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LOFT TECHNICAL REPORT LTR 1217-6

RE & C INTERNAL REPORT RE-A-78-175

SEPTEMBER 28, 1978

STRESS ANALYSIS OF LOFT PENETRATIONS
1A, 2A, 3F, 5A-F, 7A, 9A, 17A-B, 20A-C, 21-A

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EG&G Idaho, Inc.

IDAHO NATIONAL ENGINEERING LABORATORY

DEPARTMENT OF ENERGY

IDAHO OPERATIONS OFFICE UNDER CONTRACT EY-76-C-07-1570

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INTERNAL TECHNICAL REPORT

Title: STRESS ANALYSIS OF LOFT PENETRATIONS 1A, 2A, 3F, 5A-F, 7A, 9A, 17A-B, 20A-C, 21-A

Organization: APPLIED MECHANICS

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LOFT TECHNICAL REPORT
LOFT PROGRAM

TITLE
STRESS ANALYSIS OF LOFT PENETRATIONS
1A, 2A, 3F, 5A-F, 7A, 9A, 17A-B, 20A-C, 21-A

REPORT NO.
LTR 1217-6
RE-A-78-175

AUTHOR
R. J. Beers Jr.

GWA NO.

PERFORMING ORGANIZATION
Applied Mechanics Branch 8-7-78

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ABSTRACT

A stress analysis has been completed for the LOFT piping nozzles penetrating through the containment vessel in accordance with the 1965 edition of Section III of the ASME Boiler and Pressure Vessel Code[1]. LOFT Specification S-1[6] states that the 1965 edition, including the addenda through the summer 1966 issue, be used. Stresses in the containment wall and in the nozzles result from mechanical and thermal loads on the piping that penetrate the nozzles. The mechanical loads were compiled in LTR 1217-7[2] and the temperature gradients were provided by the Thermal Analysis Branch[3].

This analysis indicates that the nozzles and the containment wall are adequate to sustain the given mechanical and thermal loads. Therefore, it is recommended that paragraph number S1-04, section M of LOFT specification S-1[6] be revised to list the nozzle loads presented in Table 3, page A-3a.

TABLE OF CONTENTS

STRESS ANALYSIS OF LOFT PENETRATIONS

1A, 2A, 3F, 5A-F, 7A, 9A, 17A-B, 20A-C, 21-A

I. INTRODUCTION

A stress analysis has been completed for the LOFT piping nozzles penetrating through the containment vessel in accordance with the 1965 edition of Section III of the ASME Boiler and Pressure Vessel Code[1]. LOFT Specification S-1[6] states that the 1965 eidition, including the addenda through the summer 1966 issue, be used. A stress analysis of the containment vessel wall and of the nozzles is included in this report. A tabulation of the nozzles analyzed, the maximum pipe temperature at the nozzle and the loads on the nozzles is given in Table 1. (See page A-2)*

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*All the nozzles listed in Table 1 were analyzed in this report except Nozzle S-3E which was analyzed in Reference 4.

II. DISCUSSION

The mechanical loads on the containment vessel at the penetrations were compiled in LTR 1217-7[2]. These loads are from piping that penetrate the nozzles. They are either a combination of deadweight, thermal expansion and operating basis earthquake (OBE) or deadweight and safe shutdown earthquake (SSE), whichever leads to the highest stress in the containment wall.

A Biyjaard analysis[5] was completed for each size of nozzle penetrating the containment wall (see Appendix A). To be conservative, the highest force and moment that each nozzle size had was used for the analysis. Numbers that are circled in Table 2, page A-3, indicate these loads. For fatigue analysis, the appropriate stress concentration factors were applied.

Two of the nozzles have pipes penetrating them with high (above 250°F) operating temperatures. For these nozzles, thermal stresses combined with mechanical stresses were calculated in Appendix B. Thermal stresses arise from temperature gradients between the pipe and the nozzle. These gradients were provided by the Thermal Analysis Branch[3].

III. RESULTS

The maximum primary plus secondary stress in the containment wall due to mechanical loads is 22,440 psi which is less than the allowable stress, $3\ S_m = 68{,}220$ psi. With peak stresses added on, the maximum allowable number of cycles is 110,000.

The maximum primary plus secondary stress in the nozzles due to thermal plus mechanical loads is 14,000 psi which is less than the allowable, $3\ S_m = 53{,}850$ psi. With the peak stresses added on, the maximum allowable number of cycles is 100,000.

Nozzles S-3E and S-5E are both cone shaped nozzles with similar dimensions and both operating at high temperatures (S-3E @ 530^{o}F and S-5E @ 407^{o}F). John Canders (Reference 4) performed a finite element analysis on nozzle S-3E and arrived at a maximum stress of 34,254 psi which is much less than the allowable of 52,500 psi. Since the two nozzles have similar dimensions, nozzle S-3E operates at a higher temperature than nozzle S-5E, and the mechanical loads are higher on S-3E, stresses in S-5E will also be less than the allowable stress values.

IV. CONCLUSION

This analysis indicates that the nozzles and the containment wall are adequate to sustain the given mechanical and thermal loads.

V. RECOMMENDATION

It is recommended that paragraph number S1-04, Section M of LOFT Specification S-1[6] be revised to list the nozzle loads presented in Table 3, page A-3a.

VI. REFERENCES

1. American Society of Mechanical Engineers, ASME Boiler and Pressure Vessel Code, Section III, New York, 1965.
2. D. F. McFadden, "Recalculation of Loads on LOFT Penetrations 1A, 2A, 3F, 5A-F, 7A, 9A, 11C, 17A-B, 20A-C, 21A",LTR 1217-7, RE-A-78-176, to be published.
3. W. C. Townsend letter to R. Beers, "Containment Penetration Temperature Profile at Weld", WCT-21-78, August 3, 1978.
4. John Canders, "LOFT Main Steam Line Containment Vessel Penetration Nozzle (S-3E) Stress and Fatigue Life Analysis", LTR 1217-5, RE-A-78-162, to be published.
5. K. R. Wichman, A. G. Hopper and J. L. Mershon, "Local Stresses in Spherical and Cylindrical Shells Due to External Loadings", Welding Research Council Bulletin No. 107, New York, 1965.
6. Idaho Nuclear Corporation, "Containment Vessel", LOFT Specification S-1, Contract No. AT (10-1)-1160 (Job No. 20), Revision 12, August 17, 1970.
7. Bruno A. Boley, and Jerome H. Weiner, Theory of Thermal Stresses, John Wiley and Sons Inc., New York, 1960.
8. Raymond J. Roark, and Warren C. Young, Formulas for Stress and Strain, McGraw Hill Book Co., 1975.
9. American Society of Mechanical Engineers, ASME Boiler and Pressure Vessel Code, Section III, Subsection NB, 1977.

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APPENDIX A

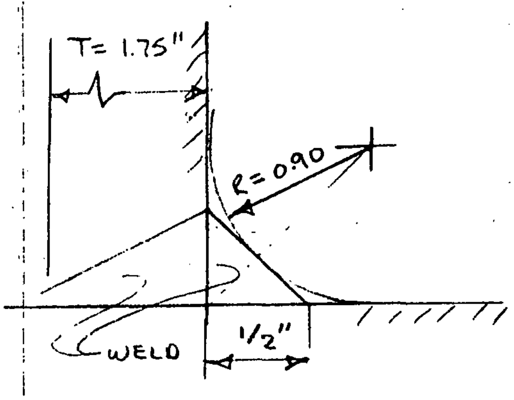
STRESSES IN THE CONTAINMENT VESSEL DUE TO MECHANICAL LOADS

1.0) LOADS ON THE CONTAINMENT VESSEL

FORCES AND MOMENTS ON THE CONTAIMENT VESSEL CAN BE FOUND IN TABLE 1. THE LOADS IN TABLE 1 WERE GATHERED AND PRESENTED IN REFERENCE 2. THESE LOADS ARE EITHER A COMBINATION OF DEADWEIGHT + THERMAL EXPANSION + OPERATING BASIS EARTHQUAKE (OBE) OR DEADWEIGHT + SAFE SHUTDOWN EARTHQUAKE (SSE), WHICHEVER LEADS TO THE HIGHEST STRESS IN THE CONTAINMENT VESSEL.

A BIYJAARD ANALYSIS[5] WAS COMPLETED FOR EACH SIZE OF NOZZLE PENETRATING THE CONTAINMENT WALL. TO BE CONSERVATIVE, THE HIGHEST LOAD THAT EACH NOZZLE SIZE HAD, WAS USED FOR THE ANALYSIS. NUMBERS THAT ARE CIRCLED IN TABLE 2 INDICATE THESE LOADS

STRESS CONCENTRATION FACTORS: FOR THE NOZZLES, THE MINIMUM SIZE OF WELD TO THE CONTAINMENT VESSEL IS 1/2". THE SMALLER THE WELD, THE SMALLER THE FILLET RADIUS WHICH LEADS TO A HIGHER STRESS CONCENTRATION FACTOR. THEREFORE IT WILL BE CONSERVATIVE TO USE 1/2" WELD TO DETERMINE THE STRESS CONCENTRATION FACTORS FOR ALL THE NOZZLES.



T = VESSEL THICKNESS

R = FILLET RADIUS

ENTERING $\frac{R}{T} = \frac{.9}{1.75} = .51$ ON THE GRAPH ON PAGE 68 OF REF 5

$K_n = 1.75 \quad K_b = 1.50$

2.0) STRESSES IN THE CONTAINMENT WALL

TWO TYPES OF STRESSES WERE CALCULATED, PRIMARY PLUS SECONDARY STRESS INTENSITIES ($P_m + Q$) (PAGES A-6 THROUGH A-17) WHICH IS THE STRESS DUE TO MAXIMUM LOADS; AND PRIMARY PLUS SECONDARY STRESS INTENSITIES (PEAK) ($P_m + Q + F$) (PAGES A-18 THROUGH A-29) WHICH IS THE STRESS DUE TO MAXIMUM LOADS AND THEN MULTIPLIED BY THE APPROPRIATE STRESS CONCENTRATION FACTORS.

NOZZLE NO.	DIA	TEMP OPERATING	LOADS AT CONTAINMENT (X OUT, Z UP)					
			F_x	F_y	F_z	M_x	M_y	M_z
20 C	10"	70°	500	500	500	5000	35,000	20,000
20 B	10"	220°	500	500	500	-5000	15,000	-5,000
20 A	10"	220°	500	500	500	-5000	10,000	-5000
21 A	12"	100°	19,500	19,500	-13,500	51,000	125,000	175,000
7 A	12"	100°	5,500	2,000	-500	15,000	-15,000	-115,000
17 A	12"	70°	500	500	500	10,000	-25,000	-40,000
17 B	12"	120°	500	500	-500	15,000	-5,000	-25,000
11 C	12"	250°	500	-500	-500	5,000	-20,000	-10,000
9 A	16"	100°	-5,500	5,500	-1000	-30,000	-220,000	-130,000
5 F	16"	150°	1,500	-5,000	3000	-250,000	260,000	-250,000
5 A	16"	110°	17,000	-3,000	1000	10,000	170,000	205,000
5 B	16"	180°	1,000	500	-2000	-5,000	-35,000	-55,000
5 C	16"	100°	-500	500	-500	-5,000	-20,000	-10,000
5 D	16"	100°	500	500	-500	10,000	-10,000	5,000
5 E	18"	107°	3000	-500	-1,000	90,000	-30,000	-65,000
3E☆	24"	530°	58,000	10,500	-3000	275,000	-505,000	-505,000
2 A	24"	100°	2,000	1,500	-2,500	30,000	-90,000	55,000
3 F	24"	70°	500	500	500	5,000	10,000	-5,000
1 A	30"	250°	1,000	1,000	-1,500	10,000	-170,000	-90,000

F - lbs ROUNDED UP TO EVEN 500 lb

M - IN-lbs ROUNDED UP TO EVEN 5000 IN-lbs

☆ NOZZLE S-3E WAS ANALYZIED IN REFERENCE 4.

TABLE 1 [2]

NOZZLE NO.	DIA	TEMP OPERATING	LOADS AT CONTAINMENT (X OUT, Z UP)					
			F_x	F_y	F_z	M_x	M_y	M_z
20 C	10"	70°	500	500	500	5000	35,000	20,000
20 B	10"	220°	500	500	500	-5000	15,000	-5,000
20 A	10"	220°	500	500	500	-5000	10,000	-5000
21 A	12"	70°	19,500	19,500	-13,500	51,000	125,000	175,000
7 A	12"	100°	5,500	2,000	-500	15,000	-15,000	-115,000
17 A	12"	70°	500	500	500	10,000	-25,000	40,000
17 B	12"	120°	500	500	-500	15,000	-5,000	-25,000
11 C	12"	250°	500	-500	-500	5,000	-20,000	-10,000
9 A	16"	100°	-5,500	5,500	-1000	-30,000	-220,000	-430,000
5 F	16"	150°	1,500	-5,000	3000	-250,000	260,000	-250,000
5 A	16"	110°	17,000	-3,000	1000	10,000	170,000	205,000
5 B	16"	180°	1,000	500	-2000	-5,000	-35,000	-55,000
5 C	16"	100°	-500	500	-500	-5,000	-20,000	-10,000
5 D	16"	100°	500	500	-500	10,000	-10,000	5,000
5 E	18"	107°	3,000	-500	-1,000	90,000	-30,000	-65,000
3 E ☆	24"	530°	58,000	10,500	-3000	275,000	-505,000	505,000
2 A	24"	100°	2,000	1,500	-2,500	30,000	-90,000	55,000
3 F	24"	70°	500	500	500	5,000	10,000	-5,000
1 A	30"	250°	1,000	1,000	-1,500	10,000	-170,000	90,000

⬭ GOVERNING LOAD FOR THAT SIZE NOZZLE

F - lbs ROUNDED UP TO EVEN 500 lb

M - IN-lbs ROUNDED UP TO EVEN 5000 IN-lbs

☆ NOZZLE S-3E WAS ANALYZIED IN REFERENCE 4.

TABLE 2 [2]

EXTERNAL LOADS ON THE NOZZLES AT THE CONTAINMENT VESSEL WALL

NOZZLE #	Fx	Fy	Fz	Mx	My	Mz
1A	1,000	1000	1,500	10,000	170,000	90,000
2A	2,000	1,500	2,500	30,000	90,000	55,000
3F	2,000	1,500	2,500	30,000	90,000	55,000
5A	17,000	5,500	3,000	250,000	260,000	430,000
5B	17,000	5,500	3,000	250,000	260,000	430,000
5C	17,000	5,500	3,000	250,000	260,000	430,000
5D	17,000	5,500	3,000	250,000	260,000	430,000
5E	3,000	500	1,000	90,000	30,000	65,000
5F	17,000	5,500	3,000	250,000	260,000	430,000
7A	19,500	19,500	13,500	51,000	125,000	175,000
9A	17,000	5,500	3,000	250,000	260,000	430,000
17A	19,500	19,500	13,500	51,000	125,000	175,000
17B	19,500	19,500	13,500	51,000	125,000	175,000
20A	500	500	500	5,000	35,000	20,000
20B	500	500	500	5,000	35,000	20,000
20C	500	500	500	5,000	35,000	20,000
21A	19,500	19,500	13,500	51,000	125,000	175,000

FORCES - lb.

MOMENTS - IN-lb.

LOADS ±

X - OUTWARD

Z - UPWARD

RIGHT HAND RULE FOR VECTORS APPLIES

TABLE 3

2.1) PRIMARY PLUS SECONDARY STRESS INTENSITIES

SINCE THIS WORK IS A MODIFICATION OF WORK THAT USED THE 1965 EDITION OF THE ASME BOILER AND PRESSURE VESSEL CODE[1] THE 1965 EDITION WILL BE USED IN THIS REPORT.

REVIEWING THE BIJLAARD ANALYSES OF EACH SIZE OF NOZZLE, THE MAXIMUM STRESS INTENSITY RESULTS IN THE 16" NOZZLE. DUE TO THE LIMITED AMOUNT OF DATA POINTS THROUGH THE THICKNESS OF THE VESSEL WALL, THIS VALUE IS THE LINEARIZED STRESS INTENSITY.

$P_m + Q$ = PRIMARY + SECONDARY STRESS

$P_m + Q = 22{,}440$ psi (SEE PAGE A-11)

LOFT SPECIFICATION S-1[6] STATES THE CONTAINMENT VESSEL IS COMPOSED OF SA-212, GRADE B CARBON STEEL WITH A DESIGN TEMPERATURE OF 260°F.

