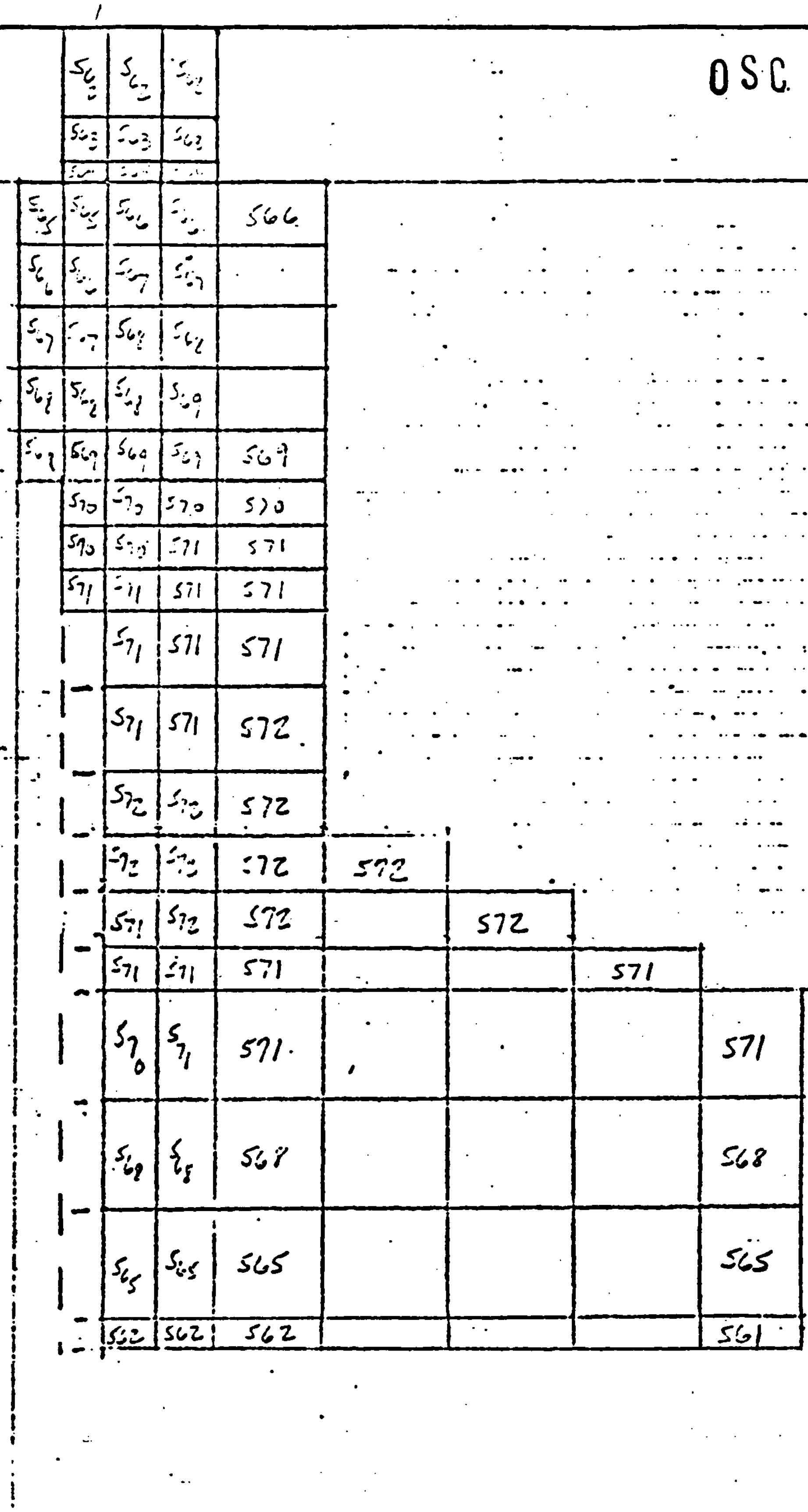


0005197409

TEMP. FOR ITER 41491

CUSTOMER		JOB No.	
SUBJECT	9167 GRID TO SCALE		
	[illegible] = 1"	BY	
	[illegible] = 1"	DATE	4-13

OSC 1522



TEMP. FOR ITER 42021

CUSTOMER	JOB No.
SUBJECT 91167 GRID T...	
... SCALE ... = 1"	BY
... SCALE ... = 1"	DATE 4-14

TEMPERATURES PER SEGMENT USED IN PEAK PRINCIPLE ANALYSIS
** Tree 3

SEGMENT	OUTSIDE T1	T2	T3	T4	INSIDE T5
1	468	458	420	330	169
2	468	458	420	330	169
3	468	458	420	330	169
4	468	458	420	330	169
5	475	468	437	350	168
6	475	468	437	350	168
7	475	468	437	350	168
8	475	468	437	350	168
9	477	474	456	394	178
10	480	480	476	438	188
11	480	480	476	438	188
12	480	480	477	470	305
13	480	480	477	470	307
14	480	480	477	470	308
15	480	480	477	470	310
16	480	480	480	480	480

SEGMENT	OUTSIDE T1	T2	T3	T4	INSIDE T5
17	480	480	480	480	480
18	480	480	480	480	480
19	480	480	480	480	480
20	480	480	480	480	480
21	480	480	480	480	480
22	480	480	480	480	480
23	480	480	480	480	480
24	480	480	480	480	480
25	480	480	480	480	480
26	480	480	480	480	480
27	480	480	480	480	480
28	480	480	480	480	480
29	480	480	480	480	480
30	480	480	480	480	480
31	480	480	480	480	480
32	480	480	480	480	480
33	480	480	480	480	480

4-1-17

THESE TEMP ARE T-70°

4-15

TEMPERATURES PER SEGMENT USED IN [illegible] ANALYSIS

	OUTSIDE				INSIDE
SEGMENT	T1	T2	T3	T4	T5
1	422	405	353	260	127
2	422	405	353	260	127
3	422	405	353	260	127
4	422	405	353	260	127
5	447	432	380	280	127
6	447	432	380	280	127
7	447	432	380	280	127
8	447	432	380	280	127
9	463	454	421	332	127
10	479	477	462	385	127
11	479	477	462	385	127
12	480	480	480	440	235
13	480	480	480	442	237
14	480	480	480	443	238
15	480	480	480	445	240
16	480	480	480	480	480

	OUTSIDE				INSIDE
SEGMENT	T1	T2	T3	T4	T5
17	480	480	480	480	480
18	480	480	480	480	[illegible]
19	480	480	480	480	480
20	480	480	480	480	480
21	480	480	480	480	480
22	480	480	480	480	480
23	480	480	480	480	[illegible]
24	480	480	480	480	480
25	480	480	480	480	480
26	480	480	480	480	480
27	480	480	480	480	[illegible]
28	480	480	480	480	[illegible]
29	480	480	480	480	480
30	480	480	480	480	480
31	480	480	480	480	480
32	480	480	480	480	[illegible]
33	480	480	480	480	480

THERE TEMP. ARE T-70

4-17

TEMPERATURES PER SEGMENT USED IN PEAK PRINCIPLE ANALYSIS *ITER 8*

SEGMENT	OUTSIDE T1	T2	T3	T4	INSIDE T5
1	385	369	317	231	111
2	385	369	317	231	111
3	385	369	317	231	111
4	385	369	317	231	111
5	421	403	349	252	112
6	421	403	349	252	112
7	421	403	349	252	112
8	421	403	349	252	112
9	449	438	399	305	112
10	478	474	450	358	112
11	478	474	450	358	112
12	480	480	465	410	210
13	480	480	466	412	212
14	480	480	467	413	215
15	460	480	468	415	217
16	480	480	480	480	480

SEGMENT	OUTSIDE T1	T2	T3	T4	INSIDE T5
17	480	480	480	480	480
18	480	480	480	480	480
19	480	480	480	480	480
20	480	480	480	480	480
21	480	480	480	480	480
22	480	480	480	480	480
23	480	480	480	480	480
24	480	480	480	480	480
25	480	480	480	480	480
26	480	480	480	480	480
27	480	480	480	480	480
28	480	480	480	480	480
29	480	480	480	480	480
30	480	480	480	480	480
31	480	480	480	480	480
32	480	480	480	480	480
33	480	480	480	480	480

THESE TEMP ARE T-70°

OSC 1522

$T_{FLUID} = 60°F$

$h = 1300$

	224	337	373	
	266	340	400	
	314	[illegible]	413	
255	326	425	456	534
282	353	440	497	537
315	404	474	515	543
324	411	472	512	544
325	416	482	520	544
	537	542	540	549
	545	548	549	550
	546	548	547	550
		548	547	550

TEMP. FOR ITER 15

CUSTOMER	JOB No.
SUBJECT 9/167 GRID [illegible]	
[illegible] 4 [illegible] = 1"	BY
[illegible] 11 [illegible] = 1"	DATE 4-18

$T_{FLUID} = 550$

$h = 35$

	357	353	352					
	360	362	361					
	[illegible]	[illegible]	[illegible]					
412	417	432	456	492				
424	431	442	471	501				
413	430	453	480	511				
416	434	458	485	514				
420	441	467	492	519				
	519	526	544	541				
	534	540	546	547				
	537	542	545	548				
		544	543	547				
		544	546	547				
		544	546	547				
		544	548	548	549			
		544	546	548	549	550		
		544	546	548	549	550		
		544	546	549	549			550
		544	545	549	549			
		544	543	549	549			
		543	540	549	549	550		550

TEMP. FOR ITER 30

CUSTOMER

JOB No.

SUBJECT ?1167 GRID T[illegible]

[illegible] = 1"

[illegible] = 1"

BY

DATE 4-19

TFLUID = 550
h = 35

	540	539	539					
	538	538	537					
	535	535	535					
	534	533	533					
532	531	531	530	530				
530	530	529	529	529				
530	529	529	529	528				
530	529	529	527	528				
530	530	529	529	529				
	530	529	530	530				
	532	530	531	531				
	533	532	533	533				
		533	535	535				
		535	538	538				
		537	540	540				
		540	541	542	542			
		541	543	542	543	543		
		543	544	544	544	544	544	
		544	545	545	545	545	545	595
		545	546	546	596	546	546	546
		546	547	547	547	547	547	547
		547	548	548	548	548	547	549

TEMP. FOR ITER 1211

CUSTOMER	JOB No.
SUBJECT 9116? GRID [illegible]	
[illegible] SCALE [illegible] = 1"	BY
[illegible] SCALE " [illegible] = 1"	DATE 4-20

0005194

ITERATION 5060

TEMPERATURES PER SEGMENT USED IN PEAK PRINCIPLE ANALYSIS

SEGMENT	OUTSIDE T1	T2	T3	T4	INSIDE T5
1	478	473	445	340	76
2	478	473	445	340	76
3	478	473	445	340	76
4	478	473	445	340	76
5	479	477	458	367	74
6	479	477	458	367	74
7	479	477	458	367	74
8	479	477	458	367	74
9	479	478	468	408	[illegible]
10	479	479	478	450	93
11	479	479	478	450	93
12	480	480	480	480	370
13	480	480	480	480	372
14	480	480	480	480	373
15	480	480	480	480	375
16	480	480	480	480	480

SEGMENT	OUTSIDE T1	T2	T3	T4	INSIDE T5
17	480	480	480	480	480
18	480	480	480	480	480
19	480	480	480	480	480
20	480	480	480	480	480
21	480	480	480	480	480
22	480	480	480	480	480
23	480	480	480	480	480
24	480	480	480	480	480
25	480	480	480	480	480
26	480	480	480	480	480
27	480	480	480	480	480
28	480	480	480	480	480
29	480	480	480	[illegible]	480
30	480	480	480	480	480
31	480	480	480	480	480
32	480	480	480	[illegible]	480
33	480	480	480	[illegible]	480

THESE TEMP. ARE T-70

ITERATION 5063

TEMPERATURES PER SEGMENT USED IN PEAK PRINCIPLE ANALYSIS

	OUTSIDE				INSIDE
SEGMENT	T1	T2	T3	T4	T5
1	407	386	317	200	38
2	407	386	317	200	38
3	407	386	317	200	38
4	407	386	317	200	38
5	439	419	352	225	38
6	439	419	352	225	38
7	439	419	352	225	38
8	439	419	352	225	38
9	458	448	407	298	37
10	478	477	462	372	37
11	478	477	462	372	37
12	480	480	478	440	255
13	480	480	479	442	271
14	480	480	479	443	286
15	480	480	480	445	302
16	480	480	480	480	480

	OUTSIDE				INSIDE
SEGMENT	T1	T2	T3	T4	T5
17	480	480	480	480	480
18	480	480	480	480	480
19	480	480	480	480	480
20	480	480	480	480	480
21	480	480	480	480	480
22	480	480	480	480	480
23	480	480	480	480	480
24	480	480	480	480	480
25	480	480	480	480	480
26	480	480	480	480	480
27	480	480	480	480	480
28	480	480	480	480	480
29	480	480	480	480	480
30	480	480	480	480	480
31	480	480	480	480	480
32	480	480	480	480	480
33	480	480	480	480	480

THESE TEMP. ARE T-70

STRESS ANALYSIS OF HIGH PRESSURE INJECTION NOZ BEHNKE ITERATION 5072

TEMPERATURES PER SEGMENT USED IN PEAK PRINCIPLE ANALYSIS

	OUTSIDE				INSIDE
SEGMENT	T1	T2	T3	T4	T5
1	245	230	184	112	18
2	245	230	184	112	18
3	245	230	184	112	18
4	245	230	184	112	18
5	307	289	232	141	21
6	307	289	232	141	21
7	307	289	232	141	21
8	307	289	232	141	21
9	386	370	314	202	22
10	465	452	397	264	23
11	465	452	397	264	23
12	480	467	437	340	190
13	480	469	441	346	194
14	480	470	446	351	197
15	480	472	450	357	201
16	480	480	480	480	480

	OUTSIDE				INSIDE
SEGMENT	T1	T2	T3	T4	T5
17	480	480	480	480	480
18	480	480	480	480	480
19	480	480	480	480	480
20	480	480	480	480	480
21	480	480	480	480	480
22	480	480	480	480	480
23	480	480	480	480	480
24	480	480	480	480	480
25	480	480	480	480	480
26	480	480	480	480	480
27	480	480	480	480	480
28	480	480	480	480	480
29	480	480	480	480	480
30	480	480	480	480	480
31	480	480	480	480	480
32	480	480	480	480	480
33	480	480	480	480	480

THESE TEMP. ARE T-70

FLUID 40°F

h = [illegible]

OSC 1522

	42	41	42					
	44	48	51					
	52	62	67					
57	76	95	111	131				
65	92	116	135	159				
96	123	147	166	185				
112	145	174	197	219				
133	185	223	250	275				
	334	344	354	364				
	379	403	411	418				
	428	438	446	453				
		463	466	470				
		473	477	480				
		483	487	491				
		494	499	505	511			
		502	507	513	519	524		
		506	511	518	524	527	532	
		510	515	522	529	533	536	538
		511	516	523	530	535	538	539
		511	516	523	530	535	538	540
		511	517	524	531	536	540	543

TEMP. FOR ITER 5237

CUSTOMER

SUBJECT 7/1/67 GRID T...

