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ANALYSIS OF LOFT CONTAINMENT NOZZLES

11A, 11B, 11D, 12A, 13B, 13C, & 13D

BY BIJLAARD METHOD

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IDAHO NATIONAL ENGINEERING LABORATORY

DEPARTMENT OF ENERGY

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APPLIED MECHANICS BRANCH

ANALYSIS OF LOFT CONTAINMENT NOZZLES

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ABSTRACT

The purpose of this analysis was the calculation of stresses in the LOFT Containment Vessel at the point of nozzle penetration produced by loads on the nozzles and to show that those stresses are within the 1965 ASME Boiler and Pressure Vessel Code allowables.

The stress determination was done by the method developed by P. P. Bijlaard on the worst load case for each diameter nozzle. The operating basis earthquake (OBE) at nozzle 11D produced the most severe load case. All load cases resulted in containment vessel stresses that were less than the allowables as stated in N-414 of the 1965 ASME Boiler and Pressure Vessel Code.

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ANALYSIS OF LOFT CONTAINMENT NOZZLES 11A, 11B,
11D, 12A, 13B, 13C, & 13D BY BIJLAARD METHOD

I. INTRODUCTION

An analysis of the LOFT containment nozzles for the heating and ventilating system piping for deadweight, thermal expansion, safe shutdown earthquake (SSE), and operating basis earthquake (OBE) load cases was made. The resulting reaction forces on the pipe ends fixed at the containment vessel nozzles were used for the determinator of the loads on the nozzle penetrations. These loads were used for the determination of the stresses in the containment vessel at the penetrations by the method developed by P. P. Bijlaard. The stresses were compared to the allowables in the 1965 ASME Boiler and Pressure Vessel Code and its Summer 1966 Addenda because this is the edition of the Code used in the design and construction of the containment.

II. STATEMENT OF PROBLEM AND SOLUTION METHOD

The problem being considered in this analysis is the calculation of stresses in a large diameter (70 feet) cylindrical shell at a nozzle penetration due to piping loads on the nozzle^[1 - 7]. The axial force and overturning moments that are applied to the nozzle cause flexure in the shell. The net effect is a tensile stress on one side of the shell thickness and compressive stress on the other side. Since the attachment is considered far more rigid than the shell, only the shell is considered to bend. The effect of the axial force and overturning moments are illustrated in Figure 1.

The method utilized in this analysis is based on the analytical work done by Prof. P. P. Bijlaard of Cornell University. His work was published as a set of curves plotted in terms of dimensionless ratios. The value of β (.875 nozzle radius/vessel radius) determines the position on a curve identified by the ratio γ (vessel radius/vessel wall thickness). A value is read on the vertical axis and is used in the calculation of stress components from given loads and stress concentration factors.

Tests were performed on several vessel nozzle configurations and seemed to provide reasonable verification for the narrow range of ratios covered. Since very little data is available over the range covered by the Bijlaard curves, values obtained near the extremes may be questionable or, at best, less conservative.

In this analysis, a more recent summarization of Bijlaard's work (Ref. 9), with the curves slightly changed to make them more conservative, was used. The computation sheet provided in the paper was used to record the values used and the resulting calculated values in an orderly manner.

FIG 1

FLEXURE OF SHELL CAUSED
BY AXIAL FORCE AND OVERTURNING
MOMENTS ACTING SINGLY.

III. ASSUMPTIONS AND PREPARATORY CALCULATIONS

The loads on the nozzles were the reaction forces on the attached piping system (Table I) with the signs changed to make these values into the forces and moments acting on the nozzle. The reaction forces were in an arbitrary coordinate system and needed to be translated to forces and moments in the axis system of the nozzle (x axis parallel to nozzle axis and y axis vertically up). This was done by calling the nozzle axis system the x' - y' - z' system and multiplying the forces and moments in the original axis system by the sine and cosine of the angle of rotation of the primed axis system. The components produced were summed in the primed axis system (Table II). The forces and moments defined by the y - y' axis were not changed by the rotation of the x' - z' axes (see Figure 2 for axis systems and tabulation of components).

These forces and moments were used to calculate the loads at the point of attachment (Table III). This was done by changing M_y and M_z to a new pair of moments M_1 and M_2 by calculating the additional increment of moment created by the shear force acting at the end of a cantilever. An example of this calculation is shown in Figure 3.

Once the load at the point of attachment was determined, the stress concentration factors F_n and F_B to be used in Bijlaard's method were calculated. A cross-section at the point of attachment, showing the thickness and weld details, is illustrated in Figure 4. The actual thickness of the containment vessel at the penetration, as built, was 1.75 inches for the 12-inch nozzles (11A, 11B, and 11D) and 2.00 inches for the 24-inch nozzle and the 36-inch nozzles (12A, 13B, 13C, and 13D). An additional 6-inch wide ring of 6.25-inch thick plate was welded around the nozzle on the outside of the containment vessel. This produced an effective wall thickness at the penetration of 2.375 inches for the 12-inch nozzles and 2.625 inches for the others. The

TABLE I
REACTION FORCES FROM PIPING ANALYSIS

NOZZLE NO	LOAD TYPE	FORCES			MOMENTS		
		F_x	F_y	F_z	M_x	M_y	M_z
11A	DEADWT	100	950	113	-19351	1356	9046
	THERMAL	288	560	540	-7429	-7	3965
	SSE	38	13	41	485	2751	1371
	OBE	19	7	21	242	1375	686
11B	DEADWT	0	700	0	20955	0	-32019
	THERMAL	0	242	0	5636	0	-16339
	SSE	1757	1077	2500	137792	340177	109362
	OBE	879	539	1250	68896	170089	54681
11D	DEADWT	279	2138	-10	-30178	9004	54460
	THERMAL	1168	4342	2038	-23632	-22354	123633
	SSE	118	190	224	2979	7564	4960
	OBE	59	95	112	1489	3782	2480
13D	DEADWT	0	9483	0	704107	0	15784
	THERMAL	0	0	0	0	0	0
	SSE	2396	1896	760	228708	332017	61806
	OBE	1198	948	380	114354	116009	30903

TABLE 1 CONTINUED
REACTION FORCES FROM PIPING ANALYSIS

NOZZLE NO.	LOAD TYPE	FORCES			MOMENTS		
		F_x	F_y	F_z	M_x	M_y	M_z
13B	DEADWT	0	7082	0	-436740	0	-10919
	THERMAL	0	-1782	0	162128	0	0
	SSE	1927	1321	1932	112125	173870	80312
	OBE	963	660	716	56063	86935	40156
13C	DEADWT	0	7088	0	23408	0	477633
	THERMAL	0	0	0	0	0	0
	SSE	386	1238	1167	20677	121236	117223
	OBE	193	619	583	10339	60618	58612
12A	DEADWT	0	1620	0	77700	0	-648
	THERMAL	-122	0	-342	0	34200	0
	SSE	-1486	-237	-1118	-14472	-229008	-9876
	OBE	-743	-118	-559	-7236	-111504	-4944

TABLE 2

COMBINED LOADS IN PIPE AXIS SYSTEM

NOZZLE NO.	LOAD TYPE	FORCES			MOMENTS		
		F_x	F_y	F_z	M_x	M_y	M_z
11A	SSE + DWT	-201	-963	50	-341	-4107	-21548
	OBE + T + DWT	-786	-1517	43	6028	-2724	-35526
11B	SSE + DWT	2773	-1777	1289	176306	-340177	-12318
	OBE + T + DWT	1387	-1239	644	85949	-170089	-42262
11D	SSE + DWT	-375	-2328	251	-39696	-16568	-51911
	OBE + T + DWT	-2597	-6575	325	-133108	9568	-130032
13D	SSE + DWT	-1880	-11378	281	-820610	-332017	308528
	OBE + T + DWT	-939	-10431	140	-728712	-116009	290274
13B	SSE + DWT	-2092	-8903	1178	68639	-173870	-324776
	OBE + T + DWT	-1046	-5960	589	62183	-86935	-208546
13C	SSE + DWT	-60	-8326	-1226	116486	-121236	-585002
	OBE + T + DWT	-30	-619	-614	110785	-60618	-525760
12A	SSE + DWT	-1118	-1383	1486	-10524	229008	-63228
	OBE + T + DWT	-901	-1502	864	-5592	77304	-70464