S_m = DESIGN STRESS INTENSITY

$S_m = 22{,}740$ psi (SEE REF 1)

$P_m + Q < 3S_m$ (SEE REF 1)

$\underline{P_m + Q = 22{,}440 \text{ psi} < 3S_m = 68{,}220 \text{ psi}}$

THEREFORE, THE REQUIREMENTS FOR PRIMARY + SECONDARY STRESS ARE SATISFIED

2.2) PRIMARY PLUS SECONDARY STRESS INTENSITIES (PEAK)

REVIEWING THE BIJLAARD ANALYSES WITH STRESS CONCENTRATION FACTORS CONSIDERED, THE MAXIMUM PRIMARY + SECONDARY + PEAK STRESS RESULTS FROM THE 16" NOZZLE. AGAIN, DUE TO THE LIMITED AMOUNT OF DATA POINTS THROUGH THE VESSEL WALL, THIS VALUE EQUALS THE LINEARIZED STRESS INTENSITY WHICH EQUALS THE COMBINED PEAK STRESS INTENITIES

$P_m + Q + F = 33{,}920$ psi (SEE PAGE A23)

THE MAXIMUM STRESS WILL FLUCTUATE BETWEEN 0.0 psi AND 33,920 psi,

$$\text{THEREFORE} \quad S_a = \frac{33,920 - 0.0}{2}$$

$$S_a = 16,960 \text{ psi}$$

ENTERING S_a ON THE FATIGUE CURVE FOR CARBON STEEL (SEE REF 1, PAGE 19),

THE MAXIMUM # OF CYCLES = 110,000 CYCLES

FROM LOFT SPECIFICATION S-1, [6] THE MAXIMUM NUMBER OF FATIGUE CYCLES ON ANY NOZZLE IS 10,000. SINCE THIS IS LESS 110,000, FATIGUE CRITERION IS SATISFIED

HP-9815

10" DIAMETER NOZZLE

7-11-78

P + Q

LTR1217 6

A-6

```
P=
MC=
    20000.00
ML=
    35000.00
MT=
    5000.00
VC=
     500.00
VL=
     500.00
T=
       1.75
RO=
       5.00
RM=
     420.90
KN=
       1.00
KB=
       1.00
GAMMA=   240.51
B=       0.01
```

```
             0.11
COEFS
2A=
             0.06
COEFS
3A=
             1.30
COEFS
4A=
             1.60
COEFS
1B=
             0.07
COEFS
1B-1=
             0.07
COEFS
2B=
             0.11
COEFS
2B-1=
             0.11
COEFS
3B=
             5.10
COEFS
4B=
             1.50
COEFS
```

```
             0.32
COEFS
2C=
             0.21
COEFS
2C-1=
             0.21
COEFS
3C=
            42.00
OEFS
C=
            50.00

            28.51
           313.47
             8.07
           985.19
            55.39
          1097.14
SUMS
         -1494.51
          1326.71
           810.55
          -756.79
         -1335.24
          1262.08
```

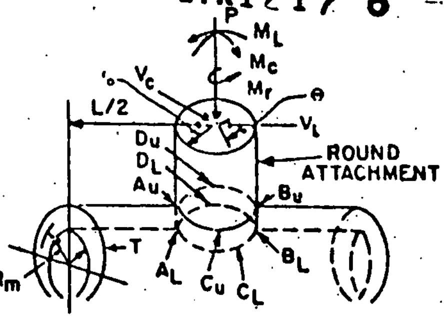
```
             9.93
           537.38
            16.29
          1724.08

SUMS
         -1980.03
          1879.56
          1500.72
         -1536.02
          -786.96
          -699.22
           307.65
          -355.67

SHEARS
            18.19
            18.19
            18.19
SUMS
            36.38
            36.
             0.00
             0.00
             0.00
             0.00
            36.38
            36.38
```

[redacted]

Table 5—Computation Sheet for Local Stresses in Cylindrical Shells

LTR1217 6 A-7

10" DIA NOZZLE Pm+Q



CYLINDRICAL SHELL

1. Applied Loads*

Radial load,	P	500 lb.
Circ. Moment,	Mc	20,009 in. lb.
Long. Moments,	ML	35,009 in. lb.
Torsion Moment,	M_T	3,009 in. lb.
Shear Load,	Vc	500 lb.
Shear Load,	VL	500 lb.

2. Geometry

Vessel thickness,	T	1.75 in.
Attachment radius,	r_o	5 in.
Vessel radius,	Rm	42.09 in.

3. Geometric Parameters

$\gamma = \frac{R_m}{T}$ = 29.05

$\beta = (0.875)\frac{r_o}{R_m}$ = 0.010

Stress Concentration due to:
a) membrane load, Kn 1.0
b) bending load, Kb 1.0

*NOTE: Enter all force values in accordance with sign convention

From Fig.	Read curves for	Compute absolute values of stress and enter result	STRESSES – if load is opposite that shown, reverse signs shown							
			Au	AL	Bu	BL	Cu	CL	Du	DL
3C	$\frac{N\phi}{P/R_m}$ = .42	$K_n\left(\frac{N\phi}{P/R_m}\right)\cdot\frac{P}{R_mT}$	−.03	−.03	−.03	−.03	−.03	−.03	−.03	−.03
1C	$\frac{M\phi}{P}$ = 0.32	$K_b\left(\frac{M\phi}{P}\right)\cdot\frac{6P}{T^2}$	−.31	+.31	−.31	+.31	−.31	+.31	−.31	+.31
3A	$\frac{N\phi}{M_c/R_m^2\beta}$ = 1.3	$K_n\left(\frac{N\phi}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$	▨	▨	▨	▨	−.01	−.01	+.01	+.01
1A	$\frac{M\phi}{M_c/R_m\beta}$ = .11	$K_b\left(\frac{M\phi}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$	▨	▨	▨	▨	−.99	+.99	+.95	−.99
3B	$\frac{N\phi}{M_L/R_m^2\beta}$ = 3.1	$K_n\left(\frac{N\phi}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$ =	−.06	−.06	+.06	+.06	▨	▨	▨	▨
1B or 1B-1	$\frac{M\phi}{M_L/R_m\beta}$ = 0.065	$K_b\left(\frac{M\phi}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$ =	−1.10	+1.10	+1.10	−1.10	▨	▨	▨	▨
Add algebraically for summation of φ stresses, σ_ϕ =			−1.49	1.33	.81	−.76	−1.34	1.26	.65	−.69
4C	$\frac{N_x}{P/R_m}$ = .50	$K_n\left(\frac{N_x}{P/R_m}\right)\cdot\frac{P}{R_mT}$ =	−.03	−.03	−.03	−.03	−.03	−.03	−.03	−.03
2C	$\frac{M_x}{P}$ = .21	$K_b\left(\frac{M_x}{P}\right)\cdot\frac{6P}{T^2}$ =	−.20	+.20	−.20	+.20	−.20	+.20	−.20	+.20
4A	$\frac{N_x}{M_c/R_m^2\beta}$ = 1.6	$K_n\left(\frac{N_x}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$ =	▨	▨	▨	▨	−.01	−.01	+.01	+.01
2A	$\frac{M_x}{M_c/R_m\beta}$ = .06	$K_b\left(\frac{M_x}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$ =	▨	▨	▨	▨	−.54	+.54	+.54	−.54
4B	$\frac{N_x}{M_L/R_m^2\beta}$ = 1.5	$K_n\left(\frac{N_x}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$ =	−.02	−.02	+.02	+.02	▨	▨	▨	▨
2B or 2B-1	$\frac{M_x}{M_L/R_m\beta}$ = 0.11	$K_b\left(\frac{M_x}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$ =	−1.72	+1.72	+1.72	−1.72	▨	▨	▨	▨
Add algebraically for summation of X stresses, σ_x =			−1.98	1.88	1.50	−1.54	−.79	.70	.31	−.36
Shear stress due to Torsion, M_T		$\tau_{\phi x} = \tau_{x\phi} = \frac{M_T}{2\pi r_o^2 T}$	+.02	+.02	+.02	+.02	+.02	+.02	+.02	+.02
Shear stress due to load, Vc		$\tau_{x\phi} = \frac{V_c}{\pi r_o T}$	+.02	+.02	−.02	−.02	▨	▨	▨	▨
Shear stress due to load, VL		$\tau_{x\phi} = \frac{V_L}{\pi r_o T}$	▨	▨	▨	▨	−.02	−.02	+.02	+.02
Add Algebraically for summation of shear stresses, τ =			.04	.04	0	0	0	0	.04	.04
COMBINED STRESS INTENSITY, S										
1) When σ_ϕ & σ_x have like signs		$S = \frac{1}{2}\left[\sigma_\phi + \sigma_x + \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2}\right]$	1.98 KSI	1.88 KSI	1.50 KSI	1.54 KSI	1.34 KSI	1.26 KSI	.66 KSI	.70 KSI
2) When τ = 0		S = largest of σ_ϕ, σ_x or $\lvert\sigma_\phi - \sigma_x\rvert$								
3) When σ_ϕ & σ_x have unlike signs		$S = \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2}$								

$N_x/(M_L/R_m^2\beta)$ so determined by (C_L) from Table 8 (see para. 4.3).

4.2.2.5.2: When considering bending moment (M_L): $\beta = K_L\sqrt[3]{\beta_1\beta_2^2}$ where K_L is given in Table 8.

4.3 Calculation of Stresses

4.3.1 STRESSES RESULTING FROM RADIAL LO P.

4.3.1.1 *Circumferential Stresses* (σ_ϕ):

Step 1. Using the applicable values of β an

```
MC=
  175000.00

ML=
  125000.00

MT=
   51000.00

VC=
   19500.00

VL=
   13500.00


T=
       1.75

RO=
       6.00

RM=
     420.90

KN=
       1.00

KB=
       1.00

GAMMA=    240.51
```

```
1A
        0.1[illegible]

COEFS
2A=
        0.07

COEFS
3A=
        2.50

COEFS
4A=
        2.40

 OEFS
 B=
        0.07

 OEFS
 B-1=
        0.07

COEFS
2B=
        0.10

COEFS
2B-1=
        0.10

COEFS
3B=
        8.00

COEFS
4B=
        2.10

COEFS
```

```
         0.26

COEFS
2C=
         0.18

COEFS
2C-1=
         0.18

COEFS
3C=
        35.00

COEFS
4C=
        45.00


       926.59
      9933.06
       113.14
      6530.61
       258.60
      3265.31


SUMS
    -14383.55
     12013.18
     -7335.74
      5999.77
    -17503.40
     15423.95
     -4215.90
     [illegible]
```

```
        10[illegible]
      4571.43
        67.88
      4664.72


SUMS
    -12800.66
     10282.25
     -3335.45
      1088.57
    -12748.10
     10148.23
     -3388.02
      1222.59


SHEARS
       128.84
       591.15
       409.26

SUMS
       719.99
       719.99
      -462.31
      -462.31
      -280.42
      -280.42
       538.10
       538.10
STRESS
[illegible]
```

1

HP-9815 12" DIAMETER NOZZLE 7-18-78

$R_m + Q$

WR1217 6

A-8

Table 5—Computation Sheet for Local Stresses in Cylindrical Shells

12" DIA. NOZZLE Pm + Q **LTR1217 6** A-9

1. Applied Loads*

Radial load, P = 19,500 lb.
Circ. Moment, Mc = 125,000 in. lb.
Long. Moments, ML = 125,000 in. lb.
Torsion Moment, M_T = 51,000 in. lb.
Shear Load, Vc = 12,500 lb.
Shear Load, VL 13,500 lb.

2. Geometry

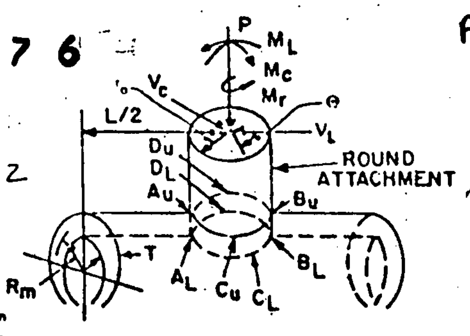
Vessel thickness, T = 1.75 in.
Attachment radius, r_o = 6.0 in.
Vessel radius, Rm 420.9 in.

3. Geometric Parameters

γ $\frac{R_m}{T}$ = 240.5
β $(0.875)\frac{r_o}{R_m}$ = 0.012

Stress Concentration due to:
a) membrane load, Kn 1.0
b) bending load, Kb 1.0

*NOTE: Enter all force values in accordance with sign convention



CYLINDRICAL SHELL

From Fig.	Read curves for	Compute absolute values of stress and enter result	STRESSES – if load is opposite that shown, reverse signs shown							
			Au	AL	Bu	BL	Cu	CL	Du	DL
3C	$\frac{N\phi}{P/R_m}$ = 35	$K_n\left(\frac{N\phi}{P/R_m}\right)\cdot\frac{P}{R_mT}$	-.92	-.92	-.92	-.92	-.92	-.92	-.92	-.92
1C	$\frac{M\phi}{P}$ = .26	$K_b\left(\frac{M\phi}{P}\right)\cdot\frac{6P}{T^2}$	-9.93	+9.93	-9.93	+9.93	-9.93	+9.93	-9.93	+9.93
3A	$\frac{N\phi}{M_c/R_m^2\beta}$ = 2.5	$K_n\left(\frac{N\phi}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$					-.11	-.11	+.11	+.11
1A	$\frac{M\phi}{M_c/R_m\beta}$ = 0.10	$K_b\left(\frac{M\phi}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$					-6.53	+6.51	+6.55	-6.53
3B	$\frac{N\phi}{M_L/R_m^2\beta}$ = 8.0	$K_n\left(\frac{N\phi}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$	-.26	-.26	+.26	+.26				
1B or 1B-1	$\frac{M\phi}{M_L/R_m\beta}$ = 0.07	$K_b\left(\frac{M\phi}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$	-3.26	+3.26	+3.26	-3.26				
Add algebraically for summation of ϕ stresses, σ_ϕ =			-19.58	12.01	-7.34	6.00	-17.50	15.42	-4.22	2.59
4C	$\frac{N_x}{P/R_m}$ = 45	$K_n\left(\frac{N_x}{P/R_m}\right)\cdot\frac{P}{R_mT}$ =	-1.19	-1.19	-1.19	-1.19	-1.19	-1.19	-1.19	-1.19
2C	$\frac{M_x}{P}$ = 0.18	$K_b\left(\frac{M_x}{P}\right)\cdot\frac{6P}{T^2}$ =	-6.88	+6.88	-6.88	+6.88	-6.88	+6.88	-6.8	+6.88
4A	$\frac{N_x}{M_c/R_m^2\beta}$ = 2.4	$K_n\left(\frac{N_x}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$ =					-.11	-.11	+.11	+.11
2A	$\frac{M_x}{M_c/R_m\beta}$ = 0.07	$K_b\left(\frac{M_x}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$ =					-4.57	+4.57	+4.57	-4.57
4B	$\frac{N_x}{M_L/R_m^2\beta}$ = 2.1	$K_n\left(\frac{N_x}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$ =	-.07	-.07	+.07	+.07				
2B or 2B-1	$\frac{M_x}{M_L/R_m\beta}$ = .11	$K_b\left(\frac{M_x}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$ =	-4.66	+4.66	+4.66	-4.66				
Add algebraically for summation of X stresses, σ_x =			-12.8	10.28	-3.34	1.09	-12.75	10.15	3.39	1.22
Shear stress due to Torsion, M_T		$\tau_{\phi x} = \tau_{x\phi} = \frac{M_T}{2\pi r_o^2 T}$	+.13	+.13	+.13	+.13	+.13	+.13	+.13	+.13
Shear stress due to load, Vc		$\tau_{x\phi} = \frac{V_c}{\pi r_o T}$	+.59	+.59	-.59	-.59				
Shear stress due to load, VL		$\tau_{x\phi} = \frac{V_L}{\pi r_o T}$					-.91	-.91	+.91	+.91
Add Algebraically for summation of shear stresses, τ =			.72	.72	-.46	-.46	-.28	-.28	.59	.59
COMBINED STRESS INTENSITY, S										
1) When σ_ϕ & σ_x have like signs 2) When τ = 0 3) When σ_ϕ & σ_x have unlike signs		$S = \frac{1}{2}\left[\sigma_\phi + \sigma_x \pm \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2}\right]$ S = largest of σ_ϕ, σ_x or $\lvert\sigma_\phi - \sigma_x\rvert$ $S = \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2}$	14.66 KSI	12.27 KSI	7.39 KSI	6.04 KSI	17.52 KSI	15.44 KSI	4.48 KSI	2.76 KSI

$N_i/(M_L/R_m^2\beta)$ so determined by (C_L) from Table 8 (see para. 4.3).

4.2.2.5.2: When considering bending moment (M_L): $\beta = K_L\sqrt[3]{\beta_1\beta_2^2}$ where K_L is given in Table 8.

4.3 Calculation of Stresses

4.3.1 STRESSES RESULTING FROM RADIAL LOAD, P.

4.3.1.1 Circumferential Stresses (σ_ϕ):

Step 1. Using the applicable values of β and γ

```
P=

MC=
  430000.00

ML=
  260000.00

MT=
  250000.00

VC=
    5500.00

VL=
    3000.00


T=
        1.75

RO=
        8.00

RM=
      420.90

KN=
        1.00

KB=
        1.00

GAMMA=    240.51

[illegible]       [illegible].02
```

```
1A=
          0.10

COEFS
2A=
          0.06

COEFS
3A=
          2.60

COEFS
4A=
          2.80

COEFS
1B=
          0.06

OEFS
B-1=
          0.06

OEFS
B=
          0.11

COEFS
2B-1=
          0.11

COEFS
3B=
          9.00

COEFS
4B=
          2.40

COEFS
```

```
COEF
1C-1
          0.28

COEFS
2C=
          0.20

COEFS
2C-1=
          0.20

COEFS
3C=
         37.00

COEFS
4C=
         47.00

        853.95
       9325.71
        216.83
      12034.99
        453.84
       4366.18

SUMS
     -14999.69
      12384.10
      -5359.65
       4559.42
     -22431.49
      20289.91
       2072.15
[illegible]
```

```
          [illegible]
       7220.99
        121.02
       8004.66

SUMS
     -15871.66
      13460.12
        379.71
      -2307.17
     -15200.48
      12563.95
       -291.47
      -1411.00


SHEARS
        355.26
        125.05
         68.21

SUMS
        480.31
        480.31
        230.21
        230.21
        287.05
        287.05
        423.47
        423.47
[illegible]
```

HP-9815 16" DIAMETER NOZZLE

Pm + Q

LTR1217 6

7-11-78

A-10

LTR1217 6

A-11

16" DIA NOZZLE Pm+Q

1. Applied Loads*

Radial load,	P	17,000 lb.
Circ. Moment,	Mc	430,000 in. lb.
Long. Moments,	ML	260,000 in. lb.
Torsion Moment,	MT	250,000 in. lb.
Shear Load,	Vc	5,500 lb.
Shear Load,	VL	3,000 lb.