... = 1"

... = 1"

JOB No.

BY

DATE 4-24

OSC 1522

	40	40	40					
	40	40	40					
	40	40	[illegible]					
40	41	41	42	42				
41	42	43	44	44				
44	46	47	49	50				
49	52	56	59	61				
58	67	74	80	84				
	114	116	119	112				
	146	149	151	154				
	178	182	185	188				
		219	220	222				
		258	260	262				
		299	302	304				
		336	340	345	355			
		362	366	372	380	387		
		381	386	391	398	404	410	
		403	407	413	419	424	428	431
		424	428	434	440	444	447	449
		443	448	454	460	465	469	470
		455	460	467	474	481	485	492

0 0 0 6 1 9 0 4 2 1

TEMP. FOR 6059

CUSTOMER

SUBJECT [illegible] GRID [illegible]

[illegible] SCALE [illegible] = 1"

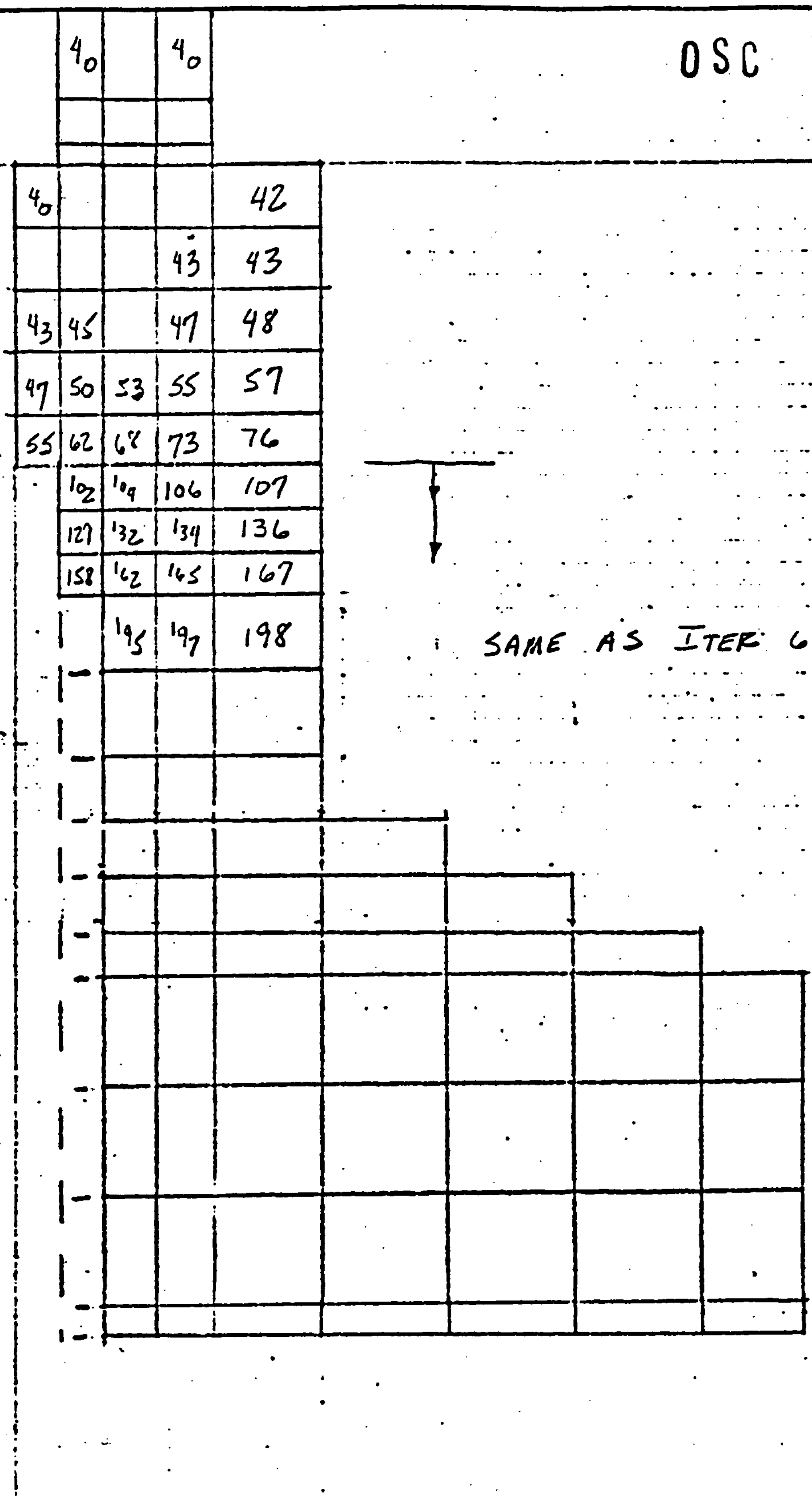
[illegible] SCALE [illegible] = 1"

JOB NO.

BY

DATE 4-25

OSC 1522



SAME AS ITER 6338

ITER 6307

CUSTOMER	JOB No.
SUBJECT 7116? GRID TO SCALE	
LONGITUDINAL SCALE 4 ROWS = 1"	BY
RADIAL SCALE 16 ROWS = 1"	DATE 4-26

E BABCOCK & WILCOX COMPA

	88	75	68					
	87	74	67					
	84	71	64					
90	76	63	55	47				
84	71	61	54	48				
79	69	60	55	51				
81	72	66	62	59				
94	87	82	79	78				
	105	103	106	107				
	130	132	133	135				
	160	163	165	167				
		196	197	198				
		233	234	236				
		274	275	277				
		310	313	318	327			
		337	340	345	352	359		
		357	360	365	371	377	382	
		380	383	388	393	398	402	405
		404	407	412	417	421	424	425
		427	431	436	442	446	450	451
		442	446	452	459	465	470	476

ITER 6338

CUSTOMER

SUBJECT 9/1/67 GRID TO SCALE

LONGITUDINAL SCALE 4 ROWS = 1"

RADIAL SCALE 16 ROWS = 1"

JOB No.

BY

DATE 4-27

CS 2027

FLUID = 490
h = [illegible]

	365	361	359					
	339	339	332					
	311	314	311					
277	291	289	272	270				
278	271	264	259	254				
269	258	252	247	243				
258	252	247	242	238				
262	255	249	245	241				
	252	251	249	247				
	265	263	261	259				
	282	281	280	279				
		301	301	301				
		325	324	329				
		349	348	347				
		367	368	368	372			
		382	382	323	384	387		
		394	394	394	395	397	399	
		410	410	410	410	411	412	413
		431	431	430	430	430	430	431
		453	452	452	453	453	453	454
		466	466	466	466	467	469	473

TEMP FOR ITER 6850

CUSTOMER | JOB NO.

SUBJECT 9116? GRID T[illegible]

[illegible] = 1" | BY

[illegible] = 1" | DATE 4-28

SECTION 5

OSC 1522

SELECTION OF CRITICAL SEGMENTS

The following pages contain a sample temperature input and stress output for iterations 27976, 6, 5060, 6307. The reader can discern from this sample that the stainless segments 5 and 8 and carbon segment 23 (Bi-Metal Weld) are representative of the highest stress area in the nozzle.

Pages 5-16 to 5-20 contain a stress intensity summary of thermal stress iterations runs. Iteration I on this summary was run of pressure only on the nozzle at a pressure of 1000 psi. This summary is for Segments 5, 8, 21, 23, 33. It can be seen that segment 33 has stresses less than or in the vicinity of those shown for the make-up nozzle. Therefore, this point is not re-analyzed for the high pressure injection nozzle.

A complete analysis will be performed on Segments 5, 8, 23 therefore justifying the acceptability of this nozzle under the design criteria. This will be discussed further later.

JMS
8-72

0 0 0 6 1 0 4 2 3

STRESS ANALYSIS OF HIGH PRESSURE INJECTION NOZ BEHNKE   ITERATION 27976

TEMPERATURES PER SEGMENT USED IN PRIMARY + SECONDARY ANALYSIS
****

	OUTSIDE				INSIDE
SEGMENT	T1	T2	T3	T4	T5
1	492	492	492	492	492
2	492	492	492	492	492
3	492	492	492	492	492
4	492	492	492	492	492
5	490	490	490	491	491
6	488	488	489	489	490
7	485	486	487	488	489
8	485	486	487	488	489
9	479	480	481	482	483
10	480	480	480	480	480
11	480	480	480	480	480
12	475	476	477	478	479
13	473	474	475	476	477
14	471	472	473	474	475
15	472	472	472	472	472
16	472	472	472	472	472
17	472	472	472	472	472
18	470	470	471	471	472
19	468	469	469	470	470
20	466	467	467	468	468
21	467	467	467	467	467
22	467	467	467	467	467
23	467	467	467	467	467
24	467	467	467	467	467
25	467	467	467	467	467
26	467	467	467	467	467
27	468	468	468	468	468
28	469	469	469	469	469
29	470	470	470	470	470
30	471	471	471	471	471
31	476	476	475	475	475
32	481	480	480	480	479
33	485	485	484	484	483

STRESS ANALYSIS OF HIGH PRESSURE INJECTION NOZ BEHNKE ITERATION 27976

PRIMARY + SECONDARY STRESSES
##############################

SEG. NO.	OUTSIDE LONG	OUTSIDE HOOP	OUTSIDE RAD.	MIDPLANE LONG	MIDPLANE HOOP	MIDPLANE RAD.	INSIDE LONG	INSIDE HOOP	INSIDE RAD.
1	.3	.1	-.0	-.0	-.0	-.0	-.3	-.1	-.0
2	-1.1	-1.1	-.0	.1	-.9	-.0	1.2	-.7	-.0
3	-9.9	4.2	.0	.5	9.2	.3	10.1	13.1	.0
4	118.9	28.7	-.2	-7.1	-7.4	-1.3	-134.9	-51.3	-.2
5	741.8	191.2	-4.1	-41.9	-195.3	-28.2	-833.4	-656.1	-4.1
	625.2	365.2	-10.8	-50.8	-117.8	-74.5	-711.0	-675.7	-10.8
	616.9	500.6	-14.4	-55.8	-118.1	-99.5	-705.0	-828.3	-14.4
8	559.7	273.3	-16.9	-58.0	-382.7	-117.1	-643.7	-1135.6	-16.9
9	-55.4	624.5	-15.6	-26.1	310.9	-105.3	54.1	-17.1	-15.6
10	73.7	129.6	-7.3	-23.7	60.7	-45.0	-98.0	-6.7	-7.3
11	122.3	10.7	-4.7	-15.9	-116.6	-30.3	-160.7	-316.6	-4.7
12	290.6	565.8	-17.2	-43.3	69.9	-111.0	-375.8	-608.9	-17.2
13	699.0	781.5	-25.8	-119.2	242.7	-161.4	-846.3	-430.6	-25.8
14	2248.5	1215.9	-32.2	-293.5	282.9	-196.2	-2848.5	-1021.5	-32.2
15	3072.7	1238.7	-36.8	-430.8	498.2	-236.3	-3864.2	-403.7	-38.8
17	4169.9	1597.3	-43.6	-472.5	494.7	-280.0	-5040.7	-823.4	-43.6
18	5170.5	1877.1	-57.9	-571.6	189.2	-376.2	-6262.2	-1963.5	-57.9
19	7563.5	556.9	-105.7	-835.5	-2626.8	-709.5	-9233.9	-7015.9	-105.7
20	6563.4	-4004.8	-192.3	-872.6	-8694.4	-1349.8	-8190.4	-15302.8	-192.3
21	1548.8	-9151.3	-247.4	-567.8	-13741.1	-1803.9	-2336.1	-20116.0	-247.4
23	3566.6	14126.9	100.6	-54.7	16799.1	811.3	-3862.1	20272.4	100.6
24	-8397.8	3083.2	117.7	779.0	7221.9	884.1	9719.8	12106.5	117.7
	-3337.8	-1831.8	62.3	361.3	-959.7	434.8	3776.6	-268.3	62.3
26	-793.5	-949.0	8.8	75.8	-895.3	53.5	898.2	-908.7	8.8
27	183.4	-246.7	-2.0	-23.3	-343.9	-18.5	-228.8	-469.8	-2.0
28	-153.6	-152.9	1.2	-9.7	-73.6	3.3	163.1	106.4	1.2
29	-229.5	-80.8	10.0	18.6	109.0	60.7	300.5	513.0	10.0
30	-152.6	36.0	22.3	47.6	315.6	137.9	280.2	934.8	22.3
31	28.7	34.5	13.4	21.8	143.8	87.7	-20.9	282.3	13.4
32	485.9	-7.6	3.2	-63.9	-64.8	22.3	-666.5	-259.8	3.2
33	802.4	-304.5	-19.8	-138.5	-645.6	-127.1	-1150.0	-1436.3	-19.8

(LONGITUDINAL DIRECTION IS N...