FIG 2

11 D

12" dia
406 TK

(SAME AS PRIMED)
AXES ON ADJ. DWG

LOADS FROM PIPING ANALYSIS

SSE + DWT

X	-397
Y	-2328
Z	-214

OBE + T + DWT

X	-1506
Y	-6575
Z	-2140

XM 27199
YM -16568
ZM -59420

52321
9568
-178572

SSE + DWT

LOAD COMPONENTS IN NOZZLE AXIS SYSTEM

NOZZLE AXIS SYSTEM

	X	Y	Z	XM	YM	ZM	TOTAL
X _p	-186		-189				-375
Y _p		-2328					-2328
Z _p	251		-100				251
MY _p				12769		-52465	-39696
MY _p					-16568		-16568
MZ _p				-24015		-27896	-51911

OBE + T + DWT

	X	Y	Z	XM	YM	ZM	TOTAL
X _p	-707		-1890				-2597
Y _p		-6575					-6575
Z _p	1330		-1005				325
MY _p				24563		-157671	-133108
MY _p					9568		9568
MZ _p				-46197		-83835	-130032

TABLE 3
LOADS AT PENETRATION FOR BIJLAARD ANALYSIS

NOZZLE NO.	LOAD TYPE	FORCES			MOMENTS		
		F_x	F_y	F_z	M_T	M_2	M_1
11A	SSE + DWT	-201	-963	50	-341	-9935	-133795
	OBE + T + DWT	-786	-1517	43	6028	-7736	-141296
11B	SSE + DWT	2773	-1777	1289	176306	-463676	-182572
	OBE + T + DWT	1387	-1239	644	85949	-231791	-160971
11D	SSE + DWT	-375	-2328	251	-39696	-45825	-323263
	OBE + T + DWT	-2597	-6575	325	-133108	-28314	-896414
13D	SSE + DWT	-1880	-11379	281	-820610	-338674	-38959
	OBE + T + DWT	-939	-10431	140	-728712	-119326	43164
13B	SSE + DWT	-2092	-8403	1178	68639	-145963	-523843
	OBE + T + DWT	-1046	-5960	589	62183	-100888	-349738
13C	SSE + DWT	-60	-8326	-1228	116486	-92145	-782245
	OBE + T + DWT	-30	-619	-614	110785	-46072	-540424
12A	SSE + DWT	-1118	-1383	1486	-10524	193805	-95991
	OBE + T + DWT	-901	-1502	864	-5592	56836	-106046

Fig 3

$$M_1 = y \cdot L + M_z$$

SSE + DWT

$$M_1 = (-2328) \cdot 116.56 + (-51911)$$

$$M_1 = -323263$$

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$$M_2 = M_y - z \cdot L$$

$$M_2 = (-16568) - 251 \cdot 116.56$$

$$M_2 = -45825$$

OBE + T + DWT

$$M_1 = (-6575) \cdot 116.56 + (-130032)$$

$$M_1 = -896414$$

$$M_2 = 9568 - 325 \cdot 116.58$$

$$M_2 = -28314$$

FIG 4
CROSS-SECTION AT ATTACHMENT

1965 ASME Code (Ref. 8) in Figure N-462.3-6 specified that in full penetration welds, the external fillet of weld metal was required to be either .25 inch or .7 times the nozzle wall thickness, whichever was greater. An estimated surface radius of .50 inch was used to calculate K_n (membrane stress concentration factor) and K_B (bending stress concentration factor). Once these values had been established, the geometric parameters and stresses could be calculated using the Bijlaard curves.

An example of the calculations on a computation sheet is given in Table IV. The Bijlaard axis system is slightly different from the nozzle axis system. The diagram on the computation sheet of a cylindrical shell with a round attachment, when compared to the nozzle axis, indicates that the Bijlaard axial force is in the nozzle - x direction but the M_T (Bijlaard) and M_x (nozzle) are equivalent. The force and moment in the circumferential direction (M_c and V_c , Bijlaard) correspond to M_1 and F_2 in the nozzle axis system. Similarly, M_L is equivalent to M_2 and V_L is equivalent to F_y .

Rather than doing all fourteen sets of calculations, the worst case for each diameter nozzle was analyzed. This was accomplished by choosing the load sets with the highest bending moments since these produce the major stress components.

Table 5—Computation Sheet for Local Stresses in Cylindrical Shells

11D

OBE + T + DWT

TABLE IV

1. Applied Loads*

Radial load, $P = 2597$ lb.
 Circ. Moment, $M_c = 28314$ in. lb.
 Long. Moments, $M_L = 8764$ in. lb.
 Torsion Moment, $M_T = 133108$ in. lb.
 Shear Load, $V_c = 825$ lb.
 Shear Load, $V_L = 6572$ lb.

2. Geometry

Vessel thickness, $T = 2.315$ in.
 Attachment radius, $r_o = 6$ in.
 Vessel radius, $R_m = 420.5$ in.

3. Geometric Parameters

$\gamma = \frac{R_m}{T} = 177$
 $\beta = (0.875) \frac{r_o}{R_m} = 0.0125$

Stress Concentration due to:
 a) membrane load, $K_n = 1.195$
 b) bending load, $K_b = 1.076$

*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							
			A _u	A _L	B _u	B _L	C _u	C _L	D _u	D _L
3C	$\frac{N_c}{P/R_m} = 33$	$K_n \left(\frac{N_c}{P/R_m} \right) \cdot \frac{P}{R_m T}$	-98	-98	-98	-98	-98	-98	-98	-98
1C	$\frac{M_c}{P} = 25$	$K_b \left(\frac{M_c}{P} \right) \cdot \frac{6P}{T^2}$	-743	+743	-743	+743	-743	+743	-743	+743
3A	$\frac{N_c}{M_c/R_m^2\beta} = 1.1$	$K_n \left(\frac{N_c}{M_c/R_m^2\beta} \right) \cdot \frac{M_c}{R_m^2\beta T}$					+7	+7	+7	+7
1A	$\frac{M_c}{M_c/R_m\beta} = 1.1$	$K_b \left(\frac{M_c}{M_c/R_m\beta} \right) \cdot \frac{6M_c}{R_m\beta T^2}$					+617	+617	+617	+617
3B	$\frac{N_L}{M_L/R_m^2\beta} = 4.1$	$K_n \left(\frac{N_L}{M_L/R_m^2\beta} \right) \cdot \frac{M_L}{R_m^2\beta T}$	-860	-860	-860	-860				
1B or 1B-1	$\frac{M_L}{M_L/R_m\beta} = 0.66$	$K_b \left(\frac{M_L}{M_L/R_m\beta} \right) \cdot \frac{6M_L}{R_m\beta T^2}$	+1288	+1288	+1288	+1288				
Add algebraically for summation of C stresses, $\sigma_C =$			12902	-11318	-14564	12666	-211	35	-1965	1255
4C	$\frac{N_x}{P/R_m} = 35$	$K_n \left(\frac{N_x}{P/R_m} \right) \cdot \frac{P}{R_m T}$	-104	-104	-104	-104	-104	-104	-104	-104
2C	$\frac{M_x}{P} = 24$	$K_b \left(\frac{M_x}{P} \right) \cdot \frac{6P}{T^2}$	-759	+759	-759	+759	-759	+759	-759	+759
4A	$\frac{N_x}{M_x/R_m^2\beta} = 1.1$	$K_n \left(\frac{N_x}{M_x/R_m^2\beta} \right) \cdot \frac{M_x}{R_m^2\beta T}$					+7	+7	+7	+7
2A	$\frac{M_x}{M_x/R_m\beta} = 0.6$	$K_b \left(\frac{M_x}{M_x/R_m\beta} \right) \cdot \frac{6M_x}{R_m\beta T^2}$					+370	+370	+370	+370
4B	$\frac{N_x}{M_L/R_m^2\beta} = 1.0$	$K_n \left(\frac{N_x}{M_L/R_m^2\beta} \right) \cdot \frac{M_L}{R_m^2\beta T}$	+196	+196	+196	+196				
2B or 2B-1	$\frac{M_L}{M_L/R_m\beta} = 1.1$	$K_b \left(\frac{M_L}{M_L/R_m\beta} \right) \cdot \frac{6M_L}{R_m\beta T^2}$	+21471	+21471	+21471	+21471				
Add algebraically for summation of X stresses, $\sigma_X =$			20804	-20620	-22530	21930	-486	292	-1240	1018
Shear stress due to Torsion, M_T			$\tau_{\phi x} = \tau_{x\phi} = \frac{M_T}{2\pi r_o^2 T}$	-248	-248	-248	-248	-248	-248	-248
Shear stress due to load, V_c			$\tau_{\phi x} = \tau_{x\phi} = \frac{V_c}{\pi r_o T}$	-7	-7	-7	-7	-7	-7	-7
Shear stress due to load, V_L			$\tau_{\phi x} = \tau_{x\phi} = \frac{V_L}{\pi r_o T}$					+147	+147	+147
Add Algebraically for summation of shear stresses, $\tau =$				-241	-241	-255	-255	-107	-101	-395
COMBINED STRESS INTENSITY, S										
1) When σ_ϕ & σ_x have like signs			$S = \frac{1}{2} \left[\sigma_\phi + \sigma_x + \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2} \right]$			20811	-11372	-14576	21937	217
2) When $\tau = 0$			$S = \text{largest of } \sigma_\phi, \sigma_x \text{ or } \sigma_\phi - \sigma_x $							292
3) When σ_ϕ & σ_x have unlike signs			$S = \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2}$							124