2. Geometry

Vessel thickness,	T	1.75 in.
Attachment radius,	r_o	8.6 in.
Vessel radius,	R_m	420.9 in.

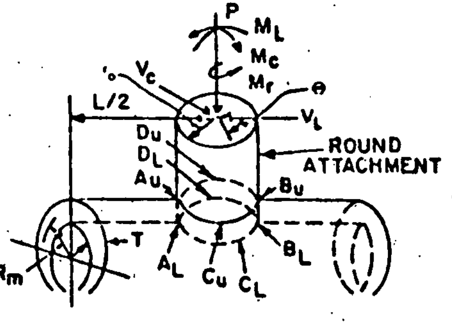
3. Geometric Parameters

γ $\frac{R_m}{T}$ = 240.5

β $(0.875)\frac{r_o}{R_m}$ = 0.0166

Stress Concentration due to:
a) membrane load, Kn 1.0
b) bending load, Kb 1.0

*NOTE: Enter all force values in accordance with sign convention



CYLINDRICAL SHELL

From Fig.	Read curves for	Compute absolute values of stress and enter result	Au	AL	Bu	BL	Cu	CL	Du	DL
			STRESSES – if load is opposite that shown, reverse signs shown							
3C	$\frac{N_\phi}{P/R_m}$ = 37	$K_n\left(\frac{N_\phi}{P/R_m}\right)\cdot\frac{P}{R_m T}$	-.85	-.85	-.85	-.85	-.85	-.85	-.85	-
1C	$\frac{M_\phi}{P}$ = .28	$K_b\left(\frac{M_\phi}{P}\right)\cdot\frac{6P}{T^2}$	-9.33	+9.33	-9.33	+9.33	-9.33	+9.33	-9.33	+9.33
3A	$\frac{N_\phi}{M_c/R_m^2\beta}$ = 2.6	$K_n\left(\frac{N_\phi}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$	▨	▨	▨	▨	-.22	-.22	+.22	+.22
1A	$\frac{M_\phi}{M_c/R_m\beta}$ = .11	$K_b\left(\frac{M_\phi}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$	▨	▨	▨	▨	-12.03	+12.03	+12.03	-12.03
3B	$\frac{N_\phi}{M_L/R_m^2\beta}$ = 9.0	$K_n\left(\frac{N_\phi}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$	-.45	-.45	+.45	+.45	▨	▨	▨	▨
1B or 1B-1	$\frac{M_\phi}{M_L/R_m\beta}$ = .06	$K_b\left(\frac{M_\phi}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$	-4.37	+4.37	+4.37	-4.37	▨	▨	▨	▨
Add algebraically for summation of ϕ stresses, σ_ϕ =			-15.00	12.38	-5.36	4.56	-22.43	20.29	2.07	-3.35
4C	$\frac{N_x}{P/R_m}$ = 47	$K_n\left(\frac{N_x}{P/R_m}\right)\cdot\frac{P}{R_m T}$ =	-1.08	-1.08	-1.08	-1.08	-1.08	-1.08	-1.08	-1.08
2C	$\frac{M_x}{P}$ = .20	$K_b\left(\frac{M_x}{P}\right)\cdot\frac{6P}{T^2}$ =	-6.66	+6.66	-6.66	+6.66	-6.66	+6.66	-6.66	+6.66
4A	$\frac{N_x}{M_c/R_m^2\beta}$ = 2.8	$K_n\left(\frac{N_x}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$ =	▨	▨	▨	▨	-.23	-.23	+.23	+.23
2A	$\frac{M_x}{M_c/R_m\beta}$ = .055	$K_b\left(\frac{M_x}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$ =	▨	▨	▨	▨	-7.22	+7.22	+7.22	-7.22
4B	$\frac{N_x}{M_L/R_m^2\beta}$ = 2.4	$K_n\left(\frac{N_x}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$ =	-.12	-.12	+.12	+.12	▨	▨	▨	▨
2B or 2B-1	$\frac{M_x}{M_L/R_m\beta}$ = .11	$K_b\left(\frac{M_x}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$ =	-8.00	+8.00	+8.00	-8.00	▨	▨	▨	▨
Add algebraically for summation of X stresses, σ_x =			-15.87	13.46	.38	-2.31	-15.20	12.56	-.29	1.41
Shear stress due to Torsion, M_T		$\tau_{\phi x} = \tau_{x\phi} = \frac{M_T}{2\pi r_o^2 T}$	+.36	+.36	+.36	+.36	+.36	+.36	+.36	+.36
Shear stress due to load, Vc		$\tau_{x\phi} = \frac{V_c}{\pi r_o T}$	+.13	+.13	-.13	-.13	▨	▨	▨	▨
Shear stress due to load, VL		$\tau_{x\phi} = \frac{V_L}{\pi r_o T}$	▨	▨	▨	▨	-.07	-.07	+.07	+.07
Add Algebraically for summation of shear stresses, τ =			.48	.48	.23	.23	.29	.29	.42	.42
COMBINED STRESS INTENSITY, S										
1) When σ_ϕ & σ_x have like signs 2) When τ = 0 3) When σ_ϕ & σ_x have unlike signs		$S = \frac{1}{2}\left[\sigma_\phi + \sigma_x + \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2}\right]$ S = largest of σ_ϕ, σ_x or $\lvert\sigma_\phi - \sigma_x\rvert$ $S = \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2}$	16.08 KSI	13.64 KSI	5.76 KSI	6.88 KSI	22.44 KSI	20.30 KSI	2.51 KSI	3.43 KSI

$N_\phi/(M_L/R_m^2\beta)$ so determined by (C_L) from Table 8 (see para. 4.3).

4.2.2.5.2: When considering bending moment (M_L): $\beta = K_L\sqrt[3]{\beta_1\beta_2^2}$ where K_L is given in Table 8.

4.3 Calculation of Stresses

4.3.1 STRESSES RESULTING FROM RADIAL LO P.

4.3.1.1 Circumferential Stresses (σ_ϕ):

Step 1. Using the applicable values of β an

```
P=

MC=
   65000.00

ML=
   30000.00

MT=
   90000.00

VC=
     500.00

VL=
    1000.00


T=
       1.75

RO=
       9.00

RM=
     420.90

KN=
       1.00

KB=
       1.00

GAMMA=    240.51

       0.02
```

```
CO
1A
            0.11

COEFS
2A=
            0.06

COEFS
3A=
            2.80

COEFS
4A=
            3.60

COEFS
1B=
            0.06

COEFS
1B-1=
            0.06

COEFS
2B=
            0.11

COEFS
2B-1=
            0.11

COEFS
3B=
           11.00

COEFS
4B=
            2.70
```

```
1C-1-
            0.28

COEFS
2C=
            0.20

COEFS
2C-1=
            0.20

COEFS
3C=
           35.00

COEFS
4C=
           45.00


          142.55
         1645.71
           31.38
         1778.81
           56.89
          447.81


SUMS
        -2292.97
         1894.08
        -1283.56
         1112.24
        -3598.46
         3250.60
           21.92
             38
```

```
           40.34
          970.26
           13.96
          820.99


SUMS
        -2193.75
         1799.26
         -523.84
          185.20
        -2369.39
         1922.15
         -348.19
           62.31


HEARS
          101.05
           10.11
           20.21

SUMS
          111.16
          111.16
           90.95
           90.95
           80.84
           80.84
          121.26
          121.26
```

Pm + Q

TR1217 6

HP-9815 18" DIAMETER NOZZLE 7-11-78

A-12

LTR1217 6

A-13

18" DIA NOZZLE Pm+Q

1. Applied Loads*

Radial load,	P	3000 lb.
Circ. Moment,	Mc	65000 in. lb.
Long. Moments,	ML	30,000 in. lb.
Torsion Moment,	M_T	90,000 in. lb.
Shear Load,	Vc	500 lb.
Shear Load,	VL	1000 lb.

2. Geometry

Vessel thickness,	T	1.75 in.
Attachment radius,	r_o	9.0 in.
Vessel radius,	Rm	420.9 in.

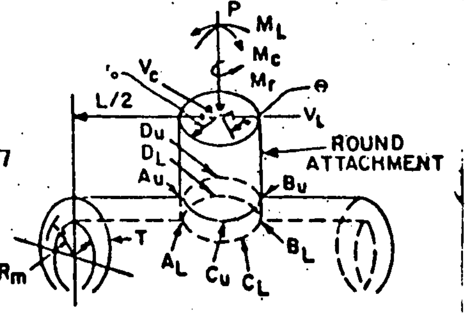
3. Geometric Parameters

$\gamma = \frac{R_m}{T} = 240.5$

$\beta = (0.875)\frac{r_o}{R_m} = 0.0187$

Stress Concentration due to:
a) membrane load, Kn 1.0
b) bending load, Kb 1.0

*NOTE: Enter all force values in accordance with sign convention



CYLINDRICAL SHELL

From Fig.	Read curves for	Compute absolute values of stress and enter result	STRESSES – if load is opposite that shown, reverse signs shown							
			Au	AL	Bu	BL	Cu	CL	Du	DL
3C	$\frac{N\phi}{P/R_m} = 35$	$K_n\left(\frac{N\phi}{P/R_m}\right)\cdot\frac{P}{R_mT}$	−.14	−.14	−.14	−.14	−.14	−.14	−.14	−.14
1C	$\frac{M\phi}{P} = .28$	$K_b\left(\frac{M\phi}{P}\right)\cdot\frac{6P}{T^2}$	−1.65	+1.65	−1.65	+1.65	−1.65	+1.65	−1.65	+1.65
3A	$\frac{N\phi}{M_c/R_m^2\beta} = 2.8$	$K_n\left(\frac{N\phi}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$					−.03	−.03	+.03	+.03
1A	$\frac{M\phi}{M_c/R_m\beta} = .11$	$K_b\left(\frac{M\phi}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$					−1.78	+1.78	+1.78	−1.78
3B	$\frac{N\phi}{M_L/R_m^2\beta} = 11$	$K_n\left(\frac{N\phi}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$	−.06	−.06	+.06	+.06				
1B or 1B−1	$\frac{M\phi}{M_L/R_m\beta} = .06$	$K_b\left(\frac{M\phi}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$	−.45	+.45	+.45	−.45				
Add algebraically for summation of ϕ stresses, σ_ϕ =			−2.29	1.89	−1.28	1.11	−3.60	3.26	.02	−.29
4C	$\frac{N_x}{P/R_m} = 45$	$K_n\left(\frac{N_x}{P/R_m}\right)\cdot\frac{P}{R_mT}$ =	−.18	−.18	−.18	−.18	−.18	−.18	−.18	−.18
2C	$\frac{M_x}{P} = .20$	$K_b\left(\frac{M_x}{P}\right)\cdot\frac{6P}{T^2}$ =	−1.18	+1.18	−1.18	+1.18	−1.18	+1.18	−1.18	+1.18
4A	$\frac{N_x}{M_c/R_m^2\beta} = 3.6$	$K_n\left(\frac{N_x}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$ =					−.04	−.04	+.04	+.04
2A	$\frac{M_x}{M_c/R_m\beta} = .055$	$K_b\left(\frac{M_x}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$ =					−.97	+.97	+.97	−.97
4B	$\frac{N_x}{M_L/R_m^2\beta} = 2.7$	$K_n\left(\frac{N_x}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$ =	−.01	−.01	+.01	+.01				
2B or 2B−1	$\frac{M_x}{M_L/R_m\beta} = 0.11$	$K_b\left(\frac{M_x}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$ =	−.82	+.82	+.82	−.82				
Add algebraically for summation of X stresses, σ_x =			−2.19	1.80	−.52	.18	−2.37	1.92	−.35	.06
Shear stress due to Torsion, M_T		$\tau_{\phi x} = \tau_{x\phi} = \frac{M_T}{2\pi r_o^2 T}$	+.10	+.10	+.10	+.10	+.10	+.10	+.10	+.10
Shear stress due to load, Vc		$\tau_{x\phi} = \frac{V_c}{\pi r_o T}$	+.01	+.01	−.01	−.01				
Shear stress due to load, VL		$\tau_{x\phi} = \frac{V_L}{\pi r_o T}$					−.02	−.02	+.02	+.02
Add Algebraically for summation of shear stresses, τ =			.11	.11	.09	.09	.08	.08	.12	.12
COMBINED STRESS INTENSITY, S										
1) When σ_ϕ & σ_x have like signs		$S = \frac{1}{2}\left[\sigma_\phi + \sigma_x + \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2}\right]$	2.37 KSI	1.97 KSI	1.29 KSI	1.12 KSI	3.60 KSI	3.26 KSI	.44 KSI	.39 KSI
2) When $\tau = 0$		S = largest of σ_ϕ, σ_x or $\lvert\sigma_\phi - \sigma_x\rvert$								
3) When σ_ϕ & σ_x have unlike signs		$S = \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2}$								

$N_x/(M_L/R_m^2\beta)$ so determined by (C_L) from Table 8 (see para. 4.3).

4.2.2.5.2: When considering bending moment (M_L): $\beta = K_L\sqrt[3]{\beta_1\beta_2^2}$ where K_L is given in Table 8.

4.3 Calculation of Stresses

4.3.1 STRESSES RESULTING FROM RADIAL LO P.

4.3.1.1 *Circumferential Stresses* (σ_ϕ):

Step 1. Using the applicable values of β an

```
P=
   2000.00

MC=
  55000.00

ML=
  90000.00

MT=
  30000.00

VC=
   2500.00

VL=
   2500.00


T=
      1.75

RO=
     12.00

RM=
    420.90


KN=
      1.00

KB=
      1.00

GAMMA=     240.51

           0.02
```

```
COEFS
1A=
            0.11
COEFS
2A=
            0.06
COEFS
3A=
            4.00
COEFS
4A=
            5.00
COEFS
1B=
            0.06
COEFS
1B-1=
            0.06
COEFS
2B=
            0.11
COEFS
2B-1=
            0.11
COEFS
3B=
           15.00
COEFS
4B=
            4.20
COEFS

            0.28
```

```
COEFS
1C-1=
            0.28
COEFS
2C=
            0.15
COEFS
2C-1=
            0.15
COEFS
3C=
           33.00
COEFS
4C=
           43.00


           89.60
         1097.14
           28.45
         1128.86
          174.55
         1007.58


SUMS
        -2368.88
         1840.57
           -4.61
          174.51
        -2344.06
         2107.96
          -29.44
          -92.88
```

```
          116.76
          587.76
           35.56
          615.74
           48.87
         1847.23

SUMS
        -2600.62
         2269.35
         1191.59
        -1327.36
        -1355.81
         1051.18
          -53.21
         -109.19


SHEARS
           18.95
           37.89
           37.89
SUMS
           56.84
           56.84
          -18.95
          -18.95
          -18.95
          -18.95
           56.84
           56.84
STRESS
INTENSITIES
         2613.81
         2276.76
         1196.81
         1502.35
         2344.42
         2108.30
          116.14
          158.46
```

Pm + Q

LTR1217

HP-9815 24" DIAMETER NOZZLE 7-26-78

A-14

Table 5 – Computation Sheet for Local Stresses in Cylindrical Shell LTR1217 6 A-15

24" DIA. NOZZLE Pm + Q

1. Applied Loads*

Radial load, P = 2000 lb.
Circ. Moment, Mc = 55,000 in. lb.
Long. Moments, ML = 90,000 in. lb.
Torsion Moment, M_T = 30,000 in. lb.
Shear Load, Vc = 2,600 lb.
Shear Load, VL = 2,400 lb.

2. Geometry

Vessel thickness, T = 1.75 in.
Attachment radius, r_o = 12 in.
Vessel radius, Rm = 420.9 in.