0 0 0 6 1 9 [illegible] 0 4 2 3

5-3

STRESS ANALYSIS OF HIGH PRESSURE INJECTION NOZ BEFORE ITERATION 27976

TEMPERATURES PER SEGMENT USED IN PEAK PRINCIPLE ANALYSIS

	OUTSIDE				INSIDE
SEGMENT	T1	T2	T3	T4	T5
1	492	492	492	492	492
2	492	492	492	492	492
3	492	492	492	492	492
4	492	492	492	492	492
5	490	490	490	491	491
6	488	488	489	489	490
7	486	486	487	488	489
8	486	486	487	488	489
9	480	480	481	482	483
10	480	480	480	480	481
11	480	480	480	480	481
12	475	476	477	478	479
13	473	474	475	476	477
14	472	472	473	474	475
15	472	472	472	472	472
16	472	472	472	472	472
17	472	472	472	472	472
18	470	470	471	471	472
19	468	468	469	469	470
20	467	467	467	468	469
21	467	467	467	467	467
22	467	467	467	467	467
23	467	467	467	467	467
24	467	467	467	467	467
25	467	467	467	467	467
26	467	467	467	467	467
27	468	468	468	468	469
28	469	469	469	469	469
29	470	470	470	470	470
30	471	471	471	471	471
31	476	476	475	475	475
32	480	480	480	480	479
33	485	485	484	484	483

5-3

STRESS ANALYSIS OF HIGH PRESSURE INJECTION NOZ BEHNKE ITERATION 27976

PEAK PRINCIPAL STRESSES

SEG. NO.	OUTSIDE LONG	OUTSIDE HOOP	OUTSIDE RAD.	MIDPLANE LONG	MIDPLANE HOOP	MIDPLANE RAD.	INSIDE LONG	INSIDE HOOP	INSIDE RAD.
1	.3	.1	-.0	-.0	-.0	-.0	-.3	-.1	-.0
2	-1.1	-1.1	-.0	.1	-.9	-.0	1.2	-.7	-.0
3	-8.9	4.2	.0	.5	6.2	.3	10.1	13.1	.0
4	119.0	28.7	-.2	-7.1	-7.3	-1.3	-134.9	-51.3	-.2
5	810.0	63.2	-3.7	-33.0	-186.4	-29.6	-1020.6	-724.7	-3.7
	465.1	203.7	-9.5	-33.8	-100.9	-79.3	-752.1	-718.5	-9.5
[illegible]	375.6	258.0	-12.3	-30.6	-93.1	-107.4	-765.0	-892.1	-12.3
8	467.2	-20.5	-14.3	-33.4	-358.7	-126.5	-829.1	-1233.1	-14.3
9	-298.4	396.3	-12.3	-2.0	334.8	-116.7	-3.4	-81.0	-12.3
10	21.9	76.7	-7.6	3.2	96.9	-40.4	-349.4	-236.3	-7.6
11	67.2	-45.1	-9.4	19.4	-79.1	-6.6	-411.9	-549.2	-9.4
12	281.5	560.9	-19.5	-37.1	72.3	-99.0	-366.3	-610.3	-19.5
13	580.3	660.5	-24.5	-106.5	255.9	-165.4	-929.0	-464.6	-24.5
14	2014.4	976.0	-28.4	-270.4	308.3	-208.7	-2916.9	-1088.2	-28.4
15	3068.3	1238.8	-36.2	-433.9	495.1	-244.3	-5151.2	-742.0	-36.2
17	4162.2	1585.3	-43.5	-471.5	495.2	-279.3	-5011.4	-820.0	-43.5
18	5037.7	1752.2	-57.7	-698.7	66.7	-377.6	-6381.3	-2079.2	-57.7
19	7415.2	408.3	-105.4	-808.3	-2597.2	-709.9	-9388.8	-7164.0	-105.4
20	6402.9	-4176.8	-192.4	-689.2	-8511.7	-1343.2	-6385.4	-15486.8	-192.4
21	1593.5	-9153.1	-247.6	-565.5	-13740.1	-1799.4	-2329.6	-20114.5	-247.6
23	3557.9	14124.0	100.7	-54.0	16796.6	811.8	-3852.2	20274.7	100.7
24	-9401.0	3090.5	117.8	779.3	7219.8	884.3	9723.5	12104.8	117.8
[illegible]	-3336.8	-1832.1	62.3	361.2	-966.4	434.8	3775.5	-289.5	62.3
26	-898.4	-913.4	8.8	75.8	-895.4	53.5	897.7	-908.9	8.8
27	206.7	-255.2	-2.0	-23.3	-343.7	-18.4	-228.9	-469.5	-2.0
28	-153.2	-152.7	1.2	-9.7	-73.3	3.3	162.7	106.7	1.2
29	-228.9	-80.5	10.0	18.6	109.3	60.7	299.9	513.2	10.0
30	-151.8	36.3	22.3	47.5	315.8	137.9	279.3	934.6	22.3
31	60.7	65.7	13.2	54.1	174.9	89.1	9.5	309.3	13.2
32	549.2	54.5	2.7	1.5	-7.1	26.6	-604.7	-206.1	2.7
33	1148.0	-319.9	-20.6	-39.9	-550.9	-119.8	-1056.1	-1355.0	-20.6

TEMPERATURES PER SEGMENT USED IN PRIMARY + SECONDARY ANALYSIS ITER 6

SEGMENT	OUTSIDE T1	T2	T3	T4	INSIDE T5	SEGMENT	OUTSIDE T1	T2	T3	T4	INSIDE T5
1	472	399	326	253	180	17	480	480	480	480	480
2	472	399	326	253	180	18	480	480	480	480	480
3	472	399	326	253	180	19	480	480	480	480	480
4	472	399	326	253	180	20	480	480	480	480	480
5	504	426	348	270	192	21	480	480	480	480	480
6	504	426	348	270	192	22	480	480	480	480	480
7	504	426	348	270	192	23	480	480	480	480	480
8	504	426	348	270	192	24	480	480	480	480	480
9	527	454	382	309	237	25	480	480	480	480	480
10	549	482	415	348	281	26	480	480	480	480	480
11	549	482	415	348	281	27	480	480	480	480	480
12	527	487	446	406	365	28	480	480	480	480	480
13	527	487	447	407	367	29	480	480	480	480	480
14	526	487	448	408	369	30	480	480	480	480	480
15	526	487	448	410	371	31	480	480	480	480	480
16	480	480	480	480	480	32	480	480	480	480	480
						33	480	480	480	480	480

PRIMARY + SECONDARY STRESSES

ITER 6

SEG. NO.	OUTSIDE LONG	OUTSIDE HOOP	OUTSIDE RAD.	MIDPLANE LONG	MIDPLANE HOOP	MIDPLANE RAD.	INSIDE LONG	INSIDE HOOP	INSIDE RAD.
1	-49756.9	-49747.3	1105.1	4195.4	365.5	7609.1	55866.3	55881.4	1105.1
2	-49744.0	-49745.1	1105.1	4194.6	363.5	7608.9	55851.7	55874.5	1105.1
3	-49794.9	-49790.8	1105.0	4197.8	326.4	7608.3	55909.6	55847.6	1105.0
4	-50148.2	-49592.8	1106.9	4217.9	668.8	7622.0	56307.7	56413.1	1106.9
5	-59698.5	-57613.8	1143.7	4766.9	-2352.6	7863.2	67062.9	58116.0	1143.7
6	-52889.4	-54992.0	1322.8	5088.5	-2648.8	9028.9	60490.7	56520.9	1322.8
7	-62580.4	-56901.5	1394.7	5765.6	-1432.6	9526.8	71427.3	61353.0	1394.7
8	-69285.5	-57986.5	1466.6	6293.2	-248.5	10026.2	79003.4	65046.7	1466.6
9	-39747.3	-42979.9	1687.3	5752.1	3125.2	11392.4	48477.6	59394.2	1687.3
10	-27896.5	-35766.0	2014.4	6081.3	3649.0	13220.0	36850.2	54778.9	2014.4
11	-29596.2	-34858.2	2166.1	6607.5	5629.2	14007.5	39221.6	57834.2	2166.1
12	-27636.1	-26944.1	1807.0	6651.6	-122.5	11664.8	36297.2	30947.4	1807.0
13	-23677.6	-23629.1	1386.1	4846.0	1798.5	8922.6	30946.7	34223.0	1386.1
14	-13782.4	-19366.8	1356.8	3769.7	3647.4	8809.3	18524.5	32303.3	1356.8
15	-7909.5	-16795.2	1229.1	2839.9	4435.0	8010.7	11155.9	31116.8	1229.1
17	-10084.4	-6895.7	52.0	1074.4	-5514.4	266.9	12082.2	-4216.6	52.0
18	-4029.8	-5647.4	1.4	459.7	-6233.9	-68.8	4747.5	-7633.2	1.4
19	6200.4	-3416.3	-110.5	-672.1	-7318.9	-811.4	-7684.6	-13089.5	-110.5
20	7597.6	-5509.4	-225.8	-1032.9	-10963.3	-1610.3	-9495.8	-18627.7	-225.8
21	2586.7	-9810.7	-281.0	-721.6	-15110.3	-2049.3	-3568.9	-22409.9	-281.0
23	5272.0	14127.9	80.1	-203.4	16142.3	666.6	-5822.8	18849.4	80.1
24	-7331.9	3523.0	103.7	676.6	7360.2	787.0	8499.8	11946.1	103.7
25	-3356.7	-1646.6	59.9	359.1	-722.4	420.4	3810.3	40.9	59.9
26	-685.3	-845.0	9.1	70.1	-801.5	56.6	775.8	-828.4	9.1
27	391.9	-94.7	-3.5	-27.4	-258.1	-27.2	-451.5	-485.2	-3.5
28	139.1	-2.0	-3.5	-24.6	-51.2	-24.9	-166.9	-101.3	-3.5
29	54.2	13.6	-1.6	-14.3	-2.6	-10.8	-74.7	-9.9	-1.6
30	23.3	13.6	-.6	-6.8	7.3	-3.2	-32.3	11.1	-.6
31	10.8	13.5	-.3	-1.8	10.0	-.6	-11.8	14.8	-.3
32	2.7	8.9	-.1	.4	6.7	.8	-.7	10.3	-.1
33	.5	7.0	-.1	.9	4.5	1.0	2.1	6.6	-.1

(LONGITUDINAL DIRECTION IS ALONG SHELL MIDSURFACE. RADIAL DIRECTION IS NORMAL TO SHELL MIDSURFACE.)

TEMPERATURES PER SEGMENT USED [illegible] FOR PRINCIPLE ANALYSIS

SEGMENT	T1 (OUTSIDE)	T2	T3	T4	T5 (INSIDE)
1	422	405	353	260	127
2	422	405	353	260	127
3	422	405	353	260	127
4	422	405	353	260	127
5	447	432	380	280	127
6	447	432	380	280	127
7	447	432	380	280	127
8	447	432	380	280	127
9	463	454	421	332	127
10	479	477	462	385	127
11	479	477	462	385	127
12	480	480	480	440	235
13	480	480	480	442	237
14	480	480	480	443	238
15	480	480	480	445	240
16	480	480	480	480	480
17	480	480	480	480	480
18	480	480	480	480	480
19	480	480	480	480	480
20	480	480	480	480	480
21	480	480	480	480	480
22	480	480	480	480	480
23	480	480	480	480	480
24	480	480	480	480	480
25	480	480	480	480	480
26	480	480	480	480	480
27	480	480	480	480	480
28	480	480	480	480	480
29	480	480	480	480	480
30	480	480	480	480	480
31	480	480	480	480	480
32	480	480	480	480	480
33	480	480	480	480	480

0 0 0 PEAK PRINCIPAL STRESSES

SEG. NO.	OUTSIDE LONG	OUTSIDE HOOP	OUTSIDE RAD.	MIDPLANE LONG	MIDPLANE HOOP	MIDPLANE RAD.	INSIDE LONG	INSIDE HOOP	INSIDE RAD.
1	-31531.0	-31516.3	1115.3	-5549.7	-9323.5	7388.8	74996.8	75020.7	1115.3
2	-31517.6	-31513.7	1115.3	-5550.5	-9325.0	7388.6	74981.6	75014.1	1115.3
3	-31563.9	-31561.6	1115.2	-5547.5	-9366.3	7387.8	75034.5	74980.5	1115.2
4	-31978.7	-31378.0	1117.2	-5523.8	-8999.6	7402.2	75502.3	75573.1	1117.2
5	-50961.3	-32896.2	1167.5	-6700.2	-13910.1	7588.2	104192.5	85987.6	1167.5
6	-32204.5	-33793.1	1368.1	-6422.1	-13476.2	8620.6	84198.5	80912.9	1368.1
7	-41056.7	-35254.2	1436.8	-5797.5	-12009.1	9098.1	94192.5	85767.7	1436.8
8	-65828.7	-29758.9	1503.5	-5324.4	-10692.6	9563.4	116512.6	93594.1	1503.5
	-16469.7	-19767.5	1871.9	-8730.6	-10722.4	10100.0	87873.7	99071.9	1871.9
1[illegible]	-4414.6	-11562.8	2593.8	-11598.5	-14031.0	9739.4	94786.3	109508.6	2593.8
11	-5496.6	-10340.7	2982.7	-11716.2	-12429.4	9165.1	96443.8	112611.9	2982.7
12	-9758.1	-9655.9	2601.0	-7000.7	-13615.7	6969.9	82689.2	76969.9	2601.0
13	-6431.4	-6633.6	2171.1	-8410.0	-10670.8	4429.8	77968.6	80662.6	2171.1
14	1698.6	-3022.5	2159.2	-9057.7	-8587.8	4359.0	67644.5	79498.9	2159.2
15	6587.7	-944.4	2058.5	-9592.1	-7630.7	3668.5	65144.2	79477.8	2058.5
17	-7596.0	-5550.8	31.9	798.4	-4672.0	146.0	9087.2	-3916.7	31.9
18	-2350.3	-4467.9	-11.5	266.7	-5280.6	-142.0	2732.9	-6856.8	-11.5
19	6572.7	-2759.2	-110.9	-717.1	-6554.3	-803.1	-8118.0	-12104.0	-110.9
20	7520.5	-5278.9	-220.3	-1016.4	-10601.2	-1567.8	-9392.8	-18083.7	-220.3
21	2481.9	-9710.3	-276.1	-702.0	-14919.7	-2013.6	-3436.4	-22105.8	-276.1
23	5088.5	14201.0	83.1	-186.0	16307.1	688.0	-5610.6	19123.0	83.1
24	-7503.0	3487.5	106.0	692.9	7382.5	803.2	8696.3	12030.1	106.0
25	-3365.9	-1672.4	60.5	360.8	-759.4	424.5	3819.2	4.9	60.5
26	-769.4	-821.3	9.0	69.5	-813.0	56.0	767.8	-845.8	9.0
2[illegible]	449.6	-112.8	-3.6	-28.0	-260.4	-27.8	-457.6	-489.6	-3.6
[illegible]	131.7	-1.7	-3.6	-25.0	-51.3	-25.2	-169.0	-101.7	-3.6
29	54.8	13.8	-1.7	-14.5	-2.4	-10.9	-75.5	-9.6	-1.7
30	23.5	13.7	-.6	-6.8	7.5	-3.2	-32.6	11.3	-.6
31	10.9	13.6	-.3	-1.8	10.1	-.6	-11.9	15.0	-.3
32	2.6	9.0	-.1	.4	6.7	.8	-.7	10.4	-.1
33	1.0	7.1	-.1	.9	4.5	1.0	2.2	6.6	-.1

(LONGITUDINAL DIRECTION IS ALONG SHELL MIDSURFACE. RADIAL DIRECTION IS NORMAL TO SHELL MIDSURFACE.)