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

4.2.2.5.2: When considering bending moment (M_L) : $\beta = K_L \sqrt{\beta_1 \beta_2}$ 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

IV. RESULTS

The nozzle with the worst bending moments of the 12-inch nozzles was 11D. Of the 36-inch nozzles, 13C had the highest bending moments. There was only one 24-inch nozzle but no calculations were made as the maximum bending moments were less than one-fourth of the maximum bending moments for either 13C or 11D. The highest stress intensity, 21,900 psi, was produced by the OBE plus thermal plus deadweight loading for 11D and was less than the $1.5 S_m$ (1.5×23.3 ksi) allowable as specified in N-414 of the 1965 ASME Code. The containment vessel is a Class B pressure vessel in the 1965 Code and N-1312 states that such pressure vessels must satisfy the allowables as stated in N-414 for Class A pressure vessels but N-1314 for Class B vessels states that the fatigue life criteria stated in N-415 need not be met.

V. CONCLUSIONS AND RECOMMENDATIONS

The calculations of stresses for the nozzles show that the stresses in the containment at the nozzle penetration are less than the allowables even though the bending moments on the nozzles are far in excess (by a factor of from 10 to a factor of 100) of the maximum permitted value of 8000 in.-lbs given in the LOFT containment vessel nozzle specifications.

It is recommended that the maximum safe forces and moments for the nozzles analyzed, as given in the specifications, be raised to the maximum values given in Table V. The values of the maximum number of cycles for fatigue life may be left as they are.

The low stresses produced by these loads, when used on the fatigue life curves in N-415, would indicate a fatigue life of 10^6 cycles.

TABLE 5

RECOMMENDED LOADS
IN SPECIFICATIONS AXIS SYSTEM
(SEE ILLUSTRATION)

ALL SIGNS ARE $\pm$

NOZZLE NO.	FORCES			MOMENTS		
	F_x	F_y	F_z	M_x	M_y	M_z
11A	5000*	500*	1600	8000*	35600	8000*
11B	5000*	1300	1800	176300	42300	340200
11D	5000*	500*	6600	133100	130100	16600
13D	1900	300	11400	820700	308600	332100
13B	2100	1200	8400	68700	324800	173900
13C	100	1300	8400	116500	585000	121300
12A	1200	1500	1500	10600	70500	229000

* THESE ARE VALUES GIVEN IN SPECIFICATIONS WHICH DID NOT CHANGE.

VI. REFERENCES

1. A. T. Pierce, "LOFT CIS Analysis S-12A, 36" H&V Duct Outside Penetration", LOFT Technical Report LTR 123-9 (RE-A-78-095), to be published.
2. C. G. Condie, "LOFT CIS Analysis Penetration S-13D 24" H&V Duct", LOFT Technical Report LTR 123-7 (RE-A-78-054), to be published.
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8. American Society of Mechanical Engineers, ASME Boiler and Pressure Vessel Code, 1965 Edition and Summer 1966 Addenda.
9. K. R. Wichman, et al, "Local Stresses in Spherical and Cylindrical Shells due to External Loadings", Bulletin 107, Welding Research Council, 1965.

APPENDIX A
PIPING ANALYSIS OUTPUT AND WORKSHEETS FROM ANALYSIS

S-11A PENETRATION

LOAD CASE:	DEADWEIGHT	THERMAL	SSE	OBE
X FORCE	100	288	38	19
Y FORCE	950	560	13	7
Z FORCE	113	540	41	21
X MOMENT	-19351	-7429	485	242
Y MOMENT	1356	-7	2751	1375
Z MOMENT	9046	3965	1371	686

J w Muffett

11 April 78

11 A

12" dia
406 TC

(SAME AS PRIMED
AXES ON ADJACENT
DRAWING)

LOADS FROM PIPING ANALYSIS

	SSE + DWT	OBE + T + DWT
X	-138	-407
Y	-963	-1517
Z	-154	-674
XM	18866	26538
YM	-4107	-2724
ZM	-10417	-13697

SSE + DWT

LOAD COMPONENTS IN NOZZLE AXIS SYST.

NOZZLE AXIS SYSTEM

	X	Y	Z	XM	YM	ZM	TOTAL
X _P	-65		-136				-201
Y _P		-963					-963
Z _P	122		-72				50
MY _P				8857		-9198	-341
MY _P					-4107		-4107
MZ _P				-16658		-4890	-21548

OBE + T + DWT

	X	Y	Z	XM	YM	ZM	TOTAL
X _P	-191		-595				-786
Y _P		-1517					-1517
Z _P	359		-316				43
MY _P				12459		-6431	6028
MY _P					-2724		-2724
MZ _P				-23432		-12094	-35526

11 A CONT

$$M_1 = y \cdot L + M_z$$

$$M_2 = M_y - z \cdot L$$

SSE + DWT

$$M_1 = (-963 \cdot 116.56) + (-21548)$$

$$M_1 = -133795$$

$$M_2 = (-4107) - 50 \cdot 116.56$$

$$M_2 = -9935$$

OBE + T + DWT

$$M_1 = (-1517) \cdot 116.56 + (-35526)$$

$$M_1 = -141296$$

$$M_2 = (-2724) - 43 \cdot 116.56$$

$$M_2 = -7736$$

11B

03/08/78

NUPIPE-IIM - NUCLEAR SERVICES CORPORATION PIPING ANALYSIS PROGRAM - VERSION 1.
LOFT CIS ANALYSIS - H & V S-11B - 12"

SUPPORT REACTIONS FOR LOAD CASE NO. 1

DEADWEIGHT

NODE	TYPE	REACTION (LBS OR IN-LBS)	DIRECTION
1	FORCE	0.	X COCRD
1	FORCE	700.	Y COCRD
1	FORCE	0.	Z COCRD
1	MOMENT	20955.	X COCRD
1	MOMENT	0.	Y COCRD
1	MOMENT	-32019.	Z COCRD
40	FORCE	722.	X COORD
65	FORCE	551.	Y COCRD
110	FORCE	744.	Y COCRD

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LTR 1217 04

03/08/78

NUPIPE-IIM - NUCLEAR SERVICES CORPORATION PIPING ANALYSIS PROGRAM - VERSION 1

LOFT CIS ANALYSIS - H & V S-11B - 12"