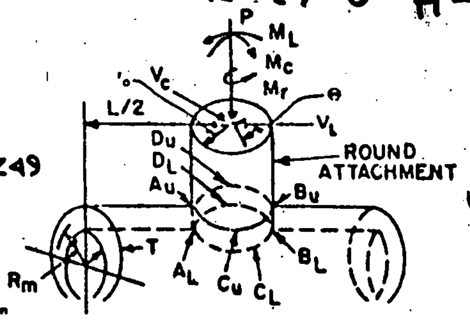
3. Geometric Parameters

$\gamma = \frac{R_m}{T}$ = 240.5

$\beta = (0.875)\frac{r_o}{R_m}$ = 0.0249

Stress Concentration due to:
a) membrane load, Kn 1.0
b) bending load, Kb 1.0

*NOTE: Enter all force values in accordance with sign convention



CYLINDRICAL SHELL

From Fig.	Read curves for	Compute absolute values of stress and enter result	STRESSES – if load is opposite that shown, reverse signs shown							
			Au	AL	Bu	BL	Cu	CL	Du	DL
3C	$\frac{N\phi}{P/R_m}$ = 33	$K_n\left(\frac{N\phi}{P/R_m}\right)\cdot\frac{P}{R_mT}$	-.09	-.09	-.09	-.09	-.09	-.09	-.09	-.09
1C	$\frac{M\phi}{P}$ = .28	$K_b\left(\frac{M\phi}{P}\right)\cdot\frac{6P}{T^2}$	-1.10	+1.10	-1.10	+1.10	-1.10	+1.10	-1.10	+1.10
3A	$\frac{N\phi}{M_c/R_m^2\beta}$ = 4.0	$K_n\left(\frac{N\phi}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$	▨	▨	▨	▨	-.03	-.03	+.03	+.03
1A	$\frac{M\phi}{M_c/R_m\beta}$ = .11	$K_b\left(\frac{M\phi}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$	▨	▨	▨	▨	-1.13	+1.13	+1.13	-1.13
3B	$\frac{N\phi}{M_L/R_m^2\beta}$ = .15	$K_n\left(\frac{N\phi}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$	-.17	-.17	+.17	+.17	▨	▨	▨	▨
1B or 1B-1	$\frac{M\phi}{M_L/R_m\beta}$ = .06	$K_b\left(\frac{M\phi}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$	-1.01	+1.01	+1.01	-1.01	▨	▨	▨	▨
Add algebraically for summation of ϕ stresses, σ_ϕ =			-2.39	1.84	0	.17	-2.39	2.12	-.03	-.09
4C	$\frac{N_x}{P/R_m}$ = 43	$K_n\left(\frac{N_x}{P/R_m}\right)\cdot\frac{P}{R_mT}$	-.12	-.12	-.12	-.12	-.12	-.12	-.12	-.12
2C	$\frac{M_x}{P}$ = .15	$K_b\left(\frac{M_x}{P}\right)\cdot\frac{6P}{T^2}$	-.59	+.59	-.59	+.59	-.59	+.59	-.59	+.59
4A	$\frac{N_x}{M_c/R_m^2\beta}$ = 5.0	$K_n\left(\frac{N_x}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$	▨	▨	▨	▨	-.04	-.04	+.04	+.04
2A	$\frac{M_x}{M_c/R_m\beta}$ = .056	$K_b\left(\frac{M_x}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$	▨	▨	▨	▨	-.62	+.62	+.62	-.62
4B	$\frac{N_x}{M_L/R_m^2\beta}$ = 4.2	$K_n\left(\frac{N_x}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$	-.05	-.05	+.05	+.05	▨	▨	▨	▨
2B or 2B-1	$\frac{M_x}{M_L/R_m\beta}$ = .11	$K_b\left(\frac{M_x}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$	-.85	+.85	+1.85	-.85	▨	▨	▨	▨
Add algebraically for summation of X stresses, σ_x =			-2.60	2.27	1.19	-1.33	-1.36	1.05	-.05	-.11
Shear stress due to Torsion, M_T		$\tau_{\phi x} = \tau_{x\phi} = \frac{M_T}{2\pi r_o^2 T}$	+.02	+.02	+.02	+.02	+.02	+.02	+.02	+.02
Shear stress due to load, Vc		$\tau_{x\phi} = \frac{V_c}{\pi r_o T}$	+.04	+.04	-.04	-.04	▨	▨	▨	▨
Shear stress due to load, VL		$\tau_{x\phi} = \frac{V_L}{\pi r_o T}$	▨	▨	▨	▨	-.04	-.04	+.04	+.04
Add Algebraically for summation of shear stresses, τ =			.06	.06	-.02	-.02	-.02	-.02	+.06	.06
COMBINED STRESS INTENSITY, S										
1) When σ_ϕ & σ_x have like signs 2) When τ = 0 3) When σ_ϕ & σ_x have unlike signs		$S = \frac{1}{2}\left[\sigma_\phi + \sigma_x + \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2}\right]$ S = largest of σ_ϕ, σ_x or $\lvert\sigma_\phi - \sigma_x\rvert$ $S = \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2}$	2.61 KSI	2.28 KSI	1.20 KSI	1.50 KSI	2.39 KSI	2.11 KSI	.12 KSI	.16 KSI

$N_i/(M_L/R_m^2\beta)$ so determined by (C_L) from Table 8 (see para. 4.3).

4.2.2.5,2: When considering bending moment (M_L): $\beta = K_L\sqrt[3]{\beta_1\beta_2^2}$ where K_L is given in Table 8.

4.3 Calculation of Stresses

4.3.1 STRESSES RESULTING FROM RADIAL LOAD, P.

4.3.1.1 Circumferential Stresses (σ_ϕ):

Step 1. Using the applicable values of β and γ

```
P

MC=
    90000.00

ML=
   170000.00

MT=
    10000.00

VC=
     1000.00

VL=
     1500.00


T=
        1.75

RO=
       15.00

RM=
      420.90


KN=
        1.00

KB=
        1.00

GAMMA=    240.51

E           03
```

```
CI
1h-
          0.11

COEFS
2A=
          0.06

COEFS
3A=
          5.10

COEFS
4A=
          6.30

COEFS
 B=
          0.06

COEFS
1B-1=
          0.06

COEFS
2B=
          0.10

COEFS
2B-1=
          0.10

COEFS
3B=
         18.00

COEFS
4B=
          5.00

COEFS_
```

```
CC
1C
          0.18

COEFS
2C=
          0.12

COEFS
2C-1=
          0.12

COEFS
3C=
         32.00

 EFS
 =
         42.00



         43.44
        352.65
         47.48
       1477.78
        316.52
       1522.57


SUMS
      -2235.19
       1515.25
       1442.99
       -896.83
      -1921.36
       1739.51
       1129.17
```

```
           -----
          806.06
           87.92
         2537.61


SUMS
        -2917.66
         2627.77
         2333.41
        -2271.60
        -1156.84
          925.50
          572.59
         -569.33


SHEARS
            4.04
           12.13
           18.19

SUMS
           16.17
           16.17
           -8.08
           -8.08
          -14.15
          -14.15
           22.23
           22.23
STRESS
INTENSITIES
[illegible]
```

HP-9815 30" DIAMETER NOZZLE 7-11-78

Pm + Q

LTR1217 6

A-16

LTR1217 6 A-17

Table 5—Computation Sheet for Local Stresses in Cylindrical Shells

30" DIA NOZZLE Pm + Q

1. Applied Loads*

Radial load,	P = 1000	lb.
Circ. Moment,	Mc = 90,000	in. lb.
Long. Moments,	ML = 170,000	in. lb.
Torsion Moment,	M_T = 40,000	in. lb.
Shear Load,	Vc = 1000	lb.
Shear Load,	VL 1500	lb.

2. Geometry

Vessel thickness,	T = 1.75	in.
Attachment radius,	r_o = 15	in.
Vessel radius,	Rm 420.9	in.

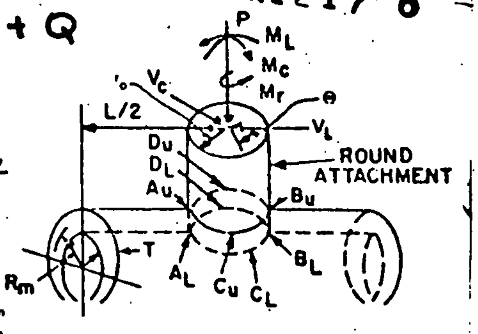
3. Geometric Parameters

$\gamma = \frac{R_m}{T} = 240.5$

$\beta = (0.875)\frac{r_o}{R_m} = .0312$

Stress Concentration due to:
a) membrane load, Kn 1.0
b) bending load, Kb 1.0

*NOTE: Enter all force values in accordance with sign convention



CYLINDRICAL SHELL

From Fig.	Read curves for	Compute absolute values of stress and enter result •	Au	AL	Bu	BL	Cu	CL	Du	DL
			STRESSES – if load is opposite that shown, reverse signs shown							
3C	$\frac{N\phi}{P/R_m}$ = 32	$K_n\left(\frac{N\phi}{P/R_m}\right)\cdot\frac{P}{R_mT}$	-.04	-.04	-.04	-.04	-.04	-.04	-.04	-.04
1C	$\frac{M\phi}{P}$ = .18	$K_b\left(\frac{M\phi}{P}\right)\cdot\frac{6P}{T^2}$	-.35	+.35	-.35	+.35	-.35	+.35	-.35	+.35
3A	$\frac{N\phi}{M_c/R_m^2\beta}$ = 5.1	$K_n\left(\frac{N\phi}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$	▨	▨	▨	▨	-.05	-.05	+.05	+.05
1A	$\frac{M\phi}{M_c/R_m\beta}$ = .11	$K_b\left(\frac{M\phi}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$	▨	▨	▨	▨	-1.48	+1.48	+1.48	-1.48
3B	$\frac{N\phi}{M_L/R_m^2\beta}$ = 18	$K_n\left(\frac{N\phi}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$	-.32	-.32	+.32	+.32	▨	▨	▨	▨
1B or 1B-1	$\frac{M\phi}{M_L/R_m\beta}$ = .06	$K_b\left(\frac{M\phi}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$	-1.52	+1.52	+1.52	-1.52	▨	▨	▨	▨
Add algebraically for summation of ϕ stresses, σ_ϕ =			-2.29	1.52	1.44	-.89	-1.92	1.74	1.13	-1.12
4C	$\frac{N_x}{P/R_m}$ = .42	$K_n\left(\frac{N_x}{P/R_m}\right)\cdot\frac{P}{R_mT}$ =	-.06	-.06	-.06	-.06	-.06	-.06	-.06	-.06
2C	$\frac{M_x}{P}$ = .12	$K_b\left(\frac{M_x}{P}\right)\cdot\frac{6P}{T^2}$ =	-.24	+.24	-.24	+.24	-.24	+.24	-.24	+.24
4A	$\frac{N_x}{M_c/R_m^2\beta}$ = 6.3	$K_n\left(\frac{N_x}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$ =	▨	▨	▨	▨	-.06	-.06	+.06	+.06
2A	$\frac{M_x}{M_c/R_m\beta}$ = .06	$K_b\left(\frac{M_x}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$ =	▨	▨	▨	▨	-.81	+.81	+.81	-.81
4B	$\frac{N_x}{M_L/R_m^2\beta}$ = 5.0	$K_n\left(\frac{N_x}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$ =	-.09	-.09	+.09	+.09	▨	▨	▨	▨
2B or 2B-1	$\frac{M_x}{M_L/R_m\beta}$ = .10	$K_b\left(\frac{M_x}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$ =	-2.59	+2.59	+2.59	-2.59	▨	▨	▨	▨
Add algebraically for summation of X stresses, σ_x =			-2.92	2.63	2.33	-2.27	-.116	.92	.57	-.57
Shear stress due to Torsion, M_T		$\tau_{\phi x} = \tau_{x\phi} = \frac{M_T}{2\pi r_o^2 T}$	+ 0	+ 0	+ 0	+ 0	+ 0	+ 0	+ 0	+ 0
Shear stress due to load, Vc		$\tau_{x\phi} = \frac{V_c}{\pi r_o T}$	+.01	+.01	-.01	-.01	▨	▨	▨	▨
Shear stress due to load, VL		$\tau_{x\phi} = \frac{V_L}{\pi r_o T}$	▨	▨	▨	▨	-.02	-.02	+.02	+.02
Add Algebraically for summation of shear stresses, τ =			.01	.01	-.01	-.01	-.02	-.02	.02	.02
COMBINED STRESS INTENSITY, S										
1) When σ_ϕ & σ_x have like signs		$S = \frac{1}{2}\left[\sigma_\phi + \sigma_x + \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2}\right]$	2.92 KSI	2.63 KSI	2.33 KSI	2.27 KSI	1.92 KSI	1.74 KSI	1.13 KSI	1.12 KSI
2) When τ = 0		S = largest of σ_ϕ, σ_x or $\lvert\sigma_\phi - \sigma_x\rvert$								
3) When σ_ϕ & σ_x have unlike signs		$S = \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2}$								

$N_x/(M_L/R_m^2\beta)$ so determined by (C_L) from Table 8 (see para. 4.3).

4.2.2.5.2: When considering bending moment (M_L): $\beta = K_L\sqrt[3]{\beta_1\beta_2^2}$ where K_L is given in Table 8.

4.3 Calculation of Stresses

4.3.1 STRESSES RESULTING FROM RADIAL LO P.

4.3.1.1 *Circumferential Stresses* (σ_ϕ):

Step 1. Using the applicable values of β an

```
 MC=
   20000.00

 ML=
   35000.00

 MT=
    5000.00

 VC=
     500.00

 VL=
     500.00


 T=
       1.75

 RO=
       5.00

 RM=
     420.90

 KN=
       1.75

 KB=
       1.50

 GAMMA=    240.51

           0.01
```

```
           0.11

COEFS
2A=
           0.06

COEFS
3A=
           1.30

COEFS
4A=
           1.60

COEFS
1B=
           0.07

COEFS
1B-1=
           0.07

COEFS
2B=
           0.11

COEFS
2B-1=
           0.11

COEFS
3B=
           5.10

COEFS
4B=
           1.50

COEFS
```

```
C
1
           0.32

COEFS
2C=
           0.21

COEFS
2C-1=
           0.21

COEFS
3C=
          42.00

COEFS
4C=
          50.00


          49.89
         470.20
          14.12
        1477.78
          96.94
        1528.16

SUMS
       -2145.20
        1851.54
        1105.00
       -1010.92
       -2012.00
        1883.98
         971.81
       -1043.35
```

```
          17.38
         806.06
          28:51
        2586.12


SUMS
       -2982.60
        2806.79
        2246.66
       -2308.44
       -1191.41
        1037.86
         455.47
        -539.51


SHEARS
          18.19
          18.19
          18.19

SUMS
          36.38
          36.38
           0.00
           0.00
           0.00
           0.00
          36.38
          36.38
STRESS
INTENSITIES
   [illegible]
   [illegible]
        2246.66
        2308.44
        2012.00
        1883.98
         971.36
   [illegible]
```

HP-9815 10" DIAMETER NOZZLE 7-7-78

Pm + Q + F

LTR1217 6

A-18

Table 5—Computation Sheet for Local Stresses in Cylindrical Shells

LTR1217 6

A-19

10" DIA. NOZZLE $P_m + Q + F$

1. Applied Loads*

Radial load, P = 500 lb.
Circ. Moment, Mc = 20,000 in. lb.
Long. Moments, ML = 35000 in. lb.
Torsion Moment, M_T = 5000 in. lb.
Shear Load, Vc = 500 lb.
Shear Load, VL 500 lb.

2. Geometry

Vessel thickness, T = 1.75 in.
Attachment radius, r_o = 5 in.
Vessel radius, Rm 4209 in.

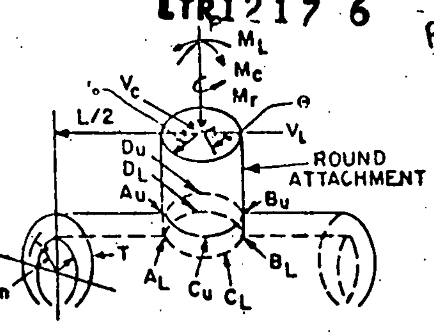
3. Geometric Parameters

$\gamma = \frac{R_m}{T} = 240.5$

$\beta = (0.875)\frac{r_o}{R_m} = 0.010$

Stress Concentration due to:
a) membrane load, Kn 1.75
b) bending load, Kb 1.50

*NOTE: Enter all force values in accordance with sign convention



CYLINDRICAL SHELL

From Fig.	Read curves for	Compute absolute values of stress and enter results	STRESSES – if load is opposite that shown, reverse signs shown							
			Au	AL	Bu	BL	Cu	CL	Du	DL
3C	$\frac{N_\phi}{P/R_m}$ =42	$K_n\left(\frac{N_\phi}{P/R_m}\right)\cdot\frac{P}{R_mT}$	-.05	-.05	-.05	-.05	-.05	-.05	-.05	-.05
1C	$\frac{M_\phi}{P}$ =0.32	$K_b\left(\frac{M_\phi}{P}\right)\cdot\frac{6P}{T^2}$	-.47	+.47	-.47	+.47	-.47	+.47	-.47	+.47
3A	$\frac{N_\phi}{M_c/R_m^2\beta}$ 1.3	$K_n\left(\frac{N_\phi}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$	▨	▨	▨	▨	-.01	-.01	+.01	+.01
1A	$\frac{M_\phi}{M_c/R_m\beta}$ =.11	$K_b\left(\frac{M_\phi}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$	▨	▨	▨	▨	-1.47	+1.47	+1.47	-1.47
3B	$\frac{N_\phi}{M_L/R_m^2\beta}$ 3.1	$K_n\left(\frac{N_\phi}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$	-.10	-.10	+.10	+.10	▨	▨	▨	▨
1B or 1B-1	$\frac{M_\phi}{M_L/R_m\beta}$ 0.065	$K_b\left(\frac{M_\phi}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$	-1.53	+1.53	+1.53	-1.53	▨	▨	▨	▨
Add algebraically for summation of ϕ stresses, σ_ϕ =			-2.15	1.85	1.10	-1.01	-2.01	1.88	.97	1.04
4C	$\frac{N_x}{P/R_m}$ =50	$K_n\left(\frac{N_x}{P/R_m}\right)\cdot\frac{P}{R_mT}$ =	-.06	-.06	-.06	-.06	-.06	-.06	-.06	-.06
2C	$\frac{M_x}{P}$ =.21	$K_b\left(\frac{M_x}{P}\right)\cdot\frac{6P}{T^2}$ =	-.31	+.31	-.31	+.31	-.31	+.31	-.31	+.31
4A	$\frac{N_x}{M_c/R_m^2\beta}$ 1.6	$K_n\left(\frac{N_x}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$ =	▨	▨	▨	▨	-.02	-.02	+.02	+.02
2A	$\frac{M_x}{M_c/R_m\beta}$ .06	$K_b\left(\frac{M_x}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$ =	▨	▨	▨	▨	-.81	+.81	+.81	-.81
4B	$\frac{N_x}{M_L/R_m^2\beta}$ 1.5	$K_n\left(\frac{N_x}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$ =	-.03	-.03	+.03	+.03	▨	▨	▨	▨
2B or 2B-1	$\frac{M_x}{M_L/R_m\beta}$ 0.11	$K_b\left(\frac{M_x}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$ =	-2.57	+2.57	+2.57	-2.57	▨	▨	▨	▨
Add algebraically for summation of X stresses, σ_x =			-2.98	2.81	2.25	-2.31	-1.19	1.04	.46	-.54
Shear stress due to Torsion, M_T		$\tau_{\phi x} = \tau_{x\phi} = \frac{M_T}{2\pi r_o^2 T}$	+.02	+.02	+.02	+.02	+.02	+.02	+.02	+.02
Shear stress due to load, Vc		$\tau_{x\phi} = \frac{V_c}{\pi r_o T}$	+.02	+.02	-.02	-.02	▨	▨	▨	▨
Shear stress due to load, VL		$\tau_{x\phi} = \frac{V_L}{\pi r_o T}$	▨	▨	▨	▨	-.02	-.02	+.02	+.02
Add Algebraically for summation of shear stresses, τ =			.04	.04	0	0	0	0	.04	.04
COMBINED STRESS INTENSITY, S										
1) When σ_ϕ & σ_x have like signs		$S = \frac{1}{2}\left[\sigma_\phi + \sigma_x + \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2}\right]$	2.98 KSI	2.81 KSI	2.25 KSI	2.31 KSI	2.01 KSI	1.88 KSI	.97 KSI	1.05 KSI
2) When $\tau = 0$		S = largest of σ_ϕ, σ_x or $\lvert\sigma_\phi - \sigma_x\rvert$								
3) When σ_ϕ & σ_x have unlike signs		$S = \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2}$								

$N_x/(M_L/R_m^2\beta)$ so determined by (C_L) from Table 8 (see para. 4.3).