TEMPERATURES PER SEGMENT USED IN PRIMARY + SECONDARY ANALYSIS
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	OUTSIDE				INSIDE
SEGMENT	T1	T2	T3	T4	T5
1	558	475	391	308	224
2	558	475	391	308	224
3	558	475	391	308	224
4	558	475	391	308	224
5	560	482	404	326	247
6	560	482	404	326	247
7	560	482	404	326	247
8	560	482	404	326	247
9	554	487	421	354	288
10	547	492	437	383	328
11	547	492	437	383	328
12	498	485	471	457	443
13	498	485	471	457	444
14	498	484	471	458	444
15	497	484	471	458	445
16	480	480	480	480	480

	OUTSIDE				INSIDE
SEGMENT	T1	T2	T3	T4	T5
17	480	480	480	480	480
18	480	480	480	480	480
19	480	480	480	480	480
20	480	480	480	480	480
21	480	480	480	480	480
22	480	480	480	480	480
23	480	480	480	480	480
24	480	480	480	480	480
25	480	480	480	480	480
26	480	480	480	480	480
27	480	480	480	480	480
28	480	480	480	480	480
29	480	480	480	480	480
30	480	480	480	480	480
31	480	480	480	480	480
32	480	480	480	480	480
33	480	480	480	480	480

PRIMARY + SECONDARY STRESSES

SEG. NO.	OUTSIDE LONG	OUTSIDE HOOP	OUTSIDE RAD.	MIDPLANE LONG	MIDPLANE HOOP	MIDPLANE RAD.	INSIDE LONG	INSIDE HOOP	INSIDE RAD.
1	-56571.9	-56563.4	1256.5	4770.1	415.0	8651.7	63518.0	63536.9	1256.5
2	-56572.3	-56572.2	1256.5	4770.2	404.6	8651.4	63518.6	63524.5	1256.5
3	-56700.0	-56566.2	1256.9	4777.7	455.8	8654.1	63663.0	63633.3	1256.9
4	-55798.1	-56129.0	1256.3	4722.8	665.0	8651.6	62638.3	63564.6	1256.3
5	-60614.9	-57521.0	1219.8	5058.8	-2350.8	8388.6	68193.0	58692.1	1219.8
[illegible]	-51951.5	-54244.5	1323.0	5043.4	-2163.6	9034.2	59439.5	56677.2	1323.0
[illegible]	-59818.5	-55870.2	1381.0	5592.9	-1269.8	9435.6	68316.7	60481.5	1381.0
8	-65323.1	-56880.6	1438.8	6023.6	-448.0	9836.2	74534.6	63327.5	1438.8
9	-35787.6	-38514.3	1595.1	5384.1	3745.0	10777.3	43760.2	55049.4	1595.1
10	-23077.5	-27950.0	1773.0	5343.9	5172.4	11667.2	30683.2	47809.5	1773.0
11	-22830.3	-26971.6	1818.7	5359.4	6419.9	11805.4	30431.8	49393.6	1818.7
12	-13865.9	-12966.9	1160.0	4522.3	-2689.1	7492.1	18381.0	5154.8	1160.0
13	-7378.9	-8930.3	449.0	1550.4	-1074.5	2851.0	9595.8	8639.1	449.0
14	-2749.4	-6064.7	434.6	1007.4	1123.7	2818.1	3843.1	10008.7	434.6
15	-430.2	-4949.9	387.8	653.9	1619.1	2534.1	945.4	9838.9	387.8
17	-369.1	-989.8	-10.6	24.3	-1245.3	-86.3	416.5	-1658.1	-10.6
18	2236.0	-627.4	-33.7	-238.2	-1791.4	-241.2	-2744.8	-3478.5	-33.7
19	7186.0	-838.8	-100.0	-777.1	-4107.2	-693.9	-8801.8	-8768.6	-100.0
20	7013.9	-4723.0	-198.6	-926.5	-9582.6	-1404.2	-8750.3	-16464.8	-198.6
21	1989.5	-9533.2	-259.7	-621.6	-14445.4	-1895.9	-2824.1	-21273.6	-259.7
23	4250.4	14269.0	93.8	-111.8	16719.1	764.4	-4645.9	19935.0	93.8
24	-8084.2	3284.5	113.6	748.4	7353.6	856.5	9362.0	12178.4	113.6
[illegible]	-3349.0	-1751.0	62.1	362.2	-853.2	434.5	3793.5	-143.5	62.1
26	-639.0	-866.9	8.6	66.2	-847.2	52.6	722.3	-903.4	8.6
27	411.5	-95.1	-3.9	-30.2	-265.5	-30.1	-475.4	-499.6	-3.9
28	136.0	-.4	-3.7	-26.1	-51.0	-26.1	-174.9	-101.8	-3.7
29	56.2	14.7	-1.7	-14.9	-1.7	-11.1	-77.6	-8.6	-1.7
30	23.9	14.1	-.6	-7.0	8.0	-3.2	-33.3	12.2	-.6
31	10.9	13.8	-.3	-1.8	10.4	-.6	-11.9	15.5	-.3
32	3.5	9.0	-.1	.4	6.8	.9	-.6	10.6	-.1
33	.3	6.9	-.0	1.0	4.5	1.0	2.3	6.7	-.0

(LONGITUDINAL DIRECTION IS ALONG SHELL MIDSURFACE. RADIAL DIRECTION IS NORMAL TO SHELL MIDSURFACE.)

TEMPERATURES PER SEGMENT USED IN PEAK PRINCIPLE ANALYSIS

SEGMENT	OUTSIDE T1	T2	T3	T4	INSIDE T5
1	478	473	445	340	76
2	478	473	445	340	76
3	478	473	445	340	76
4	478	473	445	340	76
5	479	477	458	367	74
6	479	477	458	367	74
7	479	477	458	367	74
8	479	477	458	367	74
9	479	478	468	408	86
10	479	479	478	450	98
11	479	479	478	450	98
12	480	480	480	480	370
13	480	480	480	480	372
14	480	480	480	480	373
15	480	480	480	480	375
16	480	480	480	480	480
17	480	480	480	480	480
18	480	480	480	480	480
19	480	480	480	480	480
20	480	480	480	480	480
21	480	480	480	480	480
22	480	480	480	480	480
23	480	480	480	480	480
24	480	480	480	480	480
25	480	480	480	480	480
26	480	480	480	480	480
27	480	480	480	480	480
28	480	480	480	480	480
29	480	480	480	480	480
30	480	480	480	480	480
31	480	480	480	480	480
32	480	480	480	480	480
33	480	480	480	480	480

PEAK PRINCIPAL STRESSES
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SEG. NO.	OUTSIDE LONG	OUTSIDE HOOP	OUTSIDE RAD.	MIDPLANE LONG	MIDPLANE HOOP	MIDPLANE RAD.	INSIDE LONG	INSIDE HOOP	INSIDE RAD.
1	-27543.0	-27531.5	1554.3	-15022.3	-18992.1	7070.8	116998.3	117022.5	1554.3
2	-27540.7	-27539.2	1554.3	-15022.4	-19002.2	7070.5	116995.8	117009.4	1554.3
3	-27670.4	-27543.5	1554.6	-15014.7	-18961.6	7072.8	117142.7	117104.9	1554.6
4	-26906.9	-27093.9	1554.5	-15061.5	-18689.8	7073.5	116274.4	117162.6	1554.5
5	-43079.7	-23849.0	1572.6	-14925.9	-21386.5	6593.0	144089.4	125578.1	1572.6
6	-22647.9	-24317.9	1801.7	-15130.5	-21049.4	6654.2	122157.7	120199.8	1801.7
	-29215.0	-25329.8	1853.6	-14664.7	-19869.6	7015.7	129573.0	123913.3	1853.6
8	-51361.5	-20006.5	1903.2	-14314.2	-18900.2	7361.7	149265.6	130543.4	1903.2
9	-8671.6	-11506.1	2300.6	-12467.8	-13271.0	7077.4	116882.6	127442.8	2300.6
10	-539.3	-4678.0	3021.6	-10500.4	-10790.6	5249.1	117164.4	128921.4	3021.6
11	93.7	-3446.9	3365.0	-11173.5	-10063.2	3885.7	116628.8	130656.9	3365.0
12	-5298.3	-5127.8	2185.7	-819.6	-6634.8	2194.1	43320.9	32004.4	2185.7
13	-528.6	-1967.7	964.8	-2403.5	-4147.0	286.3	35753.9	35082.0	964.8
14	3105.1	286.6	948.9	-2769.0	-2269.2	325.6	30707.9	35818.6	948.9
15	4972.5	1120.8	901.2	-3007.5	-1829.8	122.8	28163.4	35265.3	901.2
17	755.3	-309.2	-17.8	-97.4	-754.8	-127.5	-933.8	-1365.6	-17.8
18	2962.0	-47.5	-37.8	-319.1	-1279.1	-261.5	-3613.0	-3000.6	-37.8
19	7301.3	-540.5	-98.8	-789.5	-3736.0	-680.5	-8932.7	-8269.7	-98.8
20	6947.1	-4631.7	-195.5	-914.3	-9422.8	-1380.4	-8664.9	-16214.6	-195.5
21	1919.7	-9500.8	-257.3	-610.0	-14369.3	-1878.2	-2738.5	-21142.0	-257.3
23	4133.0	14285.7	95.4	-101.2	16784.9	775.7	-4510.6	20060.6	95.4
24	-8171.0	3257.1	114.8	756.7	7353.1	864.5	9461.6	12205.6	114.8
	-3348.2	-1763.1	62.3	362.5	-868.3	436.2	3791.7	-164.8	62.3
26	-718.6	-840.9	8.5	65.8	-852.5	52.1	716.1	-912.1	8.5
27	467.9	-113.8	-3.9	-30.6	-266.4	-30.5	-478.1	-501.3	-3.9
28	136.7	-.2	-3.7	-26.3	-51.0	-26.2	-175.8	-101.9	-3.7
29	56.4	14.8	-1.7	-15.0	-1.6	-11.2	-77.9	-8.4	-1.7
30	24.0	14.2	-.6	-7.0	8.1	-3.2	-33.4	12.3	-.6
31	11.0	13.8	-.3	-1.8	10.4	-.6	-11.9	15.6	-.3
32	2.5	9.0	-.1	.4	6.8	.9	-.5	10.6	-.1
33	.8	7.0	-.0	1.0	4.5	1.0	2.4	6.7	-.0

(LONGITUDINAL DIRECTION IS ALONG SHELL MIDSURFACE. RADIAL DIRECTION IS NORMAL TO SHELL MIDSURFACE.)

TEMPERATURES PER SEGMENT USED IN PRIMARY + SECONDARY ANALYSIS

OSC 1522

S-12

	OUTSIDE			INSIDE	
SEGMENT	T1	T2	T3	T4	T5
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	0	0	0	0	0
7	0	0	0	0	0
8	0	0	0	0	0
9	1	1	1	0	-0
10	3	2	1	0	-1
11	3	2	1	0	-1
12	16	13	10	7	4
13	29	24	19	13	8
14	42	35	27	20	12
15	69	68	66	65	64
16	69	68	66	65	64

	OUTSIDE			INSIDE	
SEGMENT	T1	T2	T3	T4	T5
17	69	68	66	65	64
18	69	68	66	65	64
19	99	97	96	94	92
20	129	127	125	123	120
21	139	139	138	137	136
22	139	139	138	137	136
23	139	139	138	137	136
24	159	158	157	156	155
25	200	197	195	192	190
26	230	227	224	221	218
27	260	257	254	250	247
28	290	285	281	277	272
29	319	314	308	303	298
30	348	342	336	330	323
31	377	370	363	356	349
32	407	399	391	383	374
33	436	427	418	409	400

PRIMARY + SECONDARY STRESSES

SEG. NO.	OUTSIDE LONG	OUTSIDE HOOP	OUTSIDE RAD.	MIDPLANE LONG	MIDPLANE HOOP	MIDPLANE RAD.	INSIDE LONG	INSIDE HOOP	INSIDE RAD.
1	.0	.0	.0	-.0	.0	.0	-.0	.0	.0
2	.2	-.1	-.0	-.0	-.2	-.0	-.2	-.4	-.0
3	-3.3	-.7	.0	.2	.4	.0	3.8	1.6	.0
4	11.4	11.8	.0	-.7	10.2	.2	-13.0	8.3	.0
5	102.4	-45.0	-.5	-5.9	-90.2	-3.5	-115.5	-145.9	-.5
6	-6.4	-135.3	-1.1	-1.5	-166.9	-8.1	5.4	-205.9	-1.1
7	-183.9	-248.9	-.7	9.0	-243.6	-5.8	204.5	-239.8	-.7
8	-374.8	-341.4	.4	21.6	-288.4	1.0	419.2	-230.2	.4
9	-949.0	-669.1	6.5	67.2	-308.8	40.4	994.4	155.9	6.5
10	-1272.2	-775.4	24.9	153.1	-31.2	157.6	1599.4	1048.4	24.9
11	-1668.9	-732.2	44.0	251.9	212.3	282.8	2134.1	1506.3	44.0
12	-3323.5	-2404.5	81.6	455.2	-151.7	520.5	4234.4	2980.3	81.6
13	-5822.0	-3371.7	172.9	843.6	935.5	1111.6	7481.4	7027.0	172.9
14	-5632.3	-1880.4	312.3	1016.1	4625.1	2061.4	7439.1	13877.5	312.3
15	-3848.8	-3758.9	200.0	1075.6	-2766.8	1308.0	4879.8	-3292.4	200.0
17	-4455.4	-3552.8	39.6	487.2	-2449.5	223.6	5356.4	-1223.1	39.6
18	-2533.0	-1395.2	48.2	305.8	-194.5	301.4	3090.3	1321.3	48.2
19	1279.0	-1836.3	23.8	-36.1	-1962.0	147.3	-1559.6	-2535.6	23.8
20	2986.1	-3546.1	-38.8	-311.8	-4768.8	-299.0	-3699.4	-6811.5	-38.8
21	1485.2	-4658.9	-93.7	-275.3	-6747.5	-703.7	-1961.9	-9809.9	-93.7
23	2870.7	3934.4	15.0	-165.4	4287.7	133.8	-3223.0	4807.2	15.0
24	-1979.1	898.9	32.2	174.4	2397.7	242.3	2306.2	4244.4	32.2
25	-3265.7	-1383.8	47.6	280.9	581.0	328.9	3766.7	2905.8	47.6
26	-3019.4	-2939.8	48.5	279.4	-1277.4	325.0	3466.9	565.5	48.5
27	-2289.7	-2773.8	92.2	184.2	-154.0	603.7	2695.4	3613.2	92.2
28	-2145.0	-2633.2	163.6	338.0	684.5	1048.5	2881.4	5973.4	163.6
29	-1502.4	-2753.7	239.1	476.2	834.3	1487.7	2439.1	6867.2	239.1
30	-912.2	-3242.6	283.6	520.6	191.3	1693.8	1838.4	6063.5	283.6
31	-467.7	-1867.4	205.7	294.9	884.5	1237.4	909.2	5205.6	205.7
32	1123.3	-2133.8	219.8	144.3	259.2	1333.0	-1313.0	3284.4	219.8
33	2604.2	-4118.0	105.7	-155.8	-3345.3	584.1	-3643.2	-4040.5	105.7

(LONGITUDINAL DIRECTION IS ALONG SHELL MIDSURFACE. RADIAL DIRECTION IS NORMAL TO SHELL MIDSURFACE.)