SUPPORT REACTIONS FOR LOAD CASE NO. 2

THERMAL EXPANSION PLUS ANCHOR MOVEMENTS

NODE	TYPE	REACTION (LBS OR IN-LBS)	DIRECTION
1	FORCE	0.	X COORD
1	FORCE	224.	Y COORD
1	FORCE	-0.	Z COORD
1	MOMENT	5636.	X COORD
1	MOMENT	-0.	Y COORD
1	MOMENT	-16339.	Z COORD
40	FORCE	-318.	X COORD
65	FORCE	-10.	Y COORD
110	FORCE	104.	Y COORD

NOTED AS ABOVE (PAGE 1) - PATENT PENDING

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1217 04

03/08/78

NUPIPE-IIM - NUCLEAR SERVICES CORPORATION PIPING ANALYSIS PROGRAM - VERSION 1.0

LOFT CIS ANALYSIS - H & V S-11B - 12"

SUPPORT REACTIONS FOR LOAD CASE NO. 3

SSE RESPONSE SPECTRUM - 1% DAMPING
COMBINED RESULT FOR MODE 1 THRU 7 BY RMS SUMMATION

SPECTRA SET = 1

MODE	TYPE	REACTIONS (LBS OR IN-LBS)	DIRECTION
1	FORCE	1757.	X COORD
1	FORCE	1077.	Y COORD
1	FORCE	2500.	Z COORD
1	MOMENT	137792.	X COORD
1	MOMENT	340177.	Y COORD
1	MOMENT	109362.	Z COORD
40	FORCE	1044.	X COORD
65	FORCE	3199.	Y COORD
110	FORCE	1501.	Z COORD

AF 6

JR 121702

11B

12" dia
.406 TK NOZZLE AXIS SYST
(SAME AS PRIMED AXES)
(ON ADJACENT DWG.)

LOADS FROM PIPING ANALYSIS

	SSE + DWT	OBE + T + DWT
X	-1757	-879
Y	-1777	-1239
Z	-2500	-1250
XM	-158747	-95487
YM	-340177	-170089
ZM	-77343	-6323

SSE + DWT LOAD COMPONENTS IN NOZZLE AXIS SYSTEM

NOZZLE AXIS SYSTEM

	X	Y	Z	XM	YM	ZM	TOTAL
X _p	1523		1250				2773
Y _p		-1777					-1777
Z _p	-879		2168				1289
MY _p				137634		38672	176306
MY _p					-340177		-340177
MZ _p				-79374		67056	-12318

OBE + T + DWT

	X	Y	Z	XM	YM	ZM	TOTAL
X _p	762		625				1387
Y _p		-1239					-1239
Z _p	-440		1084				644
MY _p				82787		3162	85949
MY _p					-170089		-170089
MZ _p				-47744		5482	-42262

11 B CONT

$$M_1 = y \cdot L + M_2$$

$$M_2 = M_1 - z \cdot L$$

SSE + DWT

$$M_1 = (-1777) \cdot 95.81 + (-12318)$$

$$M_1 = -182572$$

$$M_2 = (-340177) - 1289 \cdot 95.81$$

$$M_2 = -463676$$

OBE + T + DWT

$$M_1 = (-1239) \cdot 95.81 + (-42262)$$

$$M_1 = -160971$$

$$M_2 = (-170089) - 644 \cdot 95.81$$

$$M_2 = -231791$$

S-11D PENETRATION

LOAD CASE:	DEADWEIGHT	THERMAL	58E	08E
X FORCE	279	1168	118	59
Y FORCE	2138	4342	190	95
Z FORCE	-10	2038	224	112
X MOMENT	-30178	-23632	2979	1489
Y MOMENT	9004	-22354	7564	3782
Z MOMENT	54460	121633	4960	2480

J W Moffett
11 April 78

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11 D

12" dia
406 TK

(SAME AS PRIMED)
AXES ON ADJ. DWG

LOADS FROM PIPING ANALYSIS

SSE + DWT

X -397
Y -2328
Z -214

OBE + T + DWT

-1506
-6575
-2140

XM 27199
YM -16568
ZM -59420

52321
9568
-178573

SSE + DWT

LOAD COMPONENTS IN NOZZLE AXIS SYSTEM

NOZZLE AXIS SYSTEM

	X	Y	Z	XM	YM	ZM	TOTAL
X _p	-186		-189				-375
Y _p		-2328					-2328
Z _p	351		-100				251
MX _p				12769		-52465	-39696
MY _p					-16568		-16568
MZ _p				-24015		-27896	-51911

OBE + T + DWT

	X	Y	Z	XM	YM	ZM	TOTAL
X _p	-707		-1890				-2597
Y _p		-6575					-6575
Z _p	1330		-1005				325
MX _p				24563		-157671	-133108
MY _p					9568		9568
MZ _p				-46197		-83835	-130032

$$M_1 = y \cdot L + M_z$$

SSE + DWT

$$M_1 = (-2328) \cdot 116.56 + (-51911)$$

$$M_1 = -323263$$

$$M_2 = M_y - z \cdot L$$

$$M_2 = (-16568) - 251 \cdot 116.56$$

$$M_2 = -45825$$

OBE + T + DWT

$$M_1 = (-6575) \cdot 116.56 + (-130032)$$

$$M_1 = -896414$$

$$M_2 = 9568 - 325 \cdot 116.58$$

$$M_2 = -28314$$

Table 5—Computation Sheet for Local Stresses in Cylindrical Shells

LTR 1217 04

1. Applied Loads*

Radial load, $P = 375$ lb.
 Circ. Moment, $M_c = 35725$ in. lb.
 Long. Moments, $M_L = 32363$ in. lb.
 Torsion Moment, $M_t = 39686$ in. lb.
 Shear Load, $V_c = 117$ lb.
 Shear Load, $V_L = 25$ lb.

2. Geometry

Vessel thickness, $T = 2375$ in.
 Attachment radius, $r_o = 6$ in.
 Vessel radius, $R_m = 4205$ in.

3. Geometric Parameters

$$\gamma = \frac{R_m}{T} = 177$$

$$\beta = (0.875) \frac{r_o}{R_m} = 0.125$$

Stress Concentration due to:

- a) membrane load, $K_n = 1.195$
 b) bending load, $K_b = 1.076$

*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	$\frac{N\psi}{P/R_m} = 33$	$K_n \left(\frac{N\psi}{P/R_m} \right) \cdot \frac{P}{R_m T} =$	-14	-14	-14	-14	-14	-14	-14	-14
1C	$\frac{M\psi}{P} = 25$	$K_b \left(\frac{M\psi}{P} \right) \cdot \frac{6P}{T^2} =$	-107	+107	-107	+107	-107	+107	-107	+107
3A	$\frac{N\psi}{M_c/R_m^2\beta} = 1.1$	$K_n \left(\frac{N\psi}{M_c/R_m^2\beta} \right) \cdot \frac{M_c}{R_m^2\beta T} =$					+11	+11	-11	-11
1A	$\frac{M\psi}{M_c/R_m\beta} = 1$	$K_b \left(\frac{M\psi}{M_c/R_m\beta} \right) \cdot \frac{6M_c}{R_m\beta T^2} =$					+998	-998	-998	+998
3B	$\frac{N\psi}{M_L/R_m^2\beta} = 4.4$	$K_n \left(\frac{N\psi}{M_L/R_m^2\beta} \right) \cdot \frac{M_L}{R_m^2\beta T} =$	+310	+310	+310	+310				
1B or 1B-1	$\frac{M\psi}{M_L/R_m\beta} = 0.66$	$K_b \left(\frac{M\psi}{M_L/R_m\beta} \right) \cdot \frac{6M_L}{R_m\beta T^2} =$	+4646	-4646	-4646	+4646				
Add algebraically for summation of ϕ stresses, $\sigma_\phi =$			4835	-4243	-5077	9429	888	-894	-1130	1070
4C	$\frac{N_x}{P/R_m} = 35$	$K_n \left(\frac{N_x}{P/R_m} \right) \cdot \frac{P}{R_m T} =$	-15	-15	-15	-15	-15	-15	-15	-15
2C	$\frac{M_x}{P} = 24$	$K_b \left(\frac{M_x}{P} \right) \cdot \frac{6P}{T^2} =$	-100	+100	-100	+100	-100	+100	-100	+100
4A	$\frac{N_x}{M_c/R_m^2\beta} = 1.1$	$K_n \left(\frac{N_x}{M_c/R_m^2\beta} \right) \cdot \frac{M_c}{R_m^2\beta T} =$					+11	+11	-11	-11
2A	$\frac{M_x}{M_c/R_m\beta} = 0.6$	$K_b \left(\frac{M_x}{M_c/R_m\beta} \right) \cdot \frac{6M_c}{R_m\beta T^2} =$					+599	-599	-599	+599
4B	$\frac{N_x}{M_L/R_m^2\beta} = 1.0$	$K_n \left(\frac{N_x}{M_L/R_m^2\beta} \right) \cdot \frac{M_L}{R_m^2\beta T} =$	+71	+71	+71	+71				
2B or 2B-1	$\frac{M_x}{M_L/R_m\beta} = 1.1$	$K_b \left(\frac{M_x}{M_L/R_m\beta} \right) \cdot \frac{6M_L}{R_m\beta T^2} =$	+7743	-7743	-7743	+7743				
Add algebraically for summation of X stresses, $\sigma_x =$			7199	-7587	-7929	7757	495	-503	-725	673
Shear stress due to Torsion, M_t		$\tau_{\phi x} = \tau_{x\phi} = \frac{M_t}{2\pi r_o^2 T}$	-74	-74	-74	-74	-74	-74	-74	-74
Shear stress due to load, V_c		$\tau_{\phi x} = \frac{V_c}{\pi r_o T}$	-52	-52	+52	+52				
Shear stress due to load, V_L		$\tau_{\phi x} = \frac{V_L}{\pi r_o T}$					-6	-6	+6	+6
Add Algebraically for summation of shear stresses, $\tau =$			-126	126	-22	-22	80	80	68	26
COMBINED STRESS INTENSITY, S										
1) When σ_ϕ & σ_x have like signs		$S = \frac{1}{2} \left[\tau_{\phi x} + \sigma_x + \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2} \right]$	1699	7587	7929	7757	898	894	1130	1080
2) When σ_ϕ & σ_x have unlike signs		$S = \frac{1}{2} \left[\tau_{\phi x} - \sigma_x + \sqrt{(\sigma_\phi + \sigma_x)^2 + 4\tau^2} \right]$								
3) When σ_ϕ & σ_x have unlike signs		$S = \frac{1}{2} \left[\tau_{\phi x} - \sigma_x + \sqrt{(\sigma_\phi + \sigma_x)^2 + 4\tau^2} \right]$								

$N_L/(M_L/R_m^2\beta)$ so determined by (C_L) from Table 8 (see para. 4.2).

4.2.2.5.2: When considering bending moment (M_L) : $\beta = K_L \sqrt{\beta_1 \beta_2}$ 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

Table 5—Computation Sheet for Local Stresses in Cylindrical Shells

LVR 1217 04

1. Applied Loads*

Radial load, $P = 2597$ lb.
 Circ. Moment, $M_c = 257.14$ in. lb.
 Long. Moments, $M_L = 246.14$ in. lb.
 Torsion Moment, $M_t = 125.17$ in. lb.
 Shear Load, $V_c = 2.25$ lb.
 Shear Load, $V_L = 6.72$ lb.

2. Geometry

Vessel thickness, $T = 2.375$ in.
 Attachment radius, $r_o = 1.5$ in.
 Vessel radius, $R_m = 9.5$ in.

3. Geometric Parameters

$\gamma = \frac{R_m}{T} = 177$
 $H = (0.875) \frac{r_o}{R_m} = 0.125$

Stress Concentration due to:
 a) membrane load, $K_n = 1.145$
 b) bending load, $K_b = 1.076$

*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							
			A_u	A_L	B_u	B_L	C_u	C_L	D_u	D_L
3C	$\frac{N_c}{P/R_m} = 33$	$K_n \left(\frac{N_c}{P/R_m} \right) \cdot \frac{P}{R_m T}$	-98	98	-98	98	-98	98	98	-98
1C	$\frac{M_c}{P} = 25$	$K_b \left(\frac{M_c}{P} \right) \cdot \frac{6P}{T^2}$	-743	+743	-743	+743	-743	+743	-743	+743
3A	$\frac{N_c}{M_c/R_m^2\beta} = 1.1$	$K_n \left(\frac{N_c}{M_c/R_m^2\beta} \right) \cdot \frac{M_c}{R_m^2\beta T}$					-7	+7	-7	+7
1A	$\frac{M_c}{M_c/R_m\beta} = 1$	$K_b \left(\frac{M_c}{M_c/R_m\beta} \right) \cdot \frac{6M_c}{R_m\beta T^2}$					-617	+617	-617	+617
3B	$\frac{N_L}{M_L/R_m^2\beta} = 4.4$	$K_n \left(\frac{N_L}{M_L/R_m^2\beta} \right) \cdot \frac{M_L}{R_m^2\beta T}$	-860	+860	-860	+860				
1B or 1B-1	$\frac{M_L}{M_L/R_m\beta} = 0.66$	$K_b \left(\frac{M_L}{M_L/R_m\beta} \right) \cdot \frac{6M_L}{R_m\beta T^2}$	+12883	-12883	+12883	-12883				
Add algebraically for summation of ϕ stresses, $\sigma_\phi =$			12902	-11378	-14576	12637	-217	355	-11378	12902
4C	$\frac{N_x}{P/R_m} = 35$	$K_n \left(\frac{N_x}{P/R_m} \right) \cdot \frac{P}{R_m T}$	-104	104	-104	104	-104	104	-104	104
2C	$\frac{M_x}{P} = 24$	$K_b \left(\frac{M_x}{P} \right) \cdot \frac{6P}{T^2}$	-759	+759	-759	+759	-759	+759	-759	+759
4A	$\frac{N_x}{M_x/R_m^2\beta} = 1.1$	$K_n \left(\frac{N_x}{M_x/R_m^2\beta} \right) \cdot \frac{M_x}{R_m^2\beta T}$					-7	+7	-7	+7
2A	$\frac{M_x}{M_x/R_m\beta} = 0.6$	$K_b \left(\frac{M_x}{M_x/R_m\beta} \right) \cdot \frac{6M_x}{R_m\beta T^2}$					-370	+370	-370	+370
4B	$\frac{N_x}{M_L/R_m^2\beta} = 0$	$K_n \left(\frac{N_x}{M_L/R_m^2\beta} \right) \cdot \frac{M_L}{R_m^2\beta T}$	+196	-196	+196	-196				
2B or 2B-1	$\frac{M_x}{M_L/R_m\beta} = 1.1$	$K_b \left(\frac{M_x}{M_L/R_m\beta} \right) \cdot \frac{6M_L}{R_m\beta T^2}$	+21471	-21471	+21471	-21471				
Add algebraically for summation of x stresses, $\sigma_x =$			20204	-20520	-22550	21930	-486	292	-1240	21471
Shear stress due to Torsion, M_t			$r\phi_x = r\phi = \frac{M_t}{2\pi r_o^2 T}$	-248	-248	-248	-248	+248	+248	+248
Shear stress due to load, V_c			$r\phi = \frac{V_c}{\pi r_o T}$	-7	-7	-7	-7			
Shear stress due to load, V_L			$r\phi = \frac{V_L}{\pi r_o T}$					+147	+147	-147
Add Algebraically for summation of shear stresses, $\tau =$				-241	-241	-255	-355	-107	-107	355
COMBINED STRESS INTENSITY, S										
1) When σ_ϕ & σ_x have like signs		$S = \frac{1}{2} \left[\sigma_\phi + \sigma_x + \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2} \right]$	25611	-11372	-14576	21937	217	292	1242	1253
2) When $\tau = 0$		$S = \text{largest of } \sigma_\phi, \sigma_x \text{ or } \sigma_\phi - \sigma_x $								
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) : $\beta = K_L \sqrt{\beta_1 \beta_2}$ 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

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13D

NUPIPE-IIM - NUCLEAR SERVICES CORPORATION PIPING ANALYSIS PROGRAM - VERSION 1.1

LOFT CIS ANALYSIS - H & V S-13D - 24"

SUPPORT REACTIONS FOR LOAD CASE NO. 1

DEADWEIGHT

NODE	TYPE	REACTION (LBS OR IN-LBS)	DIRECTION
1	FORCE	0.	X COORD
1	FORCE	9483.	Y COORD
1	FORCE	-0.	Z COORD
1	MOMENT	704107.	X COORD
1	MOMENT	0.	Y COORD
1	MOMENT	15784.	Z COORD
40	FORCE	5.	Y COORD

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NR 1217 04

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NUPIPE-III - NUCLEAR SERVICES CORPORATION PIPING ANALYSIS PROGRAM - VERSION 1.