4.2.2.5.2: When considering bending moment (M_L): $\beta = K_L\sqrt[3]{\beta_1\beta_2^2}$ where K_L is given in Table 8.

4.3 Calculation of Stresses

4.3.1 STRESSES RESULTING FROM RADIAL LOAD, P.

4.3.1.1 *Circumferential Stresses* (σ_ϕ):

Step 1. Using the applicable values of β and γ

HP-9815 12" DIAMETER NOZZLE 7-18-78

Pm + Q + F

LTR1217 6

A-20

```
MC=
  175000.00

ML=
  125000.00

MT=
   51000.00

VC=
   19500.00

VL=
   13500.00


T=
       1.75

RO=
       6.00

RM=
     420.90

KN=
       1.75

KB=
       1.50

GAMMA=    240.51

           .01
```

```
COEFS
2A=
          0.07

COEFS
3A=
          2.50

COEFS
4A=
          2.40

COEFS
1B=
          0.07

COEFS
1B-1=
          0.07

COEFS
2B=
          0.10

COEFS
2B-1=
          0.10

COEFS
3B=
          8.00

COEFS
4B=
          2.10
```

```
                [illegible]
COEFS
2C=
                0.18

COEFS
2C-1=
                0.18

COEFS
3C=
               35.00

COEFS
4C=
               45.00


             1621.53
            14899.59
              197.99
             9795.92
              452.54
             4897.96


SUMS
           -21871.62
            17723.48
           -11170.61
             8832.65
           -26515.02
            22876.00
            -6527.21
```

```
              190.07
             6857.14
              118.79
             6997.08


SUMS
           -19515.80
            15108.58
            -5284.04
             1351.99
           -19447.13
            14897.36
            -5352.71
             1563.21


HEARS
              128.84
              591.15
              409.26

SUMS
              719.99
              719.99
             -462.31
             -462.31
             -280.42
             -280.42
              538.10
              538.10
[illegible]
```

LTR 1217 6

A-21

12" DIA. NOZZLE Pm + Q + F

1. Applied Loads*

Radial load,	P	19,500 lb.
Circ. Moment,	Mc	175,000 in. lb.
Long. Moments,	ML	125,000 in. lb.
Torsion Moment,	M_T	51,000 in. lb.
Shear Load,	Vc	19,500 lb.
Shear Load,	VL	13,500 lb.

2. Geometry

Vessel thickness,	T	1.75 in.
Attachment radius,	r_o	6.0 in.
Vessel radius,	Rm	4209 in.

3. Geometric Parameters

$\gamma \quad \frac{R_m}{T} = 250.5$

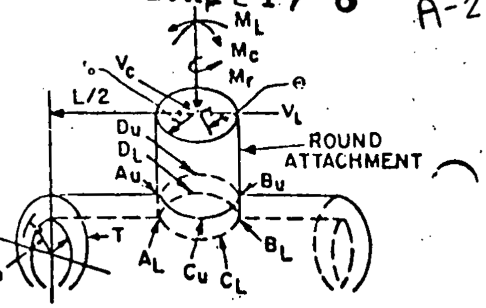
$\beta \quad (0.875)\frac{r_o}{R_m} = 0.012$

Stress Concentration due to:

a) membrane load, Kn 1.75

b) bending load, Kb 1.50

*NOTE: Enter all force values in accordance with sign convention



CYLINDRICAL SHELL

From Fig.	Read curves for	Compute absolute values of stress and enter results	STRESSES – if load is opposite that shown, reverse signs shown							
			Au	AL	Bu	BL	Cu	CL	Du	DL
3C	$\frac{N\phi}{P/R_m}$ = 35	$K_n\left(\frac{N\phi}{P/R_m}\right)\cdot\frac{P}{R_mT}$	-1.62	-1.62	-1.62	-1.62	-1.62	-1.62	-1.62	-1.62
1C	$\frac{M\phi}{P}$ = .26	$K_b\left(\frac{M\phi}{P}\right)\cdot\frac{6P}{T^2}$	-14.90	+14.90	-14.90	+14.90	-14.90	+14.90	-14.90	+14.90
3A	$\frac{N\phi}{M_c/R_m^2\beta}$ 2.5	$K_n\left(\frac{N\phi}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$	▨	▨	▨	▨	-.20	-.20	+.20	+.20
1A	$\frac{M\phi}{M_c/R_m\beta}$ 0.10	$K_b\left(\frac{M\phi}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$	▨	▨	▨	▨	-9.80	+9.80	+9.80	-9.80
3B	$\frac{N\phi}{M_L/R_m^2\beta}$ 8.0	$K_n\left(\frac{N\phi}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$	-.45	-.45	+.45	+.45	▨	▨	▨	▨
1B or 1B-1	$\frac{M\phi}{M_L/R_m\beta}$ 0.07	$K_b\left(\frac{M\phi}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$	-4.90	+4.90	+4.90	-4.90	▨	▨	▨	▨
Add algebraically for summation of ϕ stresses, $\sigma\phi$ =			-21.87	17.72	-11.17	8.83	-26.52	22.88	-6.53	3.68
4C	$\frac{N_x}{P/R_m}$ = 45	$K_n\left(\frac{N_x}{P/R_m}\right)\cdot\frac{P}{R_mT}$	-2.08	-2.08	-2.08	-2.08	-2.08	-2.08	-2.08	-2.08
2C	$\frac{M_x}{P}$ = .18	$K_b\left(\frac{M_x}{P}\right)\cdot\frac{6P}{T^2}$	-10.32	+10.32	-10.32	+10.32	-10.32	+10.32	-10.32	+10.32
4A	$\frac{N_x}{M_c/R_m^2\beta}$ 2.4	$K_n\left(\frac{N_x}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$	▨	▨	▨	▨	-.19	-.19	+.19	+.19
2A	$\frac{M_x}{M_c/R_m\beta}$ 0.07	$K_b\left(\frac{M_x}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$	▨	▨	▨	▨	-6.86	+6.86	+6.86	-6.86
4B	$\frac{N_x}{M_L/R_m^2\beta}$ 2.1	$K_n\left(\frac{N_x}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$	-.19	-.19	+.19	+.19	▨	▨	▨	▨
2B or 2B-1	$\frac{M_x}{M_L/R_m\beta}$ .11	$K_b\left(\frac{M_x}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$	-7.00	+7.00	+7.00	-7.00	▨	▨	▨	▨
Add algebraically for summation of X stresses, σ_x =			-19.52	15.11	-5.28	1.35	-19.45	14.90	5.35	1.56
Shear stress due to Torsion, M_T		$\tau\phi x = \tau x\phi = \frac{M_T}{2\pi r_o^2 T}$	+.13	+.13	+.13	+.13	+.13	+.13	+.13	+.13
Shear stress due to load, Vc		$\tau x\phi = \frac{V_c}{\pi r_o T}$	+.59	+.59	-.59	-.59	▨	▨	▨	▨
Shear stress due to load, VL		$\tau x\phi = \frac{V_L}{\pi r_o T}$	▨	▨	▨	▨	-.91	-.91	+.91	+.91
Add Algebraically for summation of shear stresses, τ =			.72	.72	-.46	-.46	.28	.28	.59	.59
COMBINED STRESS INTENSITY, S										
1) When σ_ϕ & σ_x have like signs 2) When τ = 0 3) When σ_ϕ & σ_x have unlike signs		$S = \frac{1}{2}\left[\sigma_\phi + \sigma_x \pm \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2}\right]$ S = largest of σ_ϕ, σ_x or $\lvert\sigma_\phi - \sigma_x\rvert$ $S = \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2}$	22.07 KSI	17.91 KSI	11.21 KSI	8.86 KSI	26.53 KSI	22.89 KSI	6.79 KSI	3.81 KSI

$N_t/(M_L/R_m^2\beta)$ so determined by (C_L) from Table 8 (see para. 4.3).

4.2.2.5.2: When considering bending moment (M_L): $\beta = K_L\sqrt[3]{\beta_1\beta_2^2}$ where K_L is given in Table 8.

4.3 Calculation of Stresses

4.3.1 STRESSES RESULTING FROM RADIAL LOAD, P.

4.3.1.1 Circumferential Stresses (σ_ϕ):

Step 1. Using the applicable values of β and γ

```
MC=
   430000.00

ML=
   260000.00

MT=
   250000.00

VC=
     5500.00

VL=
     3000.00


T=
        1.75

RO=
        8.00

RM=
      420.90


KN=
        1.75

KB=
        1.50

GAMMA=      240.51

BETA=        0.02
```

```
COEFS
1A=
            0.10

COEFS
2A=
            0.06

COEFS
3A=
            2.60

COEFS
4A=
            2.80

COEFS
1B=
            0.06

COEFS
1B-1=
            0.06

COEFS
2B=
            0.11

COEFS
2B-1=
            0.11

COEFS
3B=
            9.00

COEFS
4B=
            2.40

COEFS
```

```
            0.28

COEFS
2C=
            0.20

COEFS
2C-1=
            0.20

COEFS
3C=
           37.00

COEFS
4C=
           47.00


        1494.42
       13988.57
         379.46
       18052.48
         794.22
        6549.27


SUMS
      -22826.48
       18249.21
       -8139.50
        6739.10
      -33914.93
       30167.17
        2948.95
       -5178.86
```

```
   10831.49
     211.79
   12007.00


SUMS
  -24108.94
   19888.73
     328.64
   -3701.68
  -23130.28
   18516.36
    -650.01
   -2329.32


 HEARS
     355.26
     125.05
      68.21

 UMS
     480.31
     480.31
     230.21
     230.21
     287.05
     287.05
     423.47
     423.47
STRESS
[illegible]
[illegible].88
[illegible]
[illegible]
[illegible]
[illegible]922.36
[illegible]174.24
[illegible].27
    5240.46
```

HP-9815

16" DIAMETER NOZZLE

7-7-78

A-22

$P_m + Q + F$

LTR1217 6

Table 5—Computation Sheet for Local Stresses in Cylindrical Shells

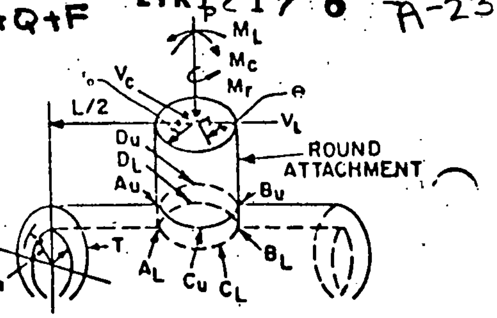
16" DIA. NOZZLE Pm+Q+F

LTR 12176 A-23

1. Applied Loads*
   - Radial load, P = 17,000 lb.
   - Circ. Moment, Mc = 430,000 in. lb.
   - Long. Moments, ML = 260,000 in. lb.
   - Torsion Moment, M_T = 250,000 in. lb.
   - Shear Load, Vc = 5,500 lb.
   - Shear Load, VL = 3,000 lb.
2. Geometry
   - Vessel thickness, T = 1.75 in.
   - Attachment radius, r_o = 8.0 in.
   - Vessel radius, R_m = 120.9 in.
3. Geometric Parameters
   - $\gamma = \frac{R_m}{T}$ = 240.5
   - $\beta = (0.875)\frac{r_o}{R_m}$ = 0.0166

Stress Concentration due to:
a) membrane load, Kn 1.75
b) bending load, Kb 1.50

*NOTE: Enter all force values in accordance with sign convention



CYLINDRICAL SHELL

From Fig.	Read curves for	Compute absolute values of stress and enter results	STRESSES – if load is opposite that shown, reverse signs shown							
			Au	AL	Bu	BL	Cu	CL	Du	DL
3C	$\frac{N_\phi}{P/R_m}$ = 37	$K_n\left(\frac{N_\phi}{P/R_m}\right)\cdot\frac{P}{R_m T}$	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49
1C	$\frac{M_\phi}{P}$ = .28	$K_b\left(\frac{M_\phi}{P}\right)\cdot\frac{6P}{T^2}$	-13.99	+13.99	-13.99	+13.99	-13.99	+13.99	-13.99	+13.99
3A	$\frac{N_\phi}{M_c/R_m^2\beta}$ = 2.6	$K_n\left(\frac{N_\phi}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$	▨	▨	▨	▨	-.38	-.38	+.38	+.38
1A	$\frac{M_\phi}{M_c/R_m\beta}$ = .11	$K_b\left(\frac{M_\phi}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$	▨	▨	▨	▨	-18.05	+18.05	+18.05	-18.05
3B	$\frac{N_\phi}{M_L/R_m^2\beta}$ = 9.0	$K_n\left(\frac{N_\phi}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$	-.79	-.79	+.79	+.79	▨	▨	▨	▨
1B or 1B-1	$\frac{M_\phi}{M_L/R_m\beta}$ = .06	$K_b\left(\frac{M_\phi}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$	-6.55	+6.55	+6.55	-6.55	▨	▨	▨	▨
Add algebraically for summation of ϕ stresses, σ_ϕ =			-27.83	18.25	-8.13	6.74	-33.91	30.12	2.95	-5.18
4C	$\frac{N_x}{P/R_m}$ = 47	$K_n\left(\frac{N_x}{P/R_m}\right)\cdot\frac{P}{R_m T}$ =	-1.90	-1.90	-1.90	-1.90	-1.90	-1.90	-1.90	-1.90
2C	$\frac{M_x}{P}$ = .20	$K_b\left(\frac{M_x}{P}\right)\cdot\frac{6P}{T^2}$ =	-9.99	+9.99	-9.99	+9.99	-9.99	+9.99	-9.99	+9.99
4A	$\frac{N_x}{M_c/R_m^2\beta}$ = 2.8	$K_n\left(\frac{N_x}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$ =	▨	▨	▨	▨	-.41	-.41	+.41	+.41
2A	$\frac{M_x}{M_c/R_m\beta}$ = 0.055	$K_b\left(\frac{M_x}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$ =	▨	▨	▨	▨	-10.83	+10.83	+10.83	-10.83
4B	$\frac{N_x}{M_L/R_m^2\beta}$ = 2.4	$K_n\left(\frac{N_x}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$ =	-.21	-.21	+.21	+.21	▨	▨	▨	▨
2B or 2B-1	$\frac{M_x}{M_L/R_m\beta}$ = .11	$K_b\left(\frac{M_x}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$ =	-2.33	+2.33	+2.33	-2.33	▨	▨	▨	▨
Add algebraically for summation of X stresses, σ_x =			-24.11	19.89	.33	-3.70	-23.13	18.52	-.65	-2.33
Shear stress due to Torsion, M_T		$\tau_{\phi x} = \tau_{x\phi} = \frac{M_T}{2\pi r_o^2 T}$	+.36	+.36	+.36	+.36	+.36	+.36	+.36	+.36
Shear stress due to load, Vc		$\tau_{x\phi} = \frac{V_c}{\pi r_o T}$	+.13	+.13	-.13	-.13	▨	▨	▨	▨
Shear stress due to load, VL		$\tau_{x\phi} = \frac{V_L}{\pi r_o T}$	▨	▨	▨	▨	-.07	-.07	+.07	+.07
Add Algebraically for summation of shear stresses, τ =			.48	.48	.23	.23	.29	.29	.42	.42
COMBINED STRESS INTENSITY, S										
1) When σ_ϕ & σ_x have like signs		$S = \frac{1}{2}\left[\sigma_\phi + \sigma_x + \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2}\right]$	24.27 KSI	20.02 KSI	8.48 KSI	10.45 KSI	33.92 KSI	30.17 KSI	3.70 KSI	5.24 KSI
2) When τ = 0		S = largest of σ_ϕ, σ_x or $\lvert\sigma_\phi - \sigma_x\rvert$								
3) When σ_ϕ & σ_x have unlike signs		$S = \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2}$								

$N_x/(M_L/R_m^2\beta)$ so determined by (C_L) from Table 8 (see para. 4.3).