0 0 0 6 1 9 0 4 4 9

TEMPERATURES PER SEGMENT USED IN PEAK PRINCIPLE ANALYSIS

OSC 1522

SEGMENT	OUTSIDE T1	T2	T3	T4	INSIDE T5
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	0	0	0	0	0
7	0	0	0	0	0
8	0	0	0	0	0
9	2	1	1	0	0
10	3	2	1	0	0
11	3	2	1	0	0
12	15	13	11	7	3
13	28	24	20	13	7
14	40	35	30	20	10
15	68	68	66	65	65
16	68	68	66	65	65
17	68	68	66	65	65
18	68	68	66	65	65
19	99	98	95	94	93
20	130	127	125	123	120
21	145	137	136	138	137
22	145	137	136	138	137
23	145	137	136	138	137
24	160	158	157	156	155
25	200	197	195	192	190
26	230	227	225	221	219
27	260	257	255	250	247
28	289	285	282	276	272
29	319	314	309	303	298
30	348	342	336	329	323
31	377	370	364	356	349
32	407	399	391	382	374
33	436	427	418	409	400

5-14

9006190441

5-15

PEAK PRINCIPAL STRESSES

SEG. NO.	OUTSIDE LONG	OUTSIDE HOOP	OUTSIDE RAD.	MIDPLANE LONG	MIDPLANE HOOP	MIDPLANE RAD.	INSIDE LONG	INSIDE HOOP	INSIDE RAD.
1	.0	.0	.0	-.0	.0	.0	-.0	.0	.0
2	.2	-.1	-.0	-.0	-.2	-.0	-.2	-.4	-.0
3	-3.4	-.7	.0	.2	.4	.0	3.8	1.7	.0
4	11.6	11.9	.0	-.7	10.3	.2	-13.2	8.3	.0
5	123.4	-52.4	-.5	-5.9	-91.4	-3.6	-139.1	-154.0	-.5
6	-7.6	-137.2	-1.1	-1.4	-168.8	-8.2	6.7	-207.9	-1.1
	-187.6	-251.9	-.7	9.2	-246.0	-5.8	208.7	-241.5	-.7
8	-483.5	-311.9	.4	22.0	-290.8	1.1	508.6	-208.6	.4
9	-879.4	-697.3	5.7	82.3	-292.1	44.7	873.0	40.5	5.7
10	-1316.8	-825.6	21.6	184.2	6.6	173.7	1336.2	817.1	21.6
11	-1709.6	-781.7	39.2	285.5	253.1	306.0	1864.6	1272.5	39.2
12	-3070.8	-2154.7	77.8	173.0	-437.6	528.1	4366.2	3109.9	77.8
13	-5276.4	-2821.5	170.9	238.2	318.3	1087.5	8016.0	7524.3	170.9
14	-4842.5	-1027.0	312.7	92.8	3700.3	2009.2	8439.9	14803.6	312.7
15	-3549.2	-3489.5	193.2	1220.9	-2613.2	1309.8	6149.8	-3155.8	193.2
17	-4155.9	-3287.6	26.4	656.5	-2278.4	275.8	4988.6	-1531.0	26.4
18	-2247.1	-1117.9	35.2	476.5	-14.9	355.0	2739.0	1031.1	35.2
19	1313.3	-1793.6	16.4	54.9	-1857.2	181.2	-1624.8	-2574.8	16.4
20	2790.7	-3722.4	-35.5	-312.1	-4751.1	-307.6	-3500.3	-6608.7	-35.5
21	-486.9	-6692.4	-69.4	358.5	-6092.9	-785.1	-2277.2	-10102.0	-69.4
23	1393.2	2425.8	36.1	297.1	4750.0	59.5	-3417.2	4604.3	36.1
24	-2151.2	728.3	43.9	177.7	2406.5	201.2	2262.7	4208.2	43.9
	-3360.4	-1475.6	48.7	184.0	487.5	324.4	3672.8	2816.4	48.7
26	-3402.1	-2784.6	48.1	56.7	-1495.5	324.1	3410.5	518.1	48.1
27	-2469.7	-2544.1	90.4	-164.7	-500.3	602.3	2690.3	3611.6	90.4
28	-2046.8	-2530.9	161.1	45.7	392.6	1043.1	2879.2	5972.6	161.1
29	-1424.7	-2672.6	236.8	240.6	598.7	1478.8	2440.2	6870.1	236.8
30	-854.6	-3182.2	281.8	342.4	13.9	1683.4	1841.4	6069.9	281.8
31	-426.8	-1825.6	204.4	174.4	766.2	1227.7	908.0	5212.2	204.4
32	1145.9	-2111.3	219.0	83.1	201.4	1327.3	-1316.6	3290.2	219.0
33	3438.5	-4462.2	105.4	-157.6	-3344.1	582.2	-3651.4	-4039.7	105.4

(LONGITUDINAL DIRECTION IS ALONG SHELL MIDSURFACE. RADIAL DIRECTION IS NORMAL TO SHELL MIDSURFACE.)

ITER.	PRIMARY + SECONDARY STRESS INTENSITIES						PEAK STRESS INTENSITIES					
	L - P		P - H		H - L		L - R		R - R		H - L	
	INSIDE	OUTSIDE	INSIDE	OUTSIDE	INSIDE	OUTSIDE	INSIDE	OUTSIDE	INSIDE	OUTSIDE	INSIDE	OUTSI
3	58.1	-53.6	-50.2	50.9	-7.9	2.7	104.1	-42.6	-88.1	25.8	-16.0	16.
6	65.9	-60.8	-57.0	58.8	-8.9	2.1	103.0	-52.1	-84.8	34.0	-18.2	18.
8	64.1	-59.2	-55.2	57.8	-8.9	1.4	97.5	-51.9	-79.6	34.8	-18.0	17.
15	49.7	-45.8	-40.0	44.1	-9.7	1.7	72.7	-50.7	-56.0	37.1	-16.7	13.
30	1.4	-1.1	1.1	-.5	-2.4	1.7	1.1	-1.5	1.6	-.4	-2.6	1.
1211	.1	-.1	-.2	-.1	.1	.2	.2	-.1	-.3	-.1	.1	.
91	-.0	.0	.0	-.0	.0	-.0	-.0	.0	.0	.0	.0	-.
1	1.7	1.4	-4.0	-2.3	2.3	.0	1.8	1.6	-4.0	-2.3	2.2	.
27976	-.8	.7	.7	-.2	.2	-.5	-1.0	.8	.7	.0	.3	-.
42021	.0	.0	.0	.0	.0	.0	-.1	.1	.1	.0	.0	-.1

STRESS OUTPUT ANALYSIS

5072	60.1	-55.4	-50.2	56.3	-9.9	-.8	87.9	-49.1	-69.5	35.3	-18.3	13.
5060	67.0	-61.8	-57.5	58.7	-9.5	3.1	142.5	-44.7	-124.0	25.4	-18.5	19.
5063	83.9	-77.5	-72.4	74.4	-11.5	3.1	129.2	-67.0	-105.9	43.5	-23.3	23.
5124	11.6	-10.6	-4.9	10.1	-6.7	.5	13.7	-12.2	-5.3	8.8	-8.4	3.
5237	2.2	-1.9	.3	1.9	-2.5	.0	2.8	-2.4	.0	1.8	-2.8	.
6059	-.1	.1	.2	.0	-.0	-.2	-.2	.1	.2	.1	-.0	-.

6307	-.1	.1	.1	.0	-.0	-.1	-.1	.1	.2	.1	-.0	-.
338	-5.7	5.3	4.5	-4.8	1.2	-.4	-7.2	6.3	5.1	-4.4	2.0	-1.
850	-6.7	6.2	6.8	-4.0	-.1	-2.2	-8.4	6.3	7.5	-2.4	.9	-3.
1	1.7	1.4	-4.0	-2.3	2.3	1.0	1.8	1.6	-4.0	-2.3	2.2	.

STRESS OUTPUT ANALYSIS

5-16

0006 [illegible] D 4.4 83

ITER	PRIMARY + SECONDARY STRESS INTENSITIES L - R INSIDE	L - R OUTSIDE	R - H INSIDE	R - H OUTSIDE	H - L INSIDE	H - L OUTSIDE	PEAK STRESS INTENSITIES L - R INSIDE	L - R OUTSIDE	R - H INSIDE	R - H OUTSIDE	H - L INSIDE	H - L OUTS
3	63.7	-59.2	-54.7	50.2	-9.0	7.9	109.0	-50.7	-92.9	22.5	-16.0	28
6	77.5	-70.8	-63.6	59.5	-14.0	11.3	115.0	-67.3	-92.1	31.3	-22.9	36
8	78.8	-71.9	-62.9	59.2	-16.0	12.6	113.3	-70.6	-88.0	32.7	-25.3	37
15	69.3	-63.0	-47.3	48.2	-22.0	14.9	95.0	-75.0	-64.2	38.0	-30.9	37
30	7.7	-6.9	-1.2	1.1	-6.5	5.8	8.7	-9.4	-1.0	1.2	-7.7	8
1211	-.4	.3	.1	-.1	.3	-.2	-.4	.4	.1	-.1	.4	-
1491	.0	-.0	.0	.0	-.0	-.0	.0	-.0	.0	.0	-.0	-
1	2.2	.6	-3.5	-1.6	1.3	1.0	2.5	.9	-3.5	-1.6	1.0	
42621	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	
[illegible]	-.7	.6	1.1	-.3	-.5	-.3	-.8	.5	1.2	.0	-.4	-

STRESS OUTPUT ANALYSIS

ITER	L - R INSIDE	L - R OUTSIDE	R - H INSIDE	R - H OUTSIDE	H - L INSIDE	H - L OUTSIDE	L - R INSIDE	L - R OUTSIDE	R - H INSIDE	R - H OUTSIDE	H - L INSIDE	H - L OUTS
5072	86.0	-78.3	-62.4	60.0	-23.6	18.3	117.3	-80.5	-83.1	34.7	-34.2	45
5060	73.1	-66.8	-61.9	58.3	-11.2	6.4	147.4	-53.3	-128.6	21.9	-18.7	31
5063	97.9	-89.3	-81.4	74.5	-16.4	14.8	143.3	-85.3	-115.7	39.3	-27.6	46
5124	33.0	-29.7	-13.1	15.1	-19.8	14.7	39.9	-36.7	-15.8	11.4	-24.1	25
5237	11.5	-10.4	-3.8	5.5	-7.7	4.9	14.2	-13.4	-5.1	4.8	-9.2	8
6059	.4	-.4	.3	.4	-.7	-.0	.5	-.5	.3	.3	-.8	
6307	.4	-.4	.2	.3	-.6	.0	.5	-.5	.2	.3	-.7	.2
6338	-7.7	7.0	5.6	-5.1	2.1	-1.9	-9.6	8.7	6.6	-4.3	3.1	-4.9
350	-3.5	3.1	-1.0	-.5	4.5	-2.6	-1.3	4.1	-3.4	-.4	4.7	-3.7
1	2.2	.6	-3.5	-1.6	1.3	1.0	2.5	.9	-3.5	-1.6	1.0	[illegible]

STRESS OUTPUT ANALYSIS

ITER	PRIMARY + SECONDARY STRESS INTENSITIES						PEAK STRESS INTENSITIES					
	L – R		R – H		H – L		L – R		R – H		H – L	
	INSIDE	OUTSIDE	INSIDE	OUTSIDE	INSIDE	OUTSIDE	INSIDE	OUTSIDE	INSIDE	OUTSIDE	INSIDE	OUTSI
3	-2.8	2.5	21.5	9.4	-18.7	-11.9	-2.7	2.4	21.3	9.3	-18.6	-11.
6	-3.3	2.9	22.1	9.5	-18.8	-12.4	-3.2	2.8	21.8	9.4	-18.7	-12.
8	-3.7	3.3	22.5	9.6	-18.8	-12.8	-3.6	3.2	22.3	9.5	-18.6	-12.
15	-4.1	3.6	24.0	10.1	-19.9	-13.7	-4.1	3.5	23.8	10.0	-19.7	-13.
30	-3.3	2.8	21.0	10.3	-17.7	-13.1	-4.1	2.5	21.7	10.6	-17.6	-13.
1211	-2.1	1.8	19.9	9.1	-17.8	-10.9	-2.2	1.4	20.0	9.6	-17.8	-10.
91	-2.4	2.1	21.3	9.5	-18.9	-11.6	-2.4	2.1	21.3	9.5	-18.9	-11.
1	1.1	.6	-3.3	-1.2	2.2	.7	1.1	.6	-3.3	-1.2	2.2	.

STRESS OUTPUT ANALYSIS

5072	-4.7	4.0	23.0	9.4	-18.4	-13.5	-4.6	4.0	22.8	9.3	-18.2	-13
5060	-2.6	2.2	21.0	9.3	-18.4	-11.5	-2.5	2.2	20.9	9.2	-18.4	-11
5063	-3.2	2.8	21.8	9.4	-18.6	-12.2	-3.1	2.7	21.6	9.3	-18.5	-12
5124	-5.6	4.7	21.6	13.3	-16.0	-13.0	-2.7	5.6	18.7	12.3	-16.0	-17
5237	-5.4	4.5	15.5	11.5	-10.2	-15.9	-4.0	4.7	14.2	11.2	-10.2	-15.
6059	-2.6	2.2	9.7	5.9	-7.1	-3.1	.1	1.8	7.1	6.3	-7.3	-8.
6307	-1.9	1.6	9.7	4.6	-7.8	-6.1	-2.2	-.4	10.0	6.6	-7.8	-6.
6338	-1.4	1.2	9.4	4.6	-8.0	-5.8	-1.8	-.8	9.7	6.6	-8.0	-5.
850	-1.2	1.1	12.2	5.5	-11.0	-6.6	-1.2	1.1	12.2	5.5	-11.0	-6.
1	1.1	.6	-3.3	-1.2	2.2	.7	1.1	.6	-3.3	-1.2	2.2	.