LOFT CIS ANALYSIS - H & V S-130 - 24"

SUPPORT REACTIONS FOR LOAD CASE NO. 2

THERMAL EXPANSION PLUS ANCHOR MOVEMENTS

NODE	TYPE	REACTION (LBS OR IN-LBS)	DIRECTION
1	FORCE	-0.	X COORD
1	FORCE	0.	Y COORD
1	FORCE	0.	Z COORD
1	MOMENT	0.	X COORD
1	MOMENT	0.	Y COORD
1	MOMENT	0.	Z COORD
40	FORCE	0.	Y COORD

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LFR 1217 04

SSE

SPECTRA SET = 1

NODE	TYPE	REACTIONS (LBS OR IN-LBS)	DIRECTION
1	FORCE	2396.	X COORD
1	FORCE	1596.	Y COORD
1	FORCE	760.	Z COORD
1	MOMENT	228702.	X COORD
1	MOMENT	332017.	Y COORD
1	MOMENT	61806.	Z COORD
40	FORCE	2.	Y COORD

7/16

13 D

24" dia
1500 TK

LTR 1212 04

LOADS FROM PIPING ANALYSIS

	SSE + DWT	OBE + T + DWT
X	-2396	-1198
Y	-11379	-10431
Z	-760	-380
XM	-932815	-818461
YM	-332017	-116009
ZM	-77590	-46687

SSE + DWT LOAD COMPONENTS IN NOZZLE AXIS SYSTEM

NOZZLE AXIS SYSTEM

	X	Y	Z	XM	YM	ZM	TOTAL
X _P	-2189		309				-1886
Y _P		-11379					-11379
Z _P	975		-694				281
MY _P				-852169		31559	-820610
MY _P					-332017		-332017
MZ _P				379410		-70882	308528

OBE + T + DWT

	X	Y	Z	XM	YM	ZM	TOTAL
X _P	-1099		155				-939
Y _P		-10431					-10431
Z _P	487		-347				140
MY _P				-747701		18989	-728712
MY _P					-116009		-116009
MZ _P				332898		-42651	290279

13 D CONT

$$M_1 = y \cdot L + M_z$$

$$M_2 = M_y - z \cdot L$$

SSE + DWT

$$M_1 = (-11379) 23.69 + 308528$$

$$M_2 = -332017 - 281 \cdot 23.69$$

$$M_1 = -38959$$

$$M_2 = -338674$$

OBE + T + DWT

$$M_1 = (-10431) 23.69 + 290274$$

$$M_2 = -116009 - 140 \cdot 23.69$$

$$M_1 = 43164$$

$$M_2 = -119326$$

Table 5—Computation Sheet for Local Stresses in Cylindrical Shells

LBR 1217 04

13-D

SSE + DWT

1. Applied Loads*

Radial load, $P = 1880$ lb.
 Circ. Moment, $M_c = 370.7$ in. lb.
 Long. Moments, $M_L = 370.7$ in. lb.
 Torsion Moment, $M_T = 370.7$ in. lb.
 Shear Load, $V_c = 271$ lb.
 Shear Load, $V_L = 1139$ lb.

3. Geometric Parameters

$\gamma = \frac{R_m}{T} = 160$
 $\beta = (0.875) \frac{r_o}{R_m} = 0.285$

2. Geometry

Vessel thickness, $T = 2.625$ in.
 Attachment radius, $r_o = 12$ in.
 Vessel radius, $R_m = 920.5$ in.

Stress Concentration due to:

a) membrane load, $K_n = 1.179$
 b) bending load, $K_b = 1.023$

*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	$\frac{N\phi}{P/R_m} = 32$	$K_n \left(\frac{N\phi}{P/R_m} \right) \cdot \frac{P}{R_m T}$	-64	-64	-64	-64	-64	-64	-64	-64
1C	$\frac{M\phi}{P} = 24$	$K_b \left(\frac{M\phi}{P} \right) \cdot \frac{6P}{T^2}$	-429	+429	-429	+429	-429	+429	-429	+429
3A	$\frac{N\phi}{M_c/R_m^2\beta} = 2.6$	$K_n \left(\frac{N\phi}{M_c/R_m^2\beta} \right) \cdot \frac{M_c}{R_m^2\beta T}$					+9	+9	+9	+9
1A	$\frac{M\phi}{M_c/R_m\beta} = 1.1$	$K_b \left(\frac{M\phi}{M_c/R_m\beta} \right) \cdot \frac{6M_c}{R_m\beta T^2}$					-301	-309	-309	-309
3B	$\frac{N\phi}{M_L/R_m^2\beta} = 10.5$	$K_n \left(\frac{N\phi}{M_L/R_m^2\beta} \right) \cdot \frac{M_L}{R_m^2\beta T}$	+317	+317	-317	-317				
1B or 1B-1	$\frac{M\phi}{M_L/R_m\beta} = 0.6$	$K_b \left(\frac{M\phi}{M_L/R_m\beta} \right) \cdot \frac{6M_L}{R_m\beta T^2}$	+1614	-1614	-1614	+1614				
Add algebraically for summation of ϕ stresses, $\sigma_\phi =$			1438	2296	-2424	1662	-175	65	-811	665
4C	$\frac{N_x}{P/R_m} = 28$	$K_n \left(\frac{N_x}{P/R_m} \right) \cdot \frac{P}{R_m T}$	-56	-56	-56	-56	-56	-56	-56	-56
2C	$\frac{M_x}{P} = 14$	$K_b \left(\frac{M_x}{P} \right) \cdot \frac{6P}{T^2}$	-250	+250	-250	+250	-250	+250	-250	+250
4A	$\frac{N_x}{M_c/R_m^2\beta} = 3.3$	$K_n \left(\frac{N_x}{M_c/R_m^2\beta} \right) \cdot \frac{M_c}{R_m^2\beta T}$					+11	+11	+11	+11
2A	$\frac{M_x}{M_c/R_m\beta} = 0.6$	$K_b \left(\frac{M_x}{M_c/R_m\beta} \right) \cdot \frac{6M_c}{R_m\beta T^2}$					+186	-186	-186	+186
4B	$\frac{N_x}{M_L/R_m^2\beta} = 2.5$	$K_n \left(\frac{N_x}{M_L/R_m^2\beta} \right) \cdot \frac{M_L}{R_m^2\beta T}$	+75	+75	-75	-75				
2B or 2B-1	$\frac{M_x}{M_L/R_m\beta} = 0.6$	$K_b \left(\frac{M_x}{M_L/R_m\beta} \right) \cdot \frac{6M_L}{R_m\beta T^2}$	+2582	-2582	-2582	+2582				
Add algebraically for summation of X stresses, $\sigma_x =$			2351	-2313	-2963	2701	-109	19	-503	369
Shear stress due to Torsion, M_T $\tau_{\phi x} = \tau_{x\phi} = \frac{M_T}{2\pi r_o^2 T}$			+346	+346	-346	-346	+346	-346	+346	-346
Shear stress due to load, V_c $\tau_{\phi\phi} = \frac{V_c}{\pi r_o T}$			-3	-3	-3	-3				
Shear stress due to load, V_L $\tau_{\phi\phi} = \frac{V_L}{\pi r_o T}$							+115	+115	+115	+115
Add Algebraically for summation of shear stresses, $\tau =$			349	349	-343	-343	461	461	231	231
COMBINED STRESS INTENSITY, S										
1) When σ_ϕ & σ_x have like signs $S = \frac{1}{2} \left[\sigma_\phi + \sigma_x + \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2} \right]$			2469	4662	2257	2809	323	504	379	805
2) When $\tau = 0$ $S = \text{largest of } \sigma_\phi, \sigma_x \text{ or } \sigma_\phi - \sigma_x $										
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) : $\beta = K_L \sqrt{\rho_1 \beta_1^2}$ 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