4.2.2.5.2: When considering bending moment (M_L): $\beta = K_L\sqrt[3]{\beta_1\beta_2^2}$ where K_L is given in Table 8.

4.3 Calculation of Stresses

4.3.1 STRESSES RESULTING FROM RADIAL LOAD, P.

4.3.1.1 Circumferential Stresses (σ_ϕ):

Step 1. Using the applicable values of β and γ

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Pm + Q + F

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```
F

MC=
     65000.00
ML=
     30000.00
MT=
     90000.00
VC=
       500.00
VL=
      1000.00


T=
         1.75
RO=
         9.00
RM=
       420.90

KN=
         1.75
KB=
         1.50

GAMMA=      240.51

             0.02
```

```
C
1..-
            0.11
COEFS
2A=
            0.06
COEFS
3A=
            2.80
COEFS
4A=
            3.60
COEFS
 B=
            0.06
COEFS
1B-1=
            0.06
COEFS
2B=
            0.11
COEFS
2B-1=
            0.11
COEFS
3B=
           11.00
COEFS
4B=
            2.70
COEFS
```

```
            0.28
COEFS
2C=
            0.20
COEFS
2C-1=
            0.20
COEFS
3C=
           35.00
COEFS
 =
           45.00


          249.47
         2468.57
           54.91
         2668.22
           99.56
          671.72

SUMS
         -3489.32
          2791.27
         -1946.76
          1646.95
         -5441.17
          4832.42
             5.09
```

```
            .. .00
          1334.11
            24.44
          1231.49


SUMS
         -3339.93
          2649.57
          -828.08
           235.47
         -3488.71
          2706.04
          -679.30
           179.01


SHEARS
           101.05
            10.11
            20.21
SUMS
           111.16
           111.16
            90.95
            90.95
            80.84
            80.84
           121.26
           121.26
[illegible]
INTENSITIES
[illegible]
```

Table 3 - Computation Sheet for Local Stresses in Cylindrical Shells

18" DIA. NOZZLE Pm+Q+F LTR 12176 - A-25

1. Applied Loads*

Radial load, P 3000 lb.
Circ. Moment, Mc 6,000 in. lb.
Long. Moments, ML 30,000 in. lb.
Torsion Moment, M_T 90,000 in. lb.
Shear Load, Vc 500 lb.
Shear Load, VL 1000 lb.

2. Geometry

Vessel thickness, T 1.75 in.
Attachment radius, r_o 9.0 in.
Vessel radius, Rm 420.9 in.

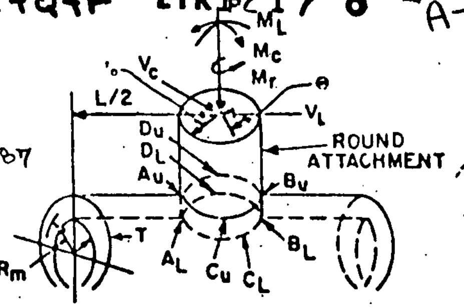
3. Geometric Parameters

$\gamma = \frac{R_m}{T} = 240.5$

$\beta = (0.875)\frac{r_o}{R_m} = 0.0187$

Stress Concentration due to:
a) membrane load, Kn 1.75
b) bending load, Kb 1.50

*NOTE: Enter all force values in accordance with sign convention.



CYLINDRICAL SHELL

From Fig.	Read curves for	Compute absolute values of stress and enter result	STRESSES – if load is opposite that shown, reverse signs shown							
			Au	AL	Bu	BL	Cu	CL	Du	DL
3C	$\frac{N_\phi}{P \cdot R_m}$ = 35	$K_n\left(\frac{N_\phi}{P \cdot R_m}\right)\cdot\frac{P}{R_m T}$	−.25	−.25	−.25	−.25	−.25	−.25	−.25	−.25
1C	$\frac{M_\phi}{P}$ = .28	$K_b\left(\frac{M_\phi}{P}\right)\cdot\frac{6P}{T^2}$	−2.47	+2.47	−2.47	+2.47	−2.47	+2.47	−2.47	+2.47
3A	$\frac{N_\phi}{M_c/R_m^2\beta}$ 2.8	$K_n\left(\frac{N_\phi}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$					−.05	−.05	+.05	+.05
1A	$\frac{M_\phi}{M_c/R_m\beta}$ = .11	$K_b\left(\frac{M_\phi}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$					−2.67	+2.67	+2.67	−2.67
3B	$\frac{N_\phi}{M_L/R_m^2\beta}$ = 11	$K_n\left(\frac{N_\phi}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$	−.10	−.10	+.10	+.10				
1B or 1B−1	$\frac{M_\phi}{M_L/R_m\beta}$ 0.06	$K_b\left(\frac{M_\phi}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$	−.67	+.67	+.67	−.67				
Add algebraically for summation of φ stresses, σ_ϕ =			−3.49	2.79	−1.95	1.65	−5.44	4.83	0.0	−.39
4C	$\frac{N_x}{P/R_m}$ = 45	$K_n\left(\frac{N_x}{P/R_m}\right)\cdot\frac{P}{R_m T}$ =	−.32	−.32	−.32	−.32	−.32	−.32	−.32	−.32
2C	$\frac{M_x}{P}$ ≈ .20	$K_b\left(\frac{M_x}{P}\right)\cdot\frac{6P}{T^2}$ =	−1.76	+1.76	−1.76	+1.76	−1.76	+1.76	−1.76	+1.76
4A	$\frac{N_x}{M_c/R_m^2\beta}$ 3.6	$K_n\left(\frac{N_x}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$					−.07	−.67	+.07	+.07
2A	$\frac{M_x}{M_c/R_m\beta}$ 0.035	$K_b\left(\frac{M_x}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$					−1.33	+1.33	+1.33	−1.33
4B	$\frac{N_x}{M_L/R_m^2\beta}$ 2.7	$K_n\left(\frac{N_x}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$ =	−.02	−.02	+.02	+.02				
2B or 2B−1	$\frac{M_x}{M_L/R_m\beta}$ 0.11	$K_b\left(\frac{M_x}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$ =	−1.23	+1.23	+1.23	−1.23				
Add algebraically for summation of X stresses, σ_x =			−3.34	2.65	−.83	.23	−3.49	2.70	−.68	.18
Shear stress due to Torsion, M_T		$\tau_{\phi x} = \tau_{x\phi} = \frac{M_T}{2\pi r_o^2 T}$	+.10	+.10	+.10	+.10	+.10	+.10	+.10	+.10
Shear stress due to load, Vc		$\tau_{x\phi} = \frac{V_c}{\pi r_o T}$	+.01	+.01	−.01	−.01				
Shear stress due to load, VL		$\tau_{x\phi} = \frac{V_L}{\pi r_o T}$					−.02	−.02	+.02	+.02
Add Algebraically for summation of shear stresses, τ =			.11	.11	.09	.09	.08	.08	.12	.12
COMBINED STRESS INTENSITY, S										
1) When σ_ϕ & σ_x have like signs		$S = \frac{1}{2}\left[\sigma_\phi + \sigma_x + \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2}\right]$	3.55 KSI	2.85 KSI	1.95 KSI	1.65 KSI	5.49 KSI	4.84 KSI	.73 KSI	.62 KSI
2) When τ = 0		S = largest of σ_ϕ, σ_x or $\lvert\sigma_\phi - \sigma_x\rvert$								
3) When σ_ϕ & σ_x have unlike signs		$S = \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2}$								

$N_i/(M_L/R_m^2\beta)$ so determined by (C_L) from Table 8 (see para. 4.3).

4.2.2.5.2: When considering bending moment (M_i): $\beta = K_L\sqrt[3]{\beta_1\beta_2^2}$ where K_L is given in Table 8.

4.3 Calculation of Stresses

4.3.1 STRESSES RESULTING FROM RADIAL LOAD, P.

4.3.1.1 *Circumferential Stresses* (σ_ϕ):

Step 1. Using the applicable values of β and γ

HP-9815 24" DIAMETER NOZZLE 7-26-78

Pm + Q + F

LTR1217 6

```
P=
   2000.00

MC=
  55000.00

ML=
  90000.00

MT=
  30000.00

VC=
   2500.00

VL=
   2500.00


T=
      1.75

RO=
     12.00

RM=
    420.90

KN=
      1.75

KB=
      1.50

GAMMA=     240.51

              0.02
```

```
COEFS
1A=
              0.11
COEFS
2A=
              0.06
COEFS
3A=
              4.00
COEFS
4A=
              5.00
COEFS
1B=
              0.06
COEFS
1B-1=
              0.06
COEFS
2B=
              0.11
COEFS
2B-1=
              0.11
COEFS
3B=
             15.00
COEFS
4B=
              4.20
COEFS

               .28
```

```
COEFS
1C-1=
              0.28
COEFS
2C=
              0.15
COEFS
2C-1=
              0.15
COEFS
3C=
             33.00
COEFS
4C=
             43.00


            156.81
           1645.71
             49.78
           1693.29
            305.47
           1511.37


SUMS
          -3619.36
           2694.81
             14.32
            283.01
          -3545.60
           3132.42
            -59.45
           -154.61
```

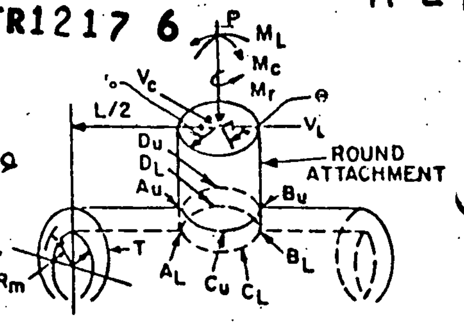
```
            204.32
            881.63
             62.22
            923.62
             85.53
           2770.85


SUMS
          -3942.33
           3362.62
           1770.42
          -2008.01
          -2071.80
           1538.70
           -100.12
           -184.08


SHEARS
             18.95
             37.89
             37.89
SUMS
             56.84
             56.84
            -18.95
            -18.95
            -18.95
            -18.95
             56.84
             56.84
STRESS
INTENSITIES
           3952.04
           3367.43
           1770.62
           2291.32
           3545.84
           3132.65
            140.15
            228.06
```

Table 5—Computation Sheet for Local Stresses in Cylindrical Shells

24" DIA. NOZZLE Pm + Q + F LTR1217 6



CYLINDRICAL SHELL

1. Applied Loads*

Radial load, P 2000 lb.
Circ. Moment, Mc 56,000 in. lb.
Long. Moments, ML 90,000 in. lb.
Torsion Moment, MT 30,000 in. lb.
Shear Load, Vc 2,500 lb.
Shear Load, VL 2,500 lb.

2. Geometry

Vessel thickness, T 1.75 in.
Attachment radius, r_o 12.0 in.
Vessel radius, R_m 420.9 in.

3. Geometric Parameters

$\gamma = \frac{R_m}{T} = 240.5$

$\beta = (0.875)\frac{r_o}{R_m} = 0.0249$

Stress Concentration due to:
a) membrane load, Kn 1.75
b) bending load, Kb 1.50

*NOTE: Enter all force values in accordance with sign convention

From Fig.	Read curves for	Compute absolute values of stress and enter result	STRESSES – if load is opposite that shown, reverse signs shown							
			Au	AL	Bu	BL	Cu	CL	Du	DL
3C	$\frac{N\phi}{P/R_m}$ = 33	$K_n\left(\frac{N\phi}{P/R_m}\right)\cdot\frac{P}{R_m T}$	-.16	-.16	-.16	-.16	-.16	-.16	-.16	-.16
1C	$\frac{M\phi}{P}$ = .28	$K_b\left(\frac{M\phi}{P}\right)\cdot\frac{6P}{T^2}$	-1.65	+1.65	-1.65	+1.65	-1.65	+1.65	-1.65	+1.65
3A	$\frac{N\phi}{M_c/R_m^2\beta}$ = 4.0	$K_n\left(\frac{N\phi}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$					-.05	-.05	+.05	+.05
1A	$\frac{M\phi}{M_c/R_m\beta}$ = .11	$K_b\left(\frac{M\phi}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$					-1.69	+1.69	+1.69	-1.69
3B	$\frac{N\phi}{M_L/R_m^2\beta}$ = 1.5	$K_n\left(\frac{N\phi}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$	-.31	-.31	+.31	+.31				
1B or 1B-1	$\frac{M\phi}{M_L/R_m\beta}$ = .06	$K_b\left(\frac{M\phi}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$	-1.51	+1.51	+1.51	-1.51				
Add algebraically for summation of ϕ stresses, σ_ϕ =			-3.62	2.62	.01	.28	-3.55	3.13	-.06	-.15
4C	$\frac{N_x}{P/R_m}$ = 43	$K_n\left(\frac{N_x}{P/R_m}\right)\cdot\frac{P}{R_m T}$ =	-.20	-.20	-.20	-.20	-.20	-.20	-.20	-.20
2C	$\frac{M_x}{P}$ = .15	$K_b\left(\frac{M_x}{P}\right)\cdot\frac{6P}{T^2}$ =	-.88	+.88	-.88	+.88	-.06	+.06	-.06	+.06
4A	$\frac{N_x}{M_c/R_m^2\beta}$ = 5.0	$K_n\left(\frac{N_x}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$ =					-.06	-.06	+.06	+.06
2A	$\frac{M_x}{M_c/R_m\beta}$ = 0.055	$K_b\left(\frac{M_x}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$ =					-.92	+.92	+.92	-.92
4B	$\frac{N_x}{M_L/R_m^2\beta}$ = 4.2	$K_n\left(\frac{N_x}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$ =	-.09	-.09	+.09	+.09				
2B or 2B-1	$\frac{M_x}{M_L/R_m\beta}$ = .11	$K_b\left(\frac{M_x}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$ =	-2.77	+2.77	+2.77	-2.77				
Add algebraically for summation of X stresses, σ_x =			-3.94	3.36	1.77	-2.01	-2.07	1.54	-.10	-.18
Shear stress due to Torsion, MT		$\tau_{\phi x} = \tau_{x\phi} = \frac{M_T}{2\pi r_o^2 T}$	+.02	+.02	+.02	+.02	+.02	+.02	+.02	+.02
Shear stress due to load, Vc		$\tau_{x\phi} = \frac{V_c}{\pi r_o T}$	+.04	+.04	-.04	-.04				
Shear stress due to load, VL		$\tau_{x\phi} = \frac{V_L}{\pi r_o T}$					-.04	-.04	+.04	+.04
Add Algebraically for summation of shear stresses, τ =			.06	.06	-.02	-.02	-.02	-.02	.06	.06
COMBINED STRESS INTENSITY, S										
1) When σ_ϕ & σ_x have like signs		$S = \frac{1}{2}\left[\sigma_\phi + \sigma_x + \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2}\right]$	3.95 KSI	3.38 KSI	1.77 KSI	2.29 KSI	3.55 KSI	3.13 KSI	.19 KSI	.28 KSI
2) When τ = 0		S = largest of σ_ϕ, σ_x or $\lvert\sigma_\phi - \sigma_x\rvert$								
3) When σ_ϕ & σ_x have unlike signs		$S = \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2}$								

$N_L/(M_L/R_m^2\beta)$ so determined by (C_L) from Table 8 (see para. 4.3).

4.2.2.5.2: When considering bending moment (M_L): $\beta = K_L\sqrt[3]{\beta_1\beta_2^2}$ where K_L is given in Table 8.

4.3 Calculation of Stresses

4.3.1 STRESSES RESULTING FROM RADIAL LOAD, P.

4.3.1.1 *Circumferential Stresses* (σ_ϕ):

Step 1. Using the applicable values of β and γ

```
P=

Mc=
    90000.00

ML=
   170000.00

MT=
    10000.00

VC=
     1000.00

VL=
     1500.00


T=
        1.75

RO=
       15.00

RM=
      420.90


KN=
        1.75

KB=
        1.50


GAMMA=     240.51

             3
```

```
COEFS
2A=
              0.06

COEFS
3A=
              5.10

COEFS
4A=
              6.30

COEFS
 B=
              0.06

COEFS
 B-1=
              0.06

COEFS
2B=
              0.10

COEFS
2B-1=
              0.10

COEFS
3B=
             18.00

COEFS
4B=
              5.00

COEFS
```

```
              0.18

COEFS
2C=
              0.12

COEFS
2C-1=
              0.12

COEFS
3C=
             32.00

COEFS
4C=
             42.00



             76.03
            528.98
             83.09
           2216.68
            553.92
           2283.95


SUMS
          -3442.77
           2182.89
           2232.76
          -1276.98
          -2904.77
           2586.54
           1694.76
```

```
            102.64
           1209.10
            153.87
           3806.41


SUMS
          -4412.72
           3905.42
           3507.84
          -3399.68
          -1764.17
           1359.33
            859.29
           -853.59