STRESS OUTPUT ANALYSIS

STRESS INSIDE OUTSIDE INSIDE OUTSIDE INSIDE OUTSIDE INSIDE OUTSIDE INSIDE OUTSIDE INSIDE OUTSI

ITER	PRIMARY + SECONDARY STRESS INTENSITIES						PEAK STRESS INTENSITIES					
	L - R		R - H		H - L		L - R		R - H		H - L	
	INSIDE	OUTSIDE	INSIDE	OUTSIDE	INSIDE	OUTSIDE	INSIDE	OUTSIDE	INSIDE	OUTSIDE	INSIDE	OUTSIDE
3	-5.2	4.6	-19.4	-14.1	24.6	9.5	-5.0	4.4	-19.6	-14.1	24.6	9.
6	-5.9	5.2	-18.8	-14.0	24.7	8.9	-5.7	5.0	-19.0	-14.1	24.7	9.
8	-6.6	5.8	-18.3	-14.1	24.9	8.3	-6.4	5.7	-18.6	-14.2	25.0	8.
15	-7.2	6.4	-17.1	-13.6	24.4	7.3	-7.2	6.3	-17.3	-13.7	24.4	7.
30	-5.8	5.1	-19.2	-13.3	25.0	8.2	-6.2	4.8	-18.9	-13.1	25.1	8.
1211	-3.9	3.4	-20.0	-13.8	23.9	10.8	-4.0	3.1	-19.9	-13.4	23.9	10.
[illegible]91	-4.4	3.9	-21.0	-14.7	25.4	10.8	-4.4	3.9	-21.0	-14.7	25.4	10.
1	1.9	.4	-3.3	-1.4	1.4	.9	1.9	.4	-3.3	-1.4	1.4	.
27976	-4.0	3.5	-20.3	-14.0	24.1	10.6	-4.0	3.5	-20.1	-14.0	24.1	10.
42321	-4.5	3.9	-20.7	-14.6	25.2	10.7	-4.5	3.1	-20.7	-14.6	24.2	10.

STRESS OUTPUT ANALYSIS

5072	-8.1	7.1	-17.7	-14.4	25.8	7.3	-8.0	7.0	-17.9	-14.4	25.9
5060	-4.7	4.2	-19.8	-14.2	24.6	10.0	-4.6	4.0	-20.0	-14.2	24.6
5063	-5.8	5.1	-19.0	-14.1	24.8	9.1	-5.6	4.9	-19.2	-14.2	24.8
5124	-9.5	8.4	-16.4	-12.3	25.9	3.9	-9.3	8.2	-16.8	-12.1	26.1
5237	-8.9	7.8	-18.9	-10.6	27.8	2.7	-8.0	8.1	-19.9	-10.9	28.0
6059	-4.5	3.9	-5.4	-4.4	9.8	.5	-5.0	3.3	-5.0	-3.7	10.0
6307	-3.2	2.9	-4.8	-3.9	8.0	1.1	-3.5	1.4	-4.6	-2.4	8.0
6338	-2.6	2.2	-5.2	-3.8	7.7	1.6	-2.8	.8	-4.9	-2.3	7.7
6850	-2.4	2.1	-11.6	-8.1	14.0	6.0	-2.4	2.1	-11.5	-8.1	13.9
1	1.9	.4	-3.3	-1.4	1.4	.9	1.9	.4	-3.3	-1.4	1.4

STRESS OUTPUT ANALYSIS

0 0 9 6 JUNCTION NO. 433

ITER	PRIMARY + SECONDARY STRESS INTENSITIES						PEAK STRESS INTENSITIES					
	L - R		R - H		H - L		L - R		R - H		H - L	
	INSIDE	OUTSIDE	INSIDE	OUTSIDE	INSIDE	OUTSIDE	INSIDE	OUTSIDE	INSIDE	OUTSIDE	INSIDE	OUTSI
3	.0	.0	-.0	-.0	.0	.0	.0	.0	-.0	-.0	.0	.0
6	.0	.0	-.0	-.0	.0	.0	.0	.0	-.0	-.0	.0	.0
8	.0	.0	-.0	-.0	.0	.0	.0	.0	-.0	-.0	.0	.0
15	.0	.0	-.0	-.0	.0	.0	.0	.0	-.0	-.0	.0	.
30	.6	-.5	-.6	.5	-.0	.0	1.5	-.3	-1.4	.1	-.0	.
1211	-.3	.3	.3	-.0	.0	-.2	-.3	.3	.3	.0	.0	-.
91	.0	.0	-.0	-.0	.0	.0	.0	.0	-.0	-.0	.0	.
1	1.1	.1	-2.2	-.3	1.2	.2	1.1	.2	-2.2	-.3	1.2	.
5072	.0	.0	-.0	-.0	.0	.0	.0	.0	-.0	-.0	.0	
5060	.0	.0	-.0	-.0	.0	.0	.0	.0	-.0	-.0	.0	
5063	.0	.0	-.0	-.0	.0	.0	.0	.0	-.0	-.0	.0	
5124	2.3	-1.8	-2.3	1.8	.1	.0	4.5	-1.4	-4.5	.6	-.1	
5237	1.8	-1.5	-2.0	3.2	.2	-1.7	3.2	-1.0	-3.3	2.0	.1	-1
6059	-1.7	1.1	2.1	3.3	-.3	-4.4	.1	2.6	.4	2.3	-.5	-
6307	-3.7	2.5	4.1	4.2	-.4	-6.7	-3.8	3.3	4.1	4.6	-.4	-7.
6338	-3.7	2.5	4.1	4.2	-.4	-6.7	-3.8	3.3	4.1	4.6	-.4	-7.
6850	-5.6	4.1	6.4	.1	-.8	-4.2	-5.6	5.4	6.4	.6	-.8	-6.
1	1.1	.1	-2.2	-.3	1.2	.2	1.1	.2	-2.2	-.3	1.2	.

STRESS OUTPUT ANALYSIS

DETERMINATION OF MAXIMUM STRESS
INTENSITIES RANGES AND FATIGUE ANALYSIS

Segment 5: Page 5-16 gives a summary of thermal stress intensities plus a stress intensity for a 1000 psi pressure. The worst stress intensity range for segment 5 would be full range of thermal stress from rapid depressurization plus pressure variation of 1500 psi (pressure at start of rapid depressurization) to 800 psi (pressure at time of reversal in thermal stress). The smaller pressure range is chosen since the pressure stresses are small and even the range of 2500 psi is less than the reversal in thermal stress. This will be assumed to occur 40 times.

The next maximum range comes from maximum thermal stress in the test transient plus range in pressure of 2200-0 psi (2200 psi is pressure at time of test).

The third range can be found using all the miscellaneous transients excluding the rapid depressurization and test transient. This last range will be shown to be acceptable for infinite number of cycles.

Segment 8 is analyzed for essentially same conditions as segment 5.

Segment 23, the carbon steel segment, is analyzed differently since it has less radial gradient thermal effects and its stress picture is more dependent on the temperature of the segment because of the bimetal weld.

Thus its highest stress intensity is derived from the range of its highest thermal stress to 0 stress plus the range of pressure from 2500 psi to 0. It is shown that all other ranges are essentially insignificant.

NOTE: This fatigue analysis includes thermal and mechanical discontinuity stresses only. For inclusion of stresses due to run and branch pipe motions, see Section "F".

D.McK.
10/29/73
REV. 1

BMS-2421

CRITICAL STRESS JUNCTURE 5 (STAINLESS)

PRIMARY + SECONDARY STRESS

MAX. THERMAL STRESS RANGE = 83.9 - (-6.7) = 90.6 KSI

ITER. 5063 ITER. 6850

MAX. PRESSURE RANGE = 1500 - 800 = 0.7(1.7) = 1.2 KSI

$S_N = 90.6 + 1.2 = 91.8 \text{ KSI} > 3S_m = 51.3 \text{ KSI}$

ELASTIC - PLASTIC ANALYSIS WILL BE PERFORMED

1.) EQUATION 9 IS SATISFIED

2.) IT WILL BE SHOWN THAT PRIMARY PLUS SECONDARY STRESS RANGES DO NOT EXCEED $3S_m$ MORE THAN 250 CYCLES.

THE ABOVE RANGE WAS REPRESENTATIVE OF THE RAPID DEPRESSURIZATION CYCLE. THEREFORE IT OCCURRED 40 CYCLES.

- NEXT MAXIMUM RANGE WILL BE FROM THE TEST TRANSIENT -

RANGE IN THERMAL STRESS = 65.9 KSI

ITER. 6

RANGE IN PRESSURE 2200 PSI - 0 = 2.2(1.7) = 3.74 KSI

$S_N = 65.9 + 3.74 = 69.64 \text{ KSI} > 3S_m = 51.3 \text{ KSI}$

ACTUAL CYCLES = 40

-2421

CRITICAL STRESS JUNCTURE 5

NEXT MAX. RANGE OF PRIMARY + SECONDARY STRESSES

RANGE OF THERMAL STRESS DISREGARDING RAPID DEPRESSURIZATION AND TEST TRANSIENT = LESS THAN 5 KSI.

RANGE OF PRESSURE = 2.5(4) = 10 KSI

$S_N = 5 + 10 = 15 \text{ KSI} < 3S_m = 51.3 \text{ KSI}$

THEREFORE, PRIMARY + SECONDARY STRESSES EXCEED $3S_m$ ONLY 80 CYCLES.

0005104449

FATIGUE ANALYSIS OF JUNCTURE 5

CASE 1 RAPID DEPRESSURIZATION CYCLES = 40

PEAK THERMAL STRESS RANGE (PG. 5-16) = 142.5 + 8.4 = 151 KSI
PEAK PRESSURE STRESS RANGE (PG. 5-16) = .7(1.8) = 1.3 KSI

$S_P = 151 + 1.3 = 152.3$ KSI $K_e = 1/3 = 1/n$ $S_n > 1.7(3S_m)$

$S_{ALT} = .5(1/3)(152.3) = 254$ KSI

ALLOWABLE CYCLES = 55 $U_1 = \frac{40}{55} = 0.727$

CASE 2 TEST TRANSIENT TO ZERO STRESS STATE CYCLES = 40

PEAK THERMAL STRESS ITER. 3 = 104.1 KSI
PEAK PRESSURE STRESS AT 2200 PSI = 2.2(1.8) = 3.96 KSI

$S_P = 104.1 + 3.96 = 108$ KSI

$$K_e = 1 + \frac{(1+n)}{n(m-1)}\left[\frac{S_n}{3S_m} - 1\right] = 1 + \frac{.7}{3(.7)}\left[\frac{74.74}{51.3} - 1\right] = 2.523$$

$S_{ALT} = 0.5(2.523)(108) = 136$ KSI

ALLOWABLE CYCLES = 360 $U_2 = \frac{40}{360} = 0.111$

NOTE: THIS FATIGUE ANALYSIS INCLUDES THERMAL AND MECHANICAL DISCONTINUITY STRESSES ONLY. FOR INCLUSION OF STRESSES DUE TO RUN AND BRANCH PIPE STRESSES, SEE SECTION "F"

0 0 0 6 1 0 0 4 5 0

BABCOCK & WILCOX
DEPARTMENT
DATE 10-29-73 BY D.MCK.
CHECKED DATE BY
REVISION REV. 1

CASE 3 ALL OTHER CONDITIONS

THERMAL STRESS RANGE LESS THAN 10 KSI
PEAK PRESSURE STRESSES = 2.5(4) = 10 KSI

S_p = 10 + 10 = 20 KSI

S_{ALT} = 10 KSI ALLOWABLE CYCLES = ∞

THEREFORE,

$U_{TOTAL} = U_1 + U_2 = 0.727 + .111 = 0.838 < 1.0$

NOTE: THIS FATIGUE ANALYSIS INCLUDES THERMAL AND MECHANICAL DISCONTINUITY STRESSES ONLY. FOR INCLUSION OF STRESSES DUE TO RUN AND BRANCH PIPE MOTIONS, SEE SECTION "F".

CRITICAL STRESS JUNCTURE 8

PRIMARY + SECONDARY RANGE

THERMAL STRESS RANGE = 97.9 − (7.7) = 105.6 KSI
ITER. 5063 ITER. 6338

PRESSURE STRESS RANGE
PRESSURE AT ITER. 5063 = 1500 PSI S = 3.3 KSI
PRESSURE AT ITER. 6338 = 800 PSI S = 1.76 KSI

TOTAL $S = 105.6 + 3.3 - 1.76 = 107 \text{ KSI} > 3S_m = 51.7 \text{ KSI}$

AN ELASTIC-PLASTIC ANALYSIS PER THE USAS B31.7 CODE, PARA. I-705.4 WILL BE PERFORMED.

DETERMINE NUMBER OF CYCLES $3S_m$ CAN BE EXCEEDED.

1.) THE ABOVE CASE COMES FROM TIMES WITHIN THE RAPID DEPRESSURIZATION TRANSIENT. THEREFORE, THE NUMBER OF CYCLES = 40

2.) DETERMINE NEXT THE MAXIMUM RANGE OF STRESSES

0005104522

BABCOCK & WILCOX
DEPARTMENT DATE 8-72 BY JMS
CHECKED DATE BY
REVISION
5-26

S-2471

OSC 1522

STRESS JUNCTURE 8

NEXT MAXIMUM RANGE COMES FROM THE TEST TRANSIENT AND A NO FLOW CONDITION. CYCLES = 40

THERMAL RANGE = 78.8 − (−.7) = 79.5 KSI
ITER. 8 ITER. 27976

PRESSURE RANGE = 2500 − 2200 = 300 PSI
MAX. TEST

A WORST CASE IS DISREGARDING THERMAL STRESS REVERSAL AND USING P_{RANGE} OF 2200

$S_{MAX} = 78.8 + 2.2(2.2)_{(L-R)} = 83.6\ KSI > 3S_m = 51.3\ KSI$

3.) NEXT MAXIMUM RANGE EXCLUDING RAPID DEPRES. / TEST TRANSIENT

THERMAL RANGE = 1.1 KSI ITER. 27976
PRESSURE RANGE = 2500 PSI; $S = 2.5(3.5)_{(R-H)} = 8.75\ KSI$

$S_{MAX} = 1.1 + 8.75 = 9.85\ KSI < 3S_m = 51.3\ KSI$

NUMBER OF CYCLES OVER $3S_m$ = 40 + 40 = 80 < 250

THEREFORE $3S_m$ IS NOT EXCEEDED MORE THAN 250 CYCLES AND ALL ELASTIC-PLASTIC REQUIREMENTS ARE MET.