THESE
LOADS!
(Signs already changed)

DESIGNER A. Pierce DATE 4-10-78 CHECKER _____ DATE _____

APPROVED: _____ DATE _____

TITLE _____ JOB NO. _____

SUBJECT NOZZLE OR PENETRATION LOADING SHEET NO. _____ OF _____

A. EQUIPMENT NAME: _____

B. NOZZLE OR PENETRATION NUMBER: S-12A

C. SIZE OF NOZZLE OR PENETRATION: 36"

D. REF'D ISOMETRIC SKETCH NUMBER: _____

E. ANALYSIS PROBLEM NUMBER: _____

F. DATA PT. NUMBER: _____

A-20

ISSUE NO.	UNIT	ITEM	OPERATING		HYDROSTATIC TEST WEIGHT	OPERATING BASIS EARTHQUAKE O.B.E. (E) (±)		DESIGN BASIS EARTHQUAKE SSE O.B.E. (E) (±)		SEISMIC MOVEMENT LOAD D.B.E.	TOTAL NET DESIGN LOAD
			THERMAL EXPANSION	WEIGHT (PIPE, FLUID & INSULATION)							
	FORCE - LBS.	F _x	+122	0		743		1486		—	
		F _y	0	-1620		118		237		—	
		F _z	+342	0		559		1118		—	
	MOMENT FT.-LBS.	M _x	0	-6475		603		1206		—	
		M _y	-2850	0		9542		19,084		—	
		M _z	0	+54		412		823		—	

Note →

NOTES:

- (A) SIGN OF SEISMIC, SEISMIC MOVEMENTS LOADS AND AMID LOADS (DUE TO STEAM OR WATER HAMMER) MAY BE EITHER (+) OR (-)
- (B) THE SEISMIC AND SEISMIC MOVEMENTS LOADS MAY BE EITHER IN THE X + Y OR Z + Y DIRECTIONS BUT NEVER SIMULTANEOUSLY
- (C) E = 2.0 E

1212 00

LTR 1217 04

12 A

36" dia
750 TK NOZZLE AXIS SYSTEM
(SAME AS PRIMED AXES)
(IN ADJACENT DWG)

LOADS FROM PIPING ANALYSIS

	SSE + DWT	OBE + T + DWT
X	1486	864
Y	-1383	-1502
Z	1118	901
XM	-63228	-70464
YM	229008	77304
ZM	10524	5592

SSE + DWT LOAD COMPONENTS IN NOZZLE AXIS SYSTEM

NOZZLE AXIS SYSTEM

	X	Y	Z	XM	YM	ZM	TOTAL
Xp			-1118				-1118
Yp		-1383					-1383
Zp	1486						1486
MXp						-10524	-10524
MYp					229008		229008
MZp				-63228			-63228

OBE + T + DWT

	X	Y	Z	XM	YM	ZM	TOTAL
Xp			-901				-901
Yp		-1502					-1502
Zp	864						864
MXp						-5592	-5592
MYp					77304		77304
MZp				-70464			-70464

12 A CONT

AVR 1217 04

$$M_1 = y \cdot L + M_z$$

$$M_2 = M_y - z \cdot L$$

SSE + DWT

$$M_1 = (-1383)23.69 - 63228$$

$$M_1 = -95991$$

$$M_2 = 229008 - 1486 \cdot 23.69$$

$$M_2 = 193805$$

OBE + T + DWT

$$M_1 = (-1502)23.69 - 70469$$

$$M_1 = -106046$$

$$M_2 = 77304 - 864 \cdot 23.69$$

$$M_2 = 56836$$

S - 13 - B PENETRATION

LOAD CASE :	DEADWEIGHT	THERMAL	SSE	OBE
X FORCE	0	0	1927	963
Y FORCE	7082	-1782	1321	660
Z FORCE	0	0	1432	716
X MOMENT	-436740	162128	112125	56063
Y MOMENT	0	0	173870	86935
Z MOMENT	-10919	0	80312	40156

J W Muffett
11 April 78

13 B

36" dia
175 TK

LOADS FROM PIPING AXES

SSE + DWT

X	-1927
Y	-8403
Z	-1432

OBE + T + DWT

	-963
	-5960
	-716

XM 324615
YM -173870
ZM -69393

218548
-86935
-29237

SSE + DWT LOAD COMPONENTS IN NOZZLE AXIS SYSTEM

	X	Y	Z	XM	YM	ZM	TOTAL
X _p	-784		-1308				-2092
Y _p		-8403					-8403
Z _p	1760		-582				1178
MX _p				132033		-63394	68639
MY _p					-173870		-173870
MZ _p				-296551		-28225	-324776

OBE + T + DWT

	X	Y	Z	XM	YM	ZM	TOTAL
X _p	-392		-654				-1046
Y _p		-5960					-5960
Z _p	880		-291				589
MX _p				88891		-26708	62183
MY _p					-86935		-86935
MZ _p				-196654		-11892	-208546

13 B CONT

$$M_1 = y \cdot L + M_2$$

$$M_2 = M_1 - z \cdot L$$

SSE + DWT

$$M_1 = (-8403) \cdot 23.69 - 324776$$

$$M_1 = -523843$$

$$M_2 = -173870 - 1178 \cdot 23.69$$

$$M_2 = -145963$$

OBE + T + DWT

$$M_1 = (-5960) \cdot 23.69 - 208546$$

$$M_1 = -349738$$

$$M_2 = -86935 - 589 \cdot 23.69$$

$$M_2 = -100888$$

03/08

NUPIPE-IIM - NUCLEAR SERVICES CORPORATION PIPING ANALYSIS PROGRAM - VERSION 1.1
LOFT CIS ANALYSIS - HEV 13-C, 36"SUPPORT REACTIONS FOR LOAD CASE NO. 1
DEADWEIGHT

NODE	TYPE	REACTION (LBS OR IN-LBS)	DIRECTION
10	FORCE	0.	X COORD
10	FORCE	7088.	Y COORD
10	FORCE	-0.	Z COORD
10	MOMENT	23408.	X COORD
10	MOMENT	0.	Y COORD
10	MOMENT	477633.	Z COORD
100	FORCE	3.	Y COORD

A-26

LPR 1217 04

03/178

NUPIPE-11M - NUCLEAR SERVICES CORPORATION PIPING ANALYSIS PROGRAM - VERSION 1.
LOFT CIS ANALYSIS - H&V 13-C 36"SUPPORT REACTIONS FOR LOAD CASE NO. 2
THERMAL EXPANSION PLUS ANCHOR MOVEMENTS

NODE	TYPE	REACTION (LBS OR IN-LBS)	DIRECTION
10	FORCE	0.	X COORD
10	FORCE	0.	Y COORD
10	FORCE	0.	Z COORD
10	MOMENT	0.	X COORD
10	MOMENT	0.	Y COORD
10	MOMENT	0.	Z COORD
100	FORCE	0.	Y COORD

A-27

LFR 1217 04

03/07/78

NUPIPE-IIM - NUCLEAR SERVICES CORPORATION PIPING ANALYSIS PROGRAM - VERSION 1.
LOFT CIS ANALYSIS - H&V 13-C 36"SUPPORT REACTIONS FOR LOAD COMBINATION CASE NO. 4
OBE RESPONSE SPECTRUM - ONE-HALF SSE