 HEARS
              4.04
             12.13
             18.19

SUMS
             16.17
             16.17
             -8.08
             -8.08
            -14.15
            -14.15
             22.23
             22.23
STRESS
INTENSITIES
           4412.99
           3905.57
           3507.89
           3399.71
           2904.95
           2586.70
           1695.35
           1681.23
```

HP-9815

30" DIAMETER NOZZLE 7-7-78

Pm + Q + F

LTR1217 6

A-28

Table 5—Computation Sheet for Local Stresses in Cylindrical Shells

30" DIA. NOZZLE Pm+Q+F LTR12176 - A-29

1. Applied Loads*

Radial load, P = 1000 lb.
Circ. Moment, M_c = 90,000 in. lb.
Long. Moments, M_L = 179,000 in. lb.
Torsion Moment, M_T = 10,000 in. lb.
Shear Load, V_c = 1000 lb.
Shear Load, V_L = 1500 lb.

2. Geometry

Vessel thickness, T = 1.75 in.
Attachment radius, r_o = 15 in.
Vessel radius, R_m = 42.09 in.

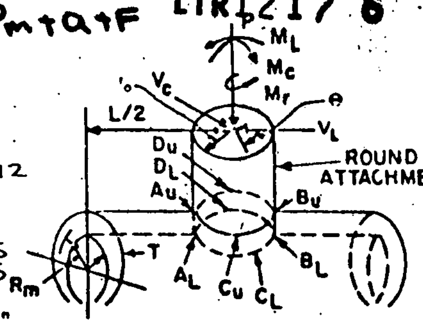
3. Geometric Parameters

$\gamma = \frac{R_m}{T}$ = 24.05

$\beta = (0.875)\frac{r_o}{R_m}$ = 0.0312

Stress Concentration due to:
a) membrane load, K_n = 1.75
b) bending load, K_b = 1.50

*NOTE: Enter all force values in accordance with sign convention



CYLINDRICAL SHELL

From Fig.	Read curves for	Compute absolute values of stress and enter result	STRESSES - if load is opposite that shown, reverse signs shown							
			Au	AL	Bu	BL	Cu	CL	Du	DL
3C	$\frac{N_\phi}{P/R_m}$ =32	$K_n\left(\frac{N_\phi}{P/R_m}\right)\cdot\frac{P}{R_mT}$	-.08	-.08	-.08	-.08	-.08	-.08	-.08	-.08
1C	$\frac{M_\phi}{P}$ =.18	$K_b\left(\frac{M_\phi}{P}\right)\cdot\frac{6P}{T^2}$	-.53	+.53	-.53	+.53	-.53	+.53	-.53	+.53
3A	$\frac{N_\phi}{M_c/R_m^2\beta}$ 5.1	$K_n\left(\frac{N_\phi}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$	▨	▨	▨	▨	-.08	-.08	+.08	+.08
1A	$\frac{M_\phi}{M_c/R_m\beta}$ =.11	$K_b\left(\frac{M_\phi}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$	▨	▨	▨	▨	-2.22	+2.22	+2.22	-2.22
3B	$\frac{N_\phi}{M_L/R_m^2\beta}$ .18	$K_n\left(\frac{N_\phi}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$	-.56	-.55	+.55	+.55	▨	▨	▨	▨
1B or 1B-1	$\frac{M_\phi}{M_L/R_m\beta}$ .06	$K_b\left(\frac{M_\phi}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$	-2.28	+2.26	+2.28	-2.28	▨	▨	▨	▨
Add algebraically for summation of ϕ stresses, σ_ϕ =			-3.44	2.18	2.23	-1.27	-2.90	2.59	1.69	-1.68
4C	$\frac{N_x}{P/R_m}$ =42	$K_n\left(\frac{N_x}{P/R_m}\right)\cdot\frac{P}{R_mT}$ =	-.10	-.10	-.10	-.10	-.10	-.10	-.10	-.10
2C	$\frac{M_x}{P}$ ≈.12	$K_b\left(\frac{M_x}{P}\right)\cdot\frac{6P}{T^2}$ =	-.35	+.35	-.35	+.35	-.35	+.35	-.35	+.35
4A	$\frac{N_x}{M_c/R_m^2\beta}$ 6.3	$K_n\left(\frac{N_x}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$ =	▨	▨	▨	▨	-.10	-.10	+.10	+.10
2A	$\frac{M_x}{M_c/R_m\beta}$ .06	$K_b\left(\frac{M_x}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$ =	▨	▨	▨	▨	-1.21	+1.21	+1.21	-1.21
4B	$\frac{N_x}{M_L/R_m^2\beta}$ 5.0	$K_n\left(\frac{N_x}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$ =	-.15	-.15	+.15	+.15	▨	▨	▨	▨
2B or 2B-1	$\frac{M_x}{M_L/R_m\beta}$ .10	$K_b\left(\frac{M_x}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$ =	-3.81	+3.81	+3.81	-3.81	▨	▨	▨	▨
Add algebraically for summation of X stresses, σ_x =			-4.41	3.91	3.51	-3.40	-1.76	1.36	.86	-.85
Shear stress due to Torsion, M_T		$\tau_{\phi x}=\tau_{x\phi}=\frac{M_T}{2\pi r_o^2T}$	+0	+0	+0	+0	+0	+0	+0	+0
Shear stress due to load, V_c		$\tau_{x\phi}=\frac{V_c}{\pi r_oT}$	+.01	+.01	-.01	-.01	▨	▨	▨	▨
Shear stress due to load, V_L		$\tau_{x\phi}=\frac{V_L}{\pi r_oT}$	▨	▨	▨	▨	-.02	-.02	+.02	+.02
Add Algebraically for summation of shear stresses, τ =			.01	.01	-.01	-.10	-.02	-.02	.02	.02
COMBINED STRESS INTENSITY, S										
1) When σ_ϕ & σ_x have like signs		$S=\frac{1}{2}\left[\sigma_\phi+\sigma_x+\sqrt{(\sigma_\phi-\sigma_x)^2+4\tau^2}\right]$	4.41 KSI	3.91 KSI	3.51 KSI	3.40 KSI	2.90 KSI	2.59 KSI	1.70 KSI	1.68 KSI
2) When τ = 0		S = largest of σ_ϕ, σ_x or $\lvert\sigma_\phi-\sigma_x\rvert$								
3) When σ_ϕ & σ_x have unlike signs		$S=\sqrt{(\sigma_\phi-\sigma_x)^2+4\tau^2}$								

$N_x/(M_L/R_m^2\beta)$ so determined by (C_L) from Table 8 (see para. 4.3).

4.2.2.5.2: When considering bending moment (M_L): $\beta = K_L\sqrt[3]{\beta_1\beta_2^2}$ where K_L is given in Table 8.

4.3 Calculation of Stresses

4.3.1 STRESSES RESULTING FROM RADIAL LOAD, P.

4.3.1.1 *Circumferential Stresses* (σ_ϕ):

Step 1. Using the applicable values of β and γ

LTR 1217-6

APPENDIX B

STRESS IN THE CONTAINMENT VESSEL AND NOZZLES DUE TO TEMPERATURE GRADIENTS

B) THERMAL STRESS IN THE NOZZLES AND IN THE PIPE WELDS AT THE AT THE PENATRATIONS

SIX NOZZLES HAD LINES PENETRATING THEM WITH TEMPERATURES HIGH ENOUGH TO LEAD TO SIGNIFICANT THERMAL STRESSES.

1.0) CONE SHAPED NOZZLES

NOZZLES S-3E AND S-5E ARE BOTH CONE SHAPED NOZZLES WITH SIMILAR DIMMENSIONS AND BOTH OPERATING AT HIGH TEMPERTURES (S-3E @ 530°F AND S-5E @ 407° F). JOHN CANDERS PERFORMED A FINITE ELEMENT ANALYSIS ON NOZZLE S-3E[4] AND ARRIVED AT A MAXIMUM STRESS OF 34,254 #/IN² WHICH IS MUCH LESS THAN THE ALLOWABLE 52,500 #/IN². SINCE THE TWO NOZZLES HAVE SIMILAR DIMMENSIONS, NOZZLE S-3E OPERATES AT A HIGHER TEMPERATURE THAN NOZZLE S-5E AND THE MECHANICAL LOADS ON S-3E ARE HIGHER THAN S-5E, STRESSES IN NOZZLE S-5E WILL ALSO BE LESS THAN THE ALLOWABLE.

2.0) PIPE WELDS AT THE PENETRATION

2.1) THERMAL STRESSES

INFORMATION ON PAGE B-10 THROUGH B-13 WAS PROVIDED TO THE THERMAL ANALYSIS BRANCH. THEY DETERMINED THE TEMPERATURE GRADIENTS AND DOCUMENTED IT IN THE FOLLOWING LETTER.

B-2

LTR 1017-6

EG&G Idaho

INTEROFFICE CORRESPONDENCE

date August 3, 1978

to R. J. Beers

from W. C. Townsend

subject CONTAINMENT PENETRATION - TEMPERATURE PROFILE AT WELD - WCT-21-78

Preliminary analyses of the temperature distribution of the containment penetration nozzle end plates and of the lines penetrating and welded to the end plates were performed. Results of these anslyses indicated that the slope of the temperature profile at the weld is small and can be used in your thermal stress analyses. Should the calculated stresses be high, we will perform detailed computer solution of the end plates and weld areas.

The preliminary analyses considered the end plate as a fin attached to the penetrating pipe wall. Parameters and assumptions used in the analyses are given below.

- Thermal conductivity of the stainless steel end plate and pipe wall: 9.75 Btu/hr-ft-°F
- Assumed natural convection film coefficient acting on the end plate: 5.0 Btu/hr-ft^2-°F
- Assumed containment temperature: 70°F
- The outside diameter of the end plate was assumed large in comparison with the inside diameter of the penetrating pipe
- Complete penetration welds at the outside pipe wall-end plate interface (penetrations) were assumed.

The slope of the temperature profile at the penetration weld is given as

$$\frac{dT}{dr} = B\,(T_p - 70)\,\frac{\text{Sinh } B\,(r_2 - r_3)}{\text{Cosh } Br_3}$$

B-2a
LTR 1217-6

where

$$B = (2h/kt)^{1/2}$$

h: outside film coefficient, Btu/hr-ft^2-°F

K: thermal conductivity, Btu/hr-ft^2-°F

t: end plate thickness, ft

T_p: temperature of fluid contained in pipe, °F

r_2: outside radius of pipe, ft

r_3: outside radius of end plate, ft

$\frac{dT}{dr}$: slope of temperature profile at weld, °F/ft

Results from the calculation are summarized below in Table I

TABLE I

Nozzle	Line Dia. Inches	Max. Fluid Temp., °F	dT/dr at Weld, °F/in
S-20A	1/2	220	-10.20
S-20B	1/2	220	-10.20
S-11C	4	250	-7.84
S-5C	1/2	100	-1.97
S-1A	2	250	-9.85

jj

cc: J. L. Liebenthal
N. E. Pace NEP/Rdw
E. D. Uldrich
W. C. Townsend File
Central File
TAB File 3.8

THERMAL STRESS WERE DETERMINED FROM EQ (2) AND (3) TAKEN FROM REFERENCE 7. (P-290)

$$\frac{dT}{dR} = K \ \frac{{}^\circ F}{IN}$$

$$dT = K\,dR$$

(1) $$T = KR$$

R = RADIUS OF POINT OF STRESS