0005100453

BABCOCK & WILCOX DEPARTMENT	DATE 8-72	BY [signature]	REVISION
	CHECKED DATE	BY ✓	5-27

5-2471

FATIGUE ANALYSIS OF JUNCTURE 8

CASE-1 RAPID DEPRESSURIZATION TRANSIENT 90 CYCLES

PEAK THERMAL RANGE (PG. 5-17) = 147.4 - (-9.6) = 157 KSI
PEAK PRESSURE RANGE (PG. 5-17) = 0.7(2.5) = 1.75 KSI

$S_{PEAK} = 157 + 1.75 = 158.7$ KSI

CALCULATE K_e FACTOR FOR ELASTIC-PLASTIC FACTOR. THE 1971 SECTION III EQUATION WILL BE USED SINCE IT IS MORE CONSERVATIVE THAN THE B31.7 1968 DRAFT VERSION.

$K_e = 1/n = 1/.3 = 3.33$ SINCE S_N EXCEEDS $1.7(3S_m) = 87.2$ KSI

$\therefore S_{ALT} = 1/2(3.33)(158.7) = 264$ KSI $\therefore$ ALLOWABLE CYCLES =

$U_1 = \frac{40}{60} = 0.667$

CASE-2 TEST TRANSIENT COMBINED WITH A NO FLOW CONDITION - 40 CYCLES

PEAK THERMAL RANGE (PG. 5-17) = 115 KSI
PEAK PRESSURE RANGE (PG. 5-17) = 2.2(2.5) = 5.5 KSI

$S_P = 115 + 5.5 = 120.5$ KSI

NOTE: THIS FATIGUE ANALYSIS INCLUDES THERMAL AND MECHANICAL DISCONTINUITY STRESSES ONLY. FOR INCLUSION OF STRESSES DUE TO RUN AND BRANCH PIPE MOTIONS, SEE SECTION "F".

0005100045

-2471

OSC 1522

JUNCTURE 8 (CONTINUED)

$K_e = 1/n = 3.33$ $S_{ALT} = 1/2(3.33)(120.5) = 201.0$ KSI

ALLOWABLE CYCLES = 140

$U_2 = \frac{40}{140} = 0.286$,

CASE - 3 MAXIMUM RANGE EXCLUDING RAPID DEPR. + TEST

PEAK THERMAL RANGE (PAGE 5-17) = 1.2 KSI
PEAK PRESSURE RANGE (PAGE 5-17) = 2.5(3.5) = 8.75 KSI

$S_p = 1.2 + 8.75 = 9.95$ KSI $S_{ALT} = 5$ KSI

ALLOWABLE CYCLES = ∞ $U_3 = 0.0$

$\therefore U_{TOTAL} = U_1 + U_2 = 0.667 + 0.286 = 0.953 < 1.0$

NOTE: THIS FATIGUE ANALYSIS INCLUDES THERMAL AND MECHANICAL DISCONTINUITY STRESSES ONLY. FOR INCLUSION OF STRESSES DUE TO RUN AND BRANCH PIPE MOTIONS, SEE SECTION "F".

0006100455

CRITICAL STRESS JUNCTURE 23 CARBON STEEL

PRIMARY + SECONDARY STRESS

MAX. RANGE OF THERMAL STRESS = 27.8 KSI [H-L INSIDE]
(PG 5-17)

MAX. RANGE OF PRESSURE = 2500 PSI

$S_{PRESS} = 2.5(3.3) = 8.25$ KSI

$S_N = 27.8 + 8.25 = 36.05$ KSI $< 3S_m = 53.4$ KSI

THEREFORE, THIS JUNCTURE DOES NOT EXCEED THE $3S_m$ LIMIT.

FATIGUE ANALYSIS OF JUNCTURE 23

CASE-1 MAXIMUM STRESS IN CONJUNCTION WITH ZERO STRESS STATE CYCLES = 240

MAX. PEAK THERMAL STRESS = 28 KSI ITER. 5237 (H-L INSIDE)

MAX. PEAK PRESSURE STRESS = 3.3(2.5) = 8.25 (R-H INSIDE)

$S_P = 28 + 8.25 = 36.25$ KSI $S_{ALT} = 18$ KSI

ALLOWABLE CYCLES = 35000

$U_1 = \frac{240}{35000} = 0.007$

NOTE: THIS FATIGUE ANALYSIS INCLUDES THERMAL AND MECHANICAL DISCONTINUITY STRESSES ONLY. FOR INCLUSION OF STRESSES DUE TO RUN AND BRANCH PIPE MOTIONS, SEE SECTION "F".

BABCOCK & WILCOX
DEPARTMENT

DATE 10-29-73 BY D. McK.

CHECKED DATE BY

REVISION REV. 1

CASE - 2 MAXIMUM STRESS RANGE DISREGARDING HEAT-UP & COOL-DOWN

PEAK THERMAL STRESS RANGE = 26.1 - 10 = 16.1 KSI
ITER. 5124 ITER. 6059

PEAK PRESSURE RANGE = (2.5 - 1.7) 3.3 = 2.64 KSI
THIS MAX. PRESSURE - MIN. PRESSURE (REACTOR TRIP + E) DISREGARDING ZERO STRESS STATE.

$S_p = 16.1 + 2.64 = 18.74$ KSI

$S_{ACT} = 9.4$ KSI ALLOWABLE CYCLES $= \infty$

$U_{TOTAL} = U_1 = 0.007 < 1.0$

O.K.

NOTE: THIS FATIGUE ANALYSIS INCLUDES MECHANICAL AND THERMAL DISCONTINUITY STRESSES ONLY. FOR INCLUSION OF STRESSES DUE TO RUN AND BRANCH PIPE MOTIONS, SEE SECTION "F" interim analysis

Scott

copy to Ed, HQ, Girard

Oconee Nuclear Station
Problem Investigation Process - PIP
Problem Investigation Form

PIP Serial No:	**0-O97-1368**	**LER Serial No:**	
MSE Serial No:		**Other Report:**	

I. Problem ID

Discovered Time/Date: 16:06 04/27/97 Occurred Time/Date: 16:06 04/27/97

Unit(s): 0

Status at Time Discovered	Unit 1	Unit 2	Unit 3
Mode	N/A	N/A	N/A
% Power			

Unit Status Remarks:

System(s) Affected: HPI Other High Pressure Injection Equip.
RC Reactor Coolant

Affected Equipment

WMS Equipment ID No.	Comp. Code	Manufacturer

Location of Problem - Bldg: R Column Line: Elev:

Location Remarks:
High Pressure Normal Injection nozzles

Method Used to Discover Problem:
Engineering review

Brief Problem Description:
Possible inadequate evaluation of thermally induced stresses at HPI normal injection nozzles.

Detailed Problem Description:
It appears that the data from letter dated 5/15/91, from David Whitaker to Bob Morgan, Jr (subject: "Data transfer for ONS Unit 1 Start up at end of EOC 12 Outage in response to NRC Bulletins 88-08 and 88-11 dealing with Thermal stratification") has not been incorporated into existing ONS calculations for the HPI system.

Originated By: CCT8276: TOMPKINS, CRAIG C Team: CCT8276 Group: MCE Date: 04/27/97

This data should be specifically reviewed for impact on calcs performed for NRC Bul 88-08 (includes Calcs OSC - 3681 and OSC-1323-06.)

Last Updated By: RPT7314: TODD, RANDALL P Team: RTB7310 Group: SRG Date: 05/13/97

Oconee Nuclear Station
Problem Investigation Process - PIP
Problem Investigation Form

PIP Serial No:	**0-O97-1368**	**LER Serial No:**	
MSE Serial No:		**Other Report:**	

Other Units/Components/Systems/Areas Affected (Y,N,U):

Industry Plants Affected (Y,N,U): U

Immediate Corrective Actions:

Impact of data included in the letter is being reviewed by the FIP team for the HP-127 HPI leak.

Originated By: CCT8276: TOMPKINS, CRAIG C Team: CCT8276 Group: MCE Date: 04/27/97

Problem Found While Working with Document No. :

Immediate Corrective Action Work Request / Work Order No. :

	Indiv	Team	Group	Date:
Problem Identified By:	CCT8276	CCT8276	MCE	04/27/97
Problem Entered By:	CCT8276	CCT8276	MCE	04/27/97

II. Screening

Is the Problem Significant? N　　Action Category: 3
Significance Codes:

MSE No:　　LER No:　　OEP No:

Other Report Nos:

Event Codes: D6　　Drawings or Calculations

Screening Remarks:

This event has been reviewed by the CST and found not to meet the MSE significance criteria.

Originated By: EHD8302: DUMMEYER, EDWARD H Team: RTB7310 Group: SRG Date: 04/28/97

Upgraded to an MSE per the FIP team that is working on this issue due to an operability evaluation needing documentation. Received information from Randy Todd.

Last Upda ted By: RSM7315: MATHESON, RICKIE S Team: RTB7310 Group: SRG Date: 05/08/97

This event has been determined to be present and past operable, and not reportable. Therefore, this PIP is being downgraded to an LSE.

Oconee Nuclear Station
Problem Investigation Process - PIP
Problem Investigation Form

PIP Serial No:	**0-O97-1368**	**LER Serial No:**	
MSE Serial No:		**Other Report:**	

Last Upda ted By: RSM7315: MATHESON, RICKIE S Team: RTB7310 Group: SRG Date: 05/28/97

Responsible Group for Proposed Resolution(s):	MCE	Mech/Civil Eq. Eng.
Responsible Group for Problem Evaluation:	MCE	Mech/Civil Eq. Eng.
Responsible Group for Overall PIP approval:	MCE	Mech/Civil Eq. Eng.

	Indiv	Team	Group	Date
Screened By:	RSM7315	RTB7310	SRG	05/28/97

This PIP has been downgraded from an MSE to an LSE status

III. Operability

Present Operability:

Responsible Group: MCE Status: Closed

Sys/Comp Operable?(Y,N,C,E) : Y

Required Mode: N/A

Comments:

STATEMENT OF PROBLEM

Thermocouple data was collected on the HPI Normal Make-up and Emergency Injection piping during heatup of Oconee Unit 1 in early June 1990 (after EOC 12). The results of this data indicated significant thermal stratification was occurring in the normal make-up line. A maximum top to bottom temperature differential of 327°F was experienced during periods when one "A" Reactor Coolant Pump was not operating, with reduced Letdown, and with reduced and oscillating make-up. This indicated that backleakage was occurring through valve 1HP-127. This information was transmitted to Robert Morgan, Jr. (ONS Pipe Stress Engineer) from David Whitaker (Nuclear Production Engineer) via letter on May 15, 1991. David's summary letter indicated that significant thermal stratification was experienced on the normal makeup line.

However, this thermocouple data on the HPI normal make-up piping was not analyzed to determine if the piping was acceptable for the thermal stratification loadings.

RELATION TO QA CONDITION

The HPI Normal Make-up Piping in question is QA Condition 1

APPLICABLE CODES AND STANDARDS

1. 1968 B31.7 Power Piping Code

Oconee Nuclear Station
Problem Investigation Process - PIP
Problem Investigation Form

PIP Serial No:	**0-O97-1368**	**LER Serial No:**	
MSE Serial No:		**Other Report:**	

2. 1983 ASME Code, Section III

EVALUATION INPUTS / METHODS USED

Structural Integrity Associates (SIA) performed a limited cycle Class I fatigue analysis per the 1983 ASME Code using the applicable design basis transients listed in UFSAR Table 5-2 and the thermocouple data taken in June 1990. Loads and moments applied on the makeup nozzle by the piping were supplied to SIA by ONS. These loads and moments came from OSC-1304-06.

To perform the analyses, SIA needed the actual number of applicable transients experienced on Unit 1 to date. This information was provided to them from the AOTC Logbook. The total number of occurrences to date for each transient considered in the analysis follows:

Heatup on ONS Unit 1 - 94
Cooldowns on ONS Unit 1 - 95
ONS Unit 1 Trip (Transient 8A) - 5
ONS Unit 1 Trip (Transient 8B) - 27
ONS Unit 1 Trip (Transient 8C) - 29

Also used in SIA's analysis was a previous analysis on the HPI Make-up nozzle performed by B&W. This analysis is contained in B&W Document No. 32-1128224-02, "Revised HPI Nozzle Usage Factor".

APPLICABLE LICENSING REFERENCES

1. UFSAR Sections 3.2.2.1, 5.2 (including subsections), and 5.4.7.2
2. UFSAR Table 5-2
3. Letter from NRC to Duke Power Dated July 10, 1995, "Reactor Coolant System (RCS) Auxillary Piping Fatigue Analysis Schedule".

ASSUMPTIONS

1. From observance of the thermocouple data, the thermal stratification on the make-up line occurred 5 times during the June 1990 heatup. In order to estimate the number of cycles for the thermal stratification, SIA assumed that the thermal stratification occurred 5 times during each heatup, and plant trip.

2. From previous calculations, it has been demonstrated that the nozzle safe-end to piping weld is the most limiting thermal fatigue location (ie has the highest Cumulative Usage Factor). Therefore, the thermal fatigue effects of the thermal stratification were analyzed at this weld. If demonstrated to be acceptable, then it is assumed all other locations (nozzle and piping) will be acceptable as well.

3. The thermal stratification observed on the make-up piping was due to backflow through valve 1HP-127. In order for this transient to occur, make-up valves HP-126 and HP-127 must leak. New check valves have been installed on Units 2 & 3. It is assumed that these new valves will not allow

backleakage, thus eliminating the thermal stratification observed from the backflow transient. New check valves are also planned to be installed in Unit 1 during the next refueling outage. These new valves should eliminate the thermal stratification resulting from backleakage.

Thermocouples are being installed on the HPI make-up lines on Units 1, 2, and 3. The data collected by the thermocouples will allow ONS Engineering to validate this assumption.