NODE	TYPE	REACTIONS (LBS OR IN-LBS)	DIRECTION
10	FORCE	193.	X COORD
10	FORCE	619.	Y COORD
10	FORCE	583.	Z COORD
10	MOMENT	10339.	X COORD
10	MOMENT	60618.	Y COORD
10	MOMENT	58612.	Z COORD
100	FORCE	0.	Y COORD

A-28

APR 12 17 04

03/08/73

NUPIPE-IIM - NUCLEAR SERVICES CORPORATION PIPING ANALYSIS PROGRAM - VERSION 1.1
 LOFT CIS ANALYSIS - HEV 13-C 36"

SUPPORT REACTIONS FOR LOAD CASE NO. 3

SSE RESPONSE SPECTRUM - 1% DAMPING

COMBINED RESULT FOR MODE 1 THRU 3 BY RMS SUMMATION

SPECTRA SET = 1

NODE	TYPE	REACTIONS (LBS OR IN-LBS)	DIRECTION
10	FORCE	366.	X COORD
10	FORCE	1236.	Y COORD
10	FORCE	1167.	Z COORD
10	MOMENT	20677.	X COORD
10	MOMENT	121236.	Y COORD
10	MOMENT	117223.	Z COORD
100	FORCE	1.	Y COORD

A-29

END 1217 04

13 C

LTR 1217 04

LOADS FROM PIPING ANALYSIS

SSE + DWT
 x -386
 y -8326
 z -1167

OBE + T + DWT
 -193
 -619
 -583

xM -44085
 yM -121236
 zM -594856

-33747
 -60618
 -536245

SSE + DWT LOAD COMPONENTS IN NOZZLE AXIS SYSTEM

NOZZLE AXIS SYSTEM

	x	y	z	xM	yM	zM	TOTAL
x _p	-372		312				-60
y _p		-8326					-8326
z _p	-103		-1125				-1228
M _{xp}				-42482		158968	116486
M _{yp}					-121236		-121236
M _{zp}				-11781		-573221	-585002

OBE + T + DWT

	x	y	z	xM	yM	zM	TOTAL
x _p	-186		156				-30
y _p		-619					-619
z _p	-52		-562				-614
M _{xp}				-32520		143305	110785
M _{yp}					-60618		-60618
M _{zp}				-9018		-516742	-525760

A-30

13 C CONT

$$M_1 = y \cdot L + M_z$$

$$M_2 = M_y - z \cdot L$$

SSE + DWT

$$M_1 = (-8326) \cdot 23.69 - 585002$$

$$M_1 = -782245$$

$$M_2 = -121236 + 1228 \cdot 23.69$$

$$M_2 = -92145$$

OBE + T + DWT

$$M_1 = (-619) \cdot 23.69 - 525760$$

$$M_1 = -540424$$

$$M_2 = -60618 + 614 \cdot 23.69$$

$$M_2 = -46072$$

Table 5—Computation Sheet for Local Stresses in Cylindrical Shells

APR 12 17 04

13C

SSE + DWT

1. Applied Loads*

Radial load, $P = 386$ lb.
 Circ. Moment, $M_c = 9210$ in. lb.
 Long. Moments, $M_L = 78223$ in. lb.
 Torsion Moment, $M_T = 1648$ in. lb.
 Shear Load, $V_c = 1167$ lb.
 Shear Load, $V_L = 8326$ lb.

2. Geometry

Vessel thickness, $T = 2.625$ in.
 Attachment radius, $r_o = 18$ in.
 Vessel radius, $R_m = 920.5$ in.

3. Geometric Parameters

$\gamma = \frac{R_m}{T} = 160$
 $\beta = (0.875) \frac{r_o}{R_m} = .0428$

Stress Concentration due to:
 a) membrane load, $K_n = 1.268$
 b) bending load, $K_b = 1.140$

*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	$\frac{N\psi}{P/R_m} = 30$	$K_n \left(\frac{N\psi}{P/R_m} \right) \cdot \frac{P}{R_m T}$	-13	-13	-13	-13	13	13	13	13
1C	$\frac{M\psi}{P} = .15$	$K_b \left(\frac{M\psi}{P} \right) \cdot \frac{6P}{T^2}$	-64	+64	-64	+64	-64	+64	-64	+64
3A	$\frac{N\psi}{M_c/R_m^2\beta} = 3.7$	$K_n \left(\frac{N\psi}{M_c/R_m^2\beta} \right) \cdot \frac{M_c}{R_m^2\beta T}$					+9151	+9151	+9151	+9151
1A	$\frac{M\psi}{M_c/R_m\beta} = .1$	$K_b \left(\frac{M\psi}{M_c/R_m\beta} \right) \cdot \frac{6M_c}{R_m\beta T^2}$					+508	+508	+508	+508
3B	$\frac{N\psi}{M_L/R_m^2\beta} = 13.7$	$K_n \left(\frac{N\psi}{M_L/R_m^2\beta} \right) \cdot \frac{M_L}{R_m^2\beta T}$	+684	+684	-684	-684				
1B or 1B-1	$\frac{M\psi}{M_L/R_m\beta} = .054$	$K_b \left(\frac{M\psi}{M_L/R_m\beta} \right) \cdot \frac{6M_L}{R_m\beta T^2}$	+2330	+2330	-2330	-2330				
Add algebraically for summation of ϕ stresses, $\sigma_\phi =$			2937	-1595	3091	1697	9582	8694	-9736	-8592
4C	$\frac{N_x}{P/R_m} = 27$	$K_n \left(\frac{N_x}{P/R_m} \right) \cdot \frac{P}{R_m T}$	-12	-12	-12	-12	-12	-12	-12	-12
2C	$\frac{M_x}{P} = .11$	$K_b \left(\frac{M_x}{P} \right) \cdot \frac{6P}{T^2}$	-51	+51	-51	+51	-51	+51	-51	+51
4A	$\frac{N_x}{M_c/R_m^2\beta} = 5.2$	$K_n \left(\frac{N_x}{M_c/R_m^2\beta} \right) \cdot \frac{M_c}{R_m^2\beta T}$					+31	+31	+31	+31
2A	$\frac{M_x}{M_c/R_m\beta} = .06$	$K_b \left(\frac{M_x}{M_c/R_m\beta} \right) \cdot \frac{6M_c}{R_m\beta T^2}$					-339	-339	-339	+339
4B	$\frac{N_x}{M_L/R_m^2\beta} = 3.8$	$K_n \left(\frac{N_x}{M_L/R_m^2\beta} \right) \cdot \frac{M_L}{R_m^2\beta T}$	+190	+190	-190	-190				
2B or 2B-1	$\frac{M_x}{M_L/R_m\beta} = .081$	$K_b \left(\frac{M_x}{M_L/R_m\beta} \right) \cdot \frac{6M_L}{R_m\beta T^2}$	+3495	+3495	-3495	-3495				
Add algebraically for summation of X stresses, $\sigma_x =$			3622	-3266	-3748	3344	307	-269	-933	347
Shear stress due to Torsion, M_T			$\tau_{\phi x} = \tau_{x\phi} = \frac{M_T}{2\pi r_o^2 T}$	+21	+21	-21	-21	+21	+21	+21
Shear stress due to load, V_c			$\tau_{\phi x} = \tau_{x\phi} = \frac{V_c}{\pi r_o T}$	+8	+8	+8	+8			
Shear stress due to load, V_L			$\tau_{\phi x} = \tau_{x\phi} = \frac{V_L}{\pi r_o T}$					+56	+56	+56
Add Algebraically for summation of shear stresses, $\tau =$				-13	-13	29	29	77	77	-35
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) When $T = 0$			$S = \text{largest of } \sigma_\phi, \sigma_x \text{ or } \sigma_\phi - \sigma_x $							
3) When σ_ϕ & σ_x have unlike signs			$S = \sqrt{(\sigma_\phi - \sigma_x)^2 + 4\tau^2}$							
			3622	3266	3748	3344	9582	8694	9736	8592

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

4.2.2.5.2: When considering bending moment (M_L) : $\beta = K_L \sqrt{\beta_1 \beta_2}$ 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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