a = INSIDE RADIUS

b = OUTSIDE RADIUS

K = $\Delta {}^\circ F / \Delta IN$

---

(2) $$\sigma_{RR} = \frac{\alpha E}{R^2}\left[\frac{R^2-a^2}{b^2-a^2}\int_a^b T\,R\,dR - \int_a^R T\,R\,dR\right]$$

SUBSTITUTING EQ (1) INTO (2)

$$\sigma_{RR} = \frac{\alpha E}{R^2}\left[\frac{R^2-a^2}{b^2-a^2}\int_a^b K R^2\,dR - \int_a^R K R^2\,dR\right]$$

$$\sigma_{RR} = \frac{\alpha E}{R^2}\left[\frac{R^2-a^2}{b^2-a^2} K\left(\frac{R^3}{3}\right)\Big|_a^b - K\left(\frac{R^3}{3}\right)\Big|_a^R\right.$$

(I) $$\sigma_{RR} = \frac{\alpha E}{R^2}\left[\frac{R^2-a^2}{b^2-a^2}(K)\left[\frac{b^3-a^3}{3}\right] - K\left[\frac{R^3-a^3}{3}\right]\right]$$

---

(3) $$\sigma_{\theta\theta} = \frac{\alpha E}{R^2}\left[\frac{R^2+a^2}{b^2-a^2}\int_a^b T\,R\,dR + \int_a^r T\,R\,dR - T R^2\right]$$

SUBSTITUTING EQ (1) INTO (3)

$$\sigma_{\theta\theta} = \frac{\alpha E}{R^2}\left[\frac{R^2+a^2}{b^2-a^2}\int_a^b K R^2\,dR + \int_a^r K R^2\,dR - K R^3\right]$$

$$\sigma_{\theta\theta} = \frac{\alpha E}{R^2}\left[\frac{R^2+a^2}{b^2-a^2}(K)\left(\frac{R^3}{3}\right)\Big|_a^b + K\left(\frac{R^3}{3}\right)\Big|_a^R - K R^3\right]$$

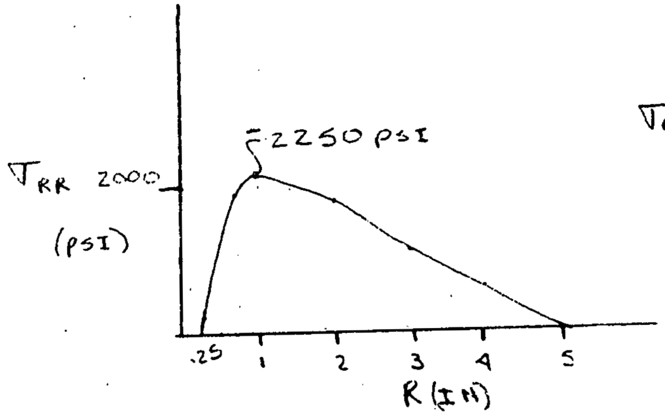
(II) $$\sigma_{\theta\theta} = \frac{\alpha E}{R^2}\left[\frac{R^2+a^2}{b^2-a^2}(K)\left[\frac{b^3-a^3}{3}\right] + K\left[\frac{R^3-a^3}{3}\right] - K R^3\right]$$

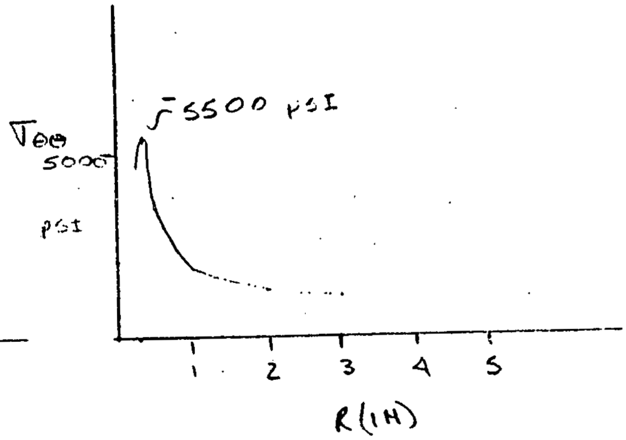
REVIEWING B-10 THROUGH B-13, AND dT/dr FOR EACH NOZZLE, NOZZLE S-20A, S-11C AND S-1A WILL BE CHECKED FOR THERMAL STRESS.

$\alpha = 6.38(10)^{-6} \frac{IN}{IN}$ °F $E = 27.7(10)^6$ PSI

S-20A

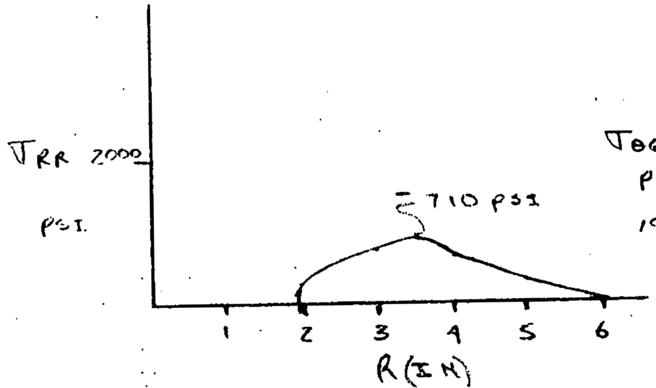
b = 5" a = .25" $K = ^{-}10.2$ °F/IN

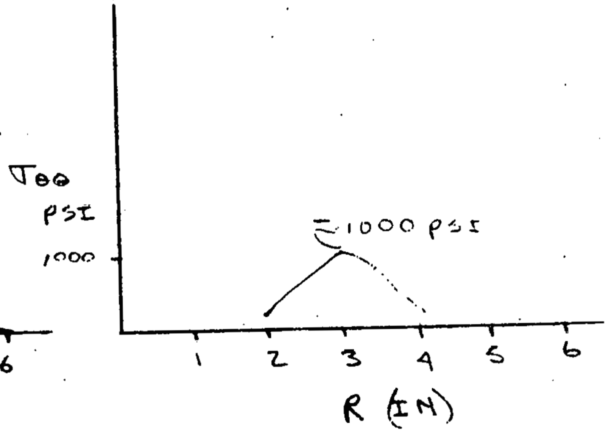




S-11C

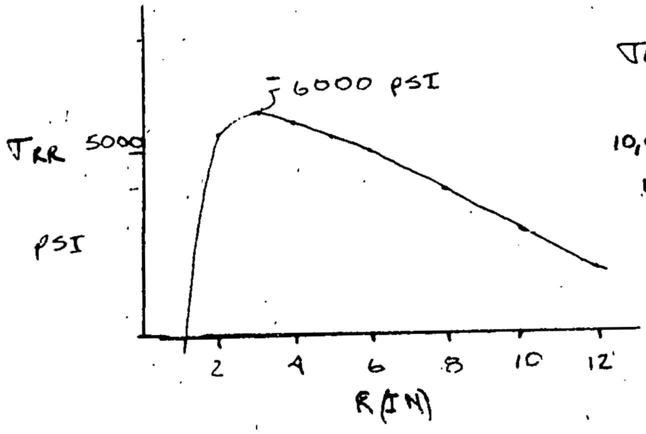
b = 6" a = 2" $K = ^{-}7.8$ °F/IN

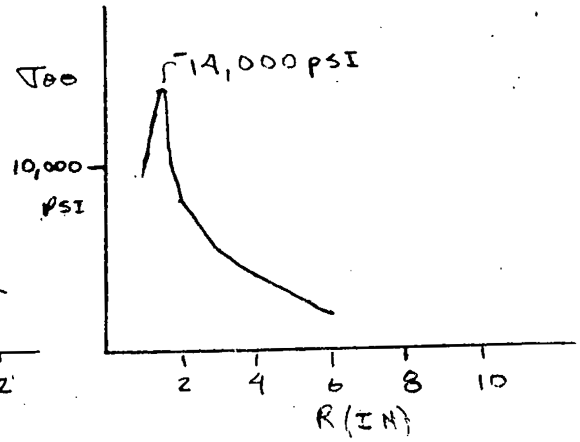




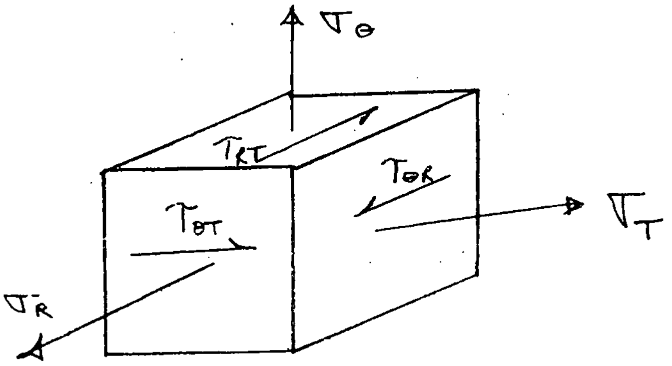
S-1A

b = 15" a = 1" K = -9.8 °F/IN





REVIEWING THE THERMAL STRESSES AND THE SIZE OF PIPE THAT CAUSES THESE STRESSES, THE WELD FOR PIPE 2"-LS-120-AB PENETRATING NOZZLE S-1A REQUIRES A COMPLETE ANALYSIS.



WELD ELEMENT S-1A (2"-LS-120 AB)

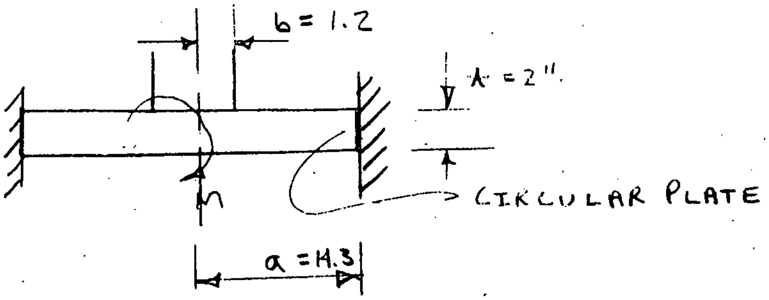
2.2) RADIAL STRESSES

THERMAL

$\sigma_R = -6000$ psi (SEE PAGE B-4)

FROM MOMENT IN PIPE

BASED ON INFORMATION ON PAGE 369, CASE 21, OF REFERENCE 8.



@ r = b

$$\text{MAX } \sigma_r = \frac{\beta M}{a t^2}$$

$$\frac{b}{a} = \frac{1.2}{14.3} \doteq .08 \Rightarrow \beta = 10.2$$

M = MOMENT ON 2" LINE TAKEN FROM REFERENCE 2.

DW + SSE - HIGHEST LOAD

$M_y = 5340$ IN-lb

$M_z = 3202$ IN-lb

$M = (5340^2 + 3202^2)^{1/2} = 6230$ IN-lb

$$\sigma_r = \frac{10.2\,(6230)}{14.3\,(2)^2}$$

$\sigma_R = \pm 1110$ PSI

<u>FROM AXIAL LOAD IN PIPE</u>

BASED ON INFORMATION ON PAGE 336,
CASE 1-5 OF REFERENCE 8.

$$M_{rb} = \frac{wa}{C_5} L_6$$

$$w = \frac{P}{\text{PERIMETER}}$$

P = AXIAL LOAD ON 2" LINE TAKEN FROM REFERENCE 2. DW+SSE GOVERN

$P = 123$ lb

$$w = \frac{123}{2\pi\,(1.2)}$$

$w = 16.3$

$$C_5 = \frac{1}{2}\left[1 - \left(\frac{b}{a}\right)^2\right] = \frac{1}{2}\left[1 - \left(\frac{1.2}{14.3}\right)^2\right]$$

$C_5 = 0.50$

$$L_6 = \frac{r_o}{4a}\left[\left(\frac{r_o}{a}\right)^2 - 1 + 2\ln\frac{a}{r_o}\right]$$

@ $r_o = b$

$$L_6 = \frac{1.2}{4(14.3)}\left[\left(\frac{1.2}{14.3}\right)^2 - 1 + 2\ln\frac{14.3}{1.2}\right]$$

$L_6 = .083$

$$M_{rb} = 16.3(14.3)\frac{(.083)}{.5}$$

$M_{rb} =$ 38 IN-lb (VERY LOW)

$\therefore \quad \sigma_r \equiv 0$

TOTAL RADIAL STRESS: $\sigma_r = -6000 - 1110 + 0$

$\underline{\sigma_r = -7110 \text{ PSI}}$

2.3) HOOP STRESS

THERMAL

$\underline{\sigma_\theta = -14{,}000 \text{ PSI}}$

STRESSES FROM OTHER LOADING IS NEGLIGIBLE

2.4) TANGENTIAL STRESS

NEGLIGIBLE $\quad \sigma_T = 0$

2.5) SHEAR STRESS

NEGLIGIBLE $\quad \tau = 0$

2.6) STRESS INTENSITIES

SINCE SHEAR IS NEGLIGIBLE, THE RADIAL, HOOP AND TANGENTIAL STRESSES ARE THE PRINCIPLE STRESSES.

$S_{1-2} = \sigma_r - \sigma_\theta = -7110 - (-14{,}000)$

$S_{1-2} = 6890$ PSI

$S_{2-3} = \sigma_\theta - \sigma_T = -14{,}000 - 0$

$\underline{S_{2-3} = 14{,}000 \text{ PSI}}$ ⟵ MAXIMUM STRESS INTENSITY

$S_{1-3} = \sigma_r - \sigma_T = -7110 - 0$

$S_{1-3} = 7110$ PSI

2.7) PRIMARY PLUS SECONDARY STRESS INTENSITIES

SINCE THIS WORK IS A MODIFICATION OF WORK THAT USED THE 1965 EDITION OF THE ASME BOILER AND PRESSURE VESSEL CODE,[1] THE 1965 EDITION WILL BE USED IN THIS REPORT.

$P_m + Q$ = PRIMARY + SECONDARY STRESS

$P_m + Q = 14{,}000$ PSI (MAX STRESS INTENSITY (SECTION 2.6))

THE FLANGES THAT THE PIPES ARE WELDED TO ARE COMPOSED OF SA-350, GRADE LF1 CARBON STEEL AT A DESIGN TEMPERATURE OF 260°F.[6]

S_m = DESIGN STRESS INTENSITY

$S_m = 17{,}950$ PSI @ 260°F (REF 1)

$P_m + Q < 3S_m$ (REF 1)

$$\underline{\underline{P_m + Q = 14{,}000 \text{ PSI} \leq 3S_m = 53{,}850 \text{ PSI}}}$$

THEREFORE THE REQUIREMENTS FOR PRIMARY + SECONDARY STRESS ARE SATISFIED

2.8) PRIMARY PLUS SECONDARY STRESS INTENSITIES (PEAK)

$P_m + Q + F$ = PRIMARY + SECONDARY + PEAK STRESS

FOR THIS WELD AREA, THE STRESS CONCETRATION FACTOR IS 3.0 [9]

$P_m + Q + F = 3.0(14{,}000)$

$P_m + Q + F = 42{,}000$ PSI

THE MAXIMUM STRESS WILL FLUCTUATE BETWEEN 0.0 PSI AND 42,000

THEREFORE $S_a = \dfrac{42{,}000 - 0}{2}$

$S_A = 21,000$ PSI

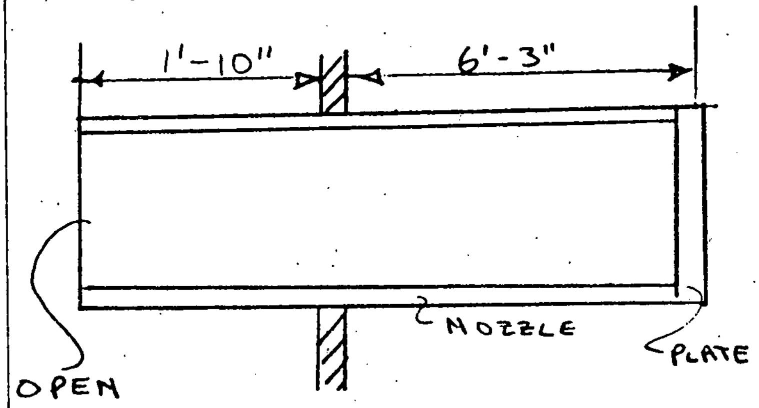
ENTERING SA ON THE FATIGUE CURVE FOR CARBON STEEL (SEE REF 1, PAGE 19)

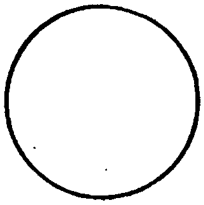
THE MAXIMUM # OF CYCLES = 100,000 CYCLES

FROM LOFT SPECIFICATION S-1,[6] THE MAXIMUM NUMBER OF FATIGUE CYCLES ON ANY NOZZLE IS 10,000. SINCE THIS IS LESS THAN 100,000, THE FATIGUE CRITERION ARE SATISFIED.

NOZZLE S-20A

NOZZLE SIZE — 10" Ø
NOZZLE THICKNESS — 0.593"
PLATE THICKNESS — 0.75"





OUTSIDE INSIDE

LINES PENETRATING	DESCRIPTION	OPERATING TEMP	MAX. TEMP	MIN TEMP		FLOW RATE
1) 1½"-BS-51-VD	BLOWDOWN SUPPRESSION SYS.	220°F	220°F	70°F		1 lb/hr

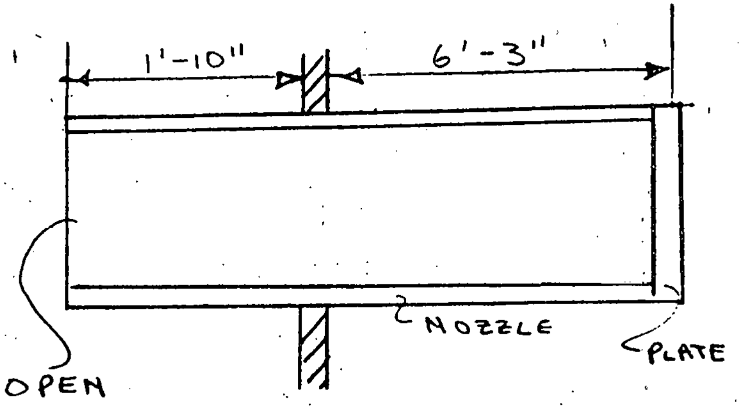
1). PROJECT ENGINEER – NANCY SMITH ; EXT-6-6319
WELDON MAKELA - EXT-6-6228

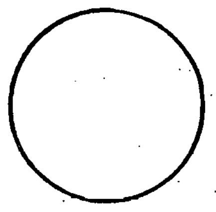
$$\left.\frac{dT}{dx}\right)_{@weld} = -1.0199_{+1} \ ^\circ F/IN.\ [3]$$

$$= -10.199 \ ^\circ F/IN$$

NOZZLE S-20B

NOZZLE SIZE — 10"
NOZZLE THICKNESS — 0.593"
PLATE THICKNESS — 0.75"





OUTSIDE INSIDE

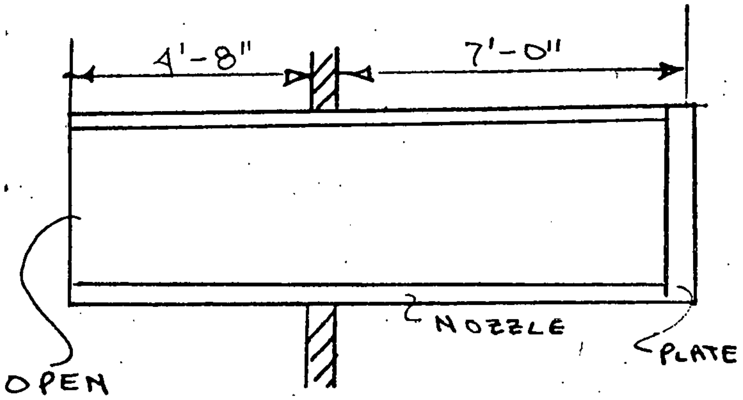
LINES PENETRATING	DESCRIPTION	OPERATING TEMP	MAX. TEMP	MIN TEMP		FLOW RATE
1) 1/2"-BS-52-VC 2) 1/2"-BS-53-VC 3) 1/2"-BS-54-VD	BLOWDOWN SUPPRESSION SYSTEM	220° F	220° F	70°		1 lb/hr

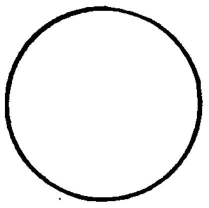
1,2,3) PROJECT ENGINEER NANCY SMITH EXT-6-6319
WELDON MAKELA EXT-6-6228

$$\left.\frac{dT}{dx}\right)_{at\ weld} = -1.01999\ ^{\circ}F/in. \ [3]$$

NOZZLE S-11C

NOZZLE SIZE – 12"
NOZZLE THICKNESS – 0.406"
PLATE THICKNESS – 1.25"





OUTSIDE INSIDE

LINES PENETRATING	DESCRIPTION	OPERATING TEMP	MAX. TEMP	MIN TEMP		FLOW RATE
1) 1"-SSS-3-E	SUMP SAMPLING SYSTEM	100°F	100°F	70°F		1 gpm MAX
2) 4"-BS-285-AB	BLOW DOWN SUPPRESSION SYSTEM	250°F	250°F	70°F		2000 lb/hr

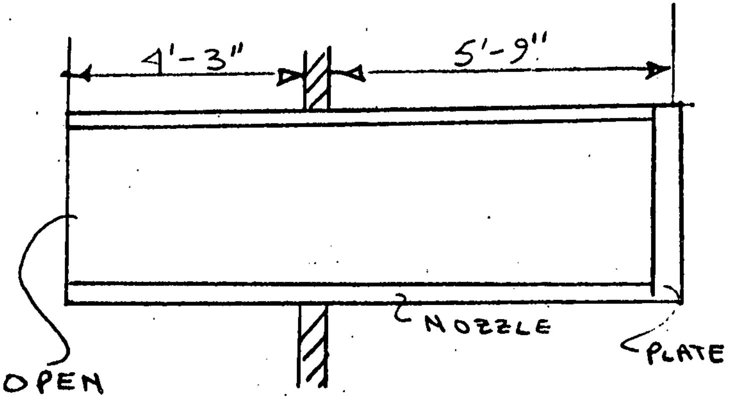
1) PROJECT ENGINEER – BUD WHITE EXT-6-6215

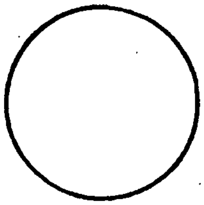
2) PROJECT ENGINEER – NANCY SMITH EXT-6-6319
WELDON MAKELA EXT-6-6228

$$\left.\frac{dT}{dx}\right)_{@\,weld} = -7.8416\ ^{\circ}F/in.$$ [3]

NOZZLE S-1A

NOZZLE SIZE — 30" ∅
NOZZLE THICKNESS — 0.50"
PLATE THICKNESS — 2.00"





OUTSIDE INSIDE

LINES PENETRATING	DESCRIPTION	OPERATING TEMP	MAX. TEMP	MIN TEMP		FLOW RATE
1) 2"-LS-120-AB	LOW PRESSURE STEAM SYSTEM	.250°	250°F	70°F	15 psig	OP - 0 500 lb/sec
2) 3"-PR-94-E	PRESSURE REDUCTION SPRAY SYSTEM	100° F	100°F	70°F		N.A.
3) 1"-PCC-77-AB	PRIMARY COMPONENT COOLING SYSTEM	80° F	80°F	70°F		10 gpm
4) 1"-PCC-78-AB	" " " "	80°F	80 F	70°F		—

1,2) PROJECT ENGINEER — BUD WHITE — EXT — 6-6215
3,4) PROJECT ENGINEER — GERRY TANGUAY EXT — 6-6293

$$\left.\frac{dT}{dx}\right)_{@\,weld} = -9.8549\ {}^{\circ}F/in. \quad [3]$$