Therefore, the analysis performed by SIA only evaluates the actual number of occurrences of each transients to date plus an estimate of transients that will occurr between now and replacement of the check valves on the make-up line. A cumulative usage factor was calculated for a limited number of transient cycles. The omission of the balance of UFSAR Table 5-2 transients is discussed below.

The additional number of cycles assumed in the analysis between now and the next refueling outage are:

Heatups - 2
Cooldowns - 2
Trips - 1
OBE 1
HPI Manual Actuation - 1

REFERENCES

1. AOTC Logbook
2. Calculation performed by SIA
3. Thermocouple data taken from June 1990 Heatup of Unit 1
4. B&W Document No. 32-1128224-02, "Revised HPI Nozzle Usage Factor"
5. OSC-1522 , RCS Piping Stress Report

CALCULATION / EVALUATION

SIA calculated a fatigue usage factor on the makeup nozzle safe-end to piping weld for a limited number of cycles. The transients considered and their associated cycles were :

Normal Operation (154 cycles)
Normal Operation with Stratification Initiation (515 cycles)
Normal Operation with Stratification Decay (510 cycles)
Trip with RCS Pressure reduction (57 cycles)
Trip with Stratification Initiation (285 cycles)
Trip with Stratification Decay (285 cycles)
HPI Manual Actuation Up (1 cycle)
OBE (1 cycle)
Zero Load (97 cycles)

The change in moments applied to the nozzle from thermal stratification were estimated as twice the thermal stratification moments on the emergency injection piping. The thermal stratification moments on the emergency injection nozzle was obtained from reference 4.

The result of the analysis was a cumulative usage factor of 0.04 which is much less than 1.0.

The analysis performed was based on the 1983 ASME Code. Reconciliation between 1983 ASME Code and B31.7 is addressed in the SIA calculation. As discussed in the calculation, the techniques used in evaluating the usage factor were more conservative than those in B31.7.

The original B&W analysis determined that the application of all Design events upon this nozzle would result in a CUF of 0.045. Due to the low predicted CUF in both evaluations, it is not necessary to merge the two to conclude CUF will not exceed 1.0 before the next refueling outage.

SIA's calculation assumed a number of future cycles between now and replacement of the HPI make-up valves. Two additional heatup and cooldown transients were assumed. The HPI make-up valves (1HP-126, -127) are going to be replaced by NSM ON-12975 during the next refueling outage which is scheduled to begin late August 1997. Given the low usage factor (0.04) on this nozzle, an engineering judgement is made that no mechanism needs to be put into place to count and limit the number of heatup and cooldown cycles that can occur before the HPI valves are replaced. Even if the number of assumed heatup, cooldown, trip, and HPI actuation cycles were exceeded, it will not result in the usage factor being greater than 1.0.

However, a corrective action to this PIP will be established to verify that valves 1HP-126, -127 were replaced by NSM ON-12975 and that the assumption of no backleakage through the new valves is valid.

SIA's calculation will be incorporated into piping analysis calculation OSC-1304-06.

Since the usage factor calculated is less than 1.0, the HPI Make-up piping is determined to be OPERABLE.

Compensatory Actions Required for Operability

None

Conclusions

The HPI Make-up piping is OPERABLE for the occurrence of the thermal stratification during back flow through valves 1HP-126, -127.

Originated By: PAW4981: WELLS, PHILLIP A Team: RAH8344 Group: MCE Date: 05/16/97

Operability evaluation was revised on 5/19/97 to incorporate editorial corrections such that the evaluation correctly corresponds with calculation performed by Structural Integrity Associates. The conclusion of OPERABLE was not changed.

Last Updated By: PAW4981: WELLS, PHILLIP A Team: RAH8344 Group: MCE Date: 05/19/97

Oconee Nuclear Station
Problem Investigation Process - PIP
Problem Investigation Form

PIP Serial No: 0-O97-1368 **LER Serial No:**
MSE Serial No: **Other Report:**

Last Updated By: PAW4981: WELLS, PHILLIP A Team: RAH8344 Group: MCE Date: 05/19/97

	Indiv	Team	Group	Date
Accepted By:	KWG7360	TKR7315	MCE	05/08/97
Due Date:	05/22/97			
Ready for Checked By:	KWG7360	TKR7315	MCE	05/22/97
Assigned To:	TDB2719	RAH8344	MCE	05/22/97
Checked By Assigned To:	TDB2719	RAH8344	MCE	05/22/97
Checked By:	TDB2719	RAH8344	MCE	05/27/97
Ready For Approval:	TDB2719	RAH8344	MCE	05/27/97
Approval Assigned To:	RAH8344	RAH8344	MCE	05/27/97
Approved By:	RAH8344	RAH8344	MCE	05/27/97
Evaluated By:	RSM7315	RTB7310	SRG	05/28/97

Past Operability:

Responsible Group: MCE Status: Closed

Sys/Comp Operable?(Y,N,C,E) : Y

Required Mode: N/A

Comments:

The calculation performed by Structural Integrity Associates that was used to demonstrate that this piping is Operable in its present condition is sufficient to demonstrate that the piping has been PAST OPERABLE. No additional analyses are required to determine the past operability condition of the HPI Normal Make-up piping on Unit 1.

Originated By: PAW4981: WELLS, PHILLIP A Team: RAH8344 Group: MCE Date: 05/22/97

	Indiv	Team	Group	Date
Due Date:	06/06/97			
Accepted By:	KWG7360	TKR7315	MCE	05/08/97
Assigned To:	PAW4981	RAH8344	MCE	05/19/97
Ready for Checked By:	PAW4981	RAH8344	MCE	05/22/97
Checked By Assigned To:	TDB2719	RAH8344	MCE	05/27/97
Checked By:	TDB2719	RAH8344	MCE	05/27/97
Ready For Approval:	TDB2719	RAH8344	MCE	05/27/97
Approval Assigned To:	RAH8344	RAH8344	MCE	05/27/97
Approved By:	RAH8344	RAH8344	MCE	05/27/97
Evaluated By:	RSM7315	RTB7310	SRG	05/28/97

IV. Reportability/Investigation

Responsible Group: SRG Status: Closed

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Problem Investigation Process - PIP
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PIP Serial No: 0-O97-1368 **LER Serial No:**
MSE Serial No: **Other Report:**

Problem Reportable(Y,N,E):

Reportable Per:

Comments:

This event is not reportable.

Originated By: RSM7315: MATHESON, RICKIE S Team: RTB7310 Group: SRG Date: 05/28/97

	Indiv	Team	Group	Date
Assigned To:			SRG	05/08/97
Ready For Approval:	RSM7315	RTB7310	SRG	05/28/97
Approval Assigned To:	RSM7315	RTB7310	SRG	05/28/97
Approved By:	RSM7315	RTB7310	SRG	05/28/97
Concurrence By:	MEB2307	JEB8371	RGC	05/28/97

Investigation Report:

Responsible Group: Act Date:

Investigator: Due Date:

Date Due to VP or Sta. Mgr:

Date Regulatory or Agency Rpt Due:

Date Investigation Report Approved:

NRC Cause Codes:

V. Problem Evaluation

Responsible Group: MCE Status: Closed

System(s) Affected: HPI Other High Pressure Injection Equip.
RC Reactor Coolant

Affected Equipment

WMS Equipment ID No.	Comp. Code	Manufacturer

Event	Cause Cd	Cause Description	Primary	Causing Group(s)
D6	YYY	Incomplete Problem Evaluation	No	

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MSE Serial No: **Other Report:**

Problem Evaluation:

The causes of not incorporating the thermo-couple data into the appropriate Oconee stress analysis calculations is covered in PIP O-97-01324. This PIP documents the efforts and reports the results of the Failure Investigation Process (FIP) team report concerning the weld failure of the 2A1 HPI/MU safe-end to pipe weld. A full detailed report of the human performance error associated with not incorporating the data is included in the FIP report.

Originated By: TDB2719: BROWN, TIMOTHY D Team: RAH8344 Group: MCE Date: 05/30/97

Last Updated By: TDB2719: BROWN, TIMOTHY D Team: RAH8344 Group: MCE Date: 05/30/97

	Indiv	Team	Group	Date
Due Date:	05/27/97			
Accepted By:	KWG7360	TKR7315	MCE	04/28/97
Assigned To:	TDB2719	RAH8344	MCE	05/28/97
Ready For Approval:	TDB2719	RAH8344	MCE	05/30/97
Approval Assigned To:	TDB2719	RAH8344	MCE	05/30/97
Approved By:	RAH8344	RAH8344	MCE	06/01/97

VI. Proposed Resolution

Proposed Resolution From: Resp. Group: MCE Status: Closed OEDB Checked: Yes

The thermal stratification noted as a result of the thermo-couple data taken in 1990 and transmitted via David Whitaker's letter to Robert Morgan in 1991 will be fully evaluated within the Reactor Coolant Class 1 Branch Line project currently in progress. Duke Power has contracted with Structural Integrity Associates of San Jose California to complete Class 1 evaluations on all of the Reactor Coolant branch lines that were previously evaluated to Class 2 rules. The HPI & HPI/MU lines are included within the scope of the project. The expectation of the project is that all loading including the noted thermal stratification will be included in the determination of the fatigue life of the various components. The schedule for completion of the project, including all plant modifications is August of 1999.

Originated By: TDB2719: BROWN, TIMOTHY D Team: RAH8344 Group: MCE Date: 05/30/97

	Indiv	Team	Group	Date
Due Date:	05/27/97			
Accepted By:	KWG7360	TKR7315	MCE	04/28/97
Assigned To:	TDB2719	RAH8344	MCE	05/28/97
Ready For Approval:	TDB2719	RAH8344	MCE	05/30/97
Approval Assigned To:	TDB2719	RAH8344	MCE	05/30/97
Approved By:	RAH8344	RAH8344	MCE	06/01/97

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PIP Serial No:	**0-O97-1368**	**LER Serial No:**	
MSE Serial No:		**Other Report:**	

VII. Corrective Actions

Seq. No: 1

Resp Group:	MCE	Status:	Closed
Orig Group:	MCE	Event Code:	D6
Prop CAC:	B	Cause Code:	YYY

Proposed Corrective Action:

Civil Engineering should verify that the HPI Make-up valves (1HP-126 & 1HP-127), Class I HPI Make-up piping, and make-up piping to nozzle welds were replaced by NSM ON-12975.

Originated By: PAW4981: WELLS, PHILLIP A Team: RAH8344 Group: MCE Date: 05/16/97

	Indiv	Team	Group	Date
Assigned To:	PAW4981	RAH8344	MCE	05/19/97
Ready For Approval:	KWG7360	TKR7315	MCE	05/19/97
Approval Assigned To:	RAH8344	RAH8344	MCE	05/19/97
Approved By:	RAH8344	RAH8344	MCE	05/22/97

General:

Outage: Mode:

Other Tracking Processes

Type	Number	Text

Actual Corrective Action:

Actual CAC:
Due Date: 10/24/97
Status: Open

	Indiv	Team	Group	Date
Due Date:	10/24/97			
Accepted By:	RAH8344	RAH8344	MCE	05/22/97
Assigned To:	TDB2719	RAH8344	MCE	05/22/97

Seq. No: 2

Resp Group:	MCE	Status:	Closed
Orig Group:	MCE	Event Code:	D6
Prop CAC:	B3a	Cause Code:	YYY

Proposed Corrective Action:

Civil Engineering needs to evaluate the thermocouple data taken on the HPI Normal Make-up System after replacement of valves 1HP-126, -127 to verify backleakage through the new check valves is not occurring. If backleakage is still

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MSE Serial No:		**Other Report:**	

occurring, further evaluations will be necessary.

Originated By: PAW4981: WELLS, PHILLIP A Team: RAH8344 Group: MCE Date: 05/19/97

	Indiv	Team	Group	Date
Assigned To:	PAW4981	RAH8344	MCE	05/19/97
Ready For Approval:	KWG7360	TKR7315	MCE	05/19/97
Approval Assigned To:	RAH8344	RAH8344	MCE	05/19/97
Approved By:	RAH8344	RAH8344	MCE	05/22/97

General:

Outage: Mode:

Other Tracking Processes

Type	Number	Text

Actual Corrective Action: Actual CAC: Due Date: 10/24/97 Status: Open

	Indiv	Team	Group	Date
Due Date:	10/24/97			
Accepted By:	RAH8344	RAH8344	MCE	05/22/97
Assigned To:	TDB2719	RAH8344	MCE	05/22/97

VIII. Final and Overall PIP Approval

Responsible Group: MCE Status: Screened

	Indiv	Team	Group	Date
Assigned To:			MCE	04/28/97
Accepted By:	KWG7360	TKR7315	MCE	04/28/97
Approval Assigned To:	RAH8344	RAH8344	MCE	04/29/97

Closure Document Type   Closure Document No

Supplemental Concurrences - These do not affect PIP closure.

Concurrences Associated with External Commitments:

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PIP Serial No:	**0-O97-1368**	**LER Serial No:**	
MSE Serial No:		**Other Report:**	

Indiv	Team	Group	Date
Concurred By:			

IX. Attachments

Generic Applicability

Generic Applicability Review Not Required for this PIP.

Environmental

No Environmental for this PIP.

Failure Prevention Investigation:

No FPI for this PIP.

Remarks

No Remarks for this PIP

Maintenance Rule

Responsible Group: SES Status: Closed

Maintenance Rule SSC:

SSC	Description	Risk Significant
HPI	High Pressure Injection System	Yes

Equipment Group: P01
Applicable Unit: Unit 1
Unit 2
Unit 3
Functional Failure: No MPFF: None Repetitive MPFF: None

Functional Failure Comments:
No functional failure is attributed to the documentation deficiency described within this PIP. PIP 97-1324, as identified in the Cause Evaluation section of this PIP, directly addresses the Unit 2 HPI nozzle failure and accordingly all MR implications.

Originated By: RSL7360: LEATHERWOOD, ROBERT S Team: SLN8374 Group: SES Date: 06/05/97

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MSE Serial No: **Other Report:**

MPFF Comments:

Repetitive MPFF Comments:

Reactor Trip: No Safety System Actuation: No Loss of Heat Decay Removal: No
Contrib. Force Outage Rate: No

Comments:

	Indiv	Team	Group	Date
Assigned To:	RSL7360	SLN8374	SES	05/08/97
Due Date:	07/01/97			
Ready For Approval:	RSL7360	SLN8374	SES	06/05/97
Approval Assigned To:	SLN8374	SLN8374	SES	06/09/97
Approved By:	SLN8374	DBC7309	SES	06/16/97

End of the Document for PIP No: 0-O97-1368
The status of this PIP is: Screened
The duration of this PIP was: 31 days