VERIFICATION OF CBI AXISYMMETRIC SHELL ANALYSIS COMPUTER PROGRAM 'E0781'

PROBLEM NO. 2
Non-axisymmetric Loading
('n ≥ 0' Fourier Harmonics)

August 16, 1996

VERIFICATION OF CBI AXISYMMETRIC SHELL ANALYSIS COMPUTER PROGRAM 'E0781'

PROBLEM NO. 2†: NON-AXISYMMETRIC PRESSURE APPLIED TO AP600 CONTAINMENT VESSEL, ($n \geq 0$ FOURIER HARMONICS)

ANALYTICAL METHOD AND MODEL

CBI Computer Program 'E0781', "General Shell of Revolution Stress Analysis" based on the method presented by A. Kalnins in the Journal of Applied Mechanics, Vol. 31, September 1964 is used for the analysis.

Model is shown in Figure 1. The stiffeners are modeled as branches. The crane girder is modeled as a closed section using branches and a closed loop.

The radial web plates of the crane girder are considered as the additional orthotropic layers along each of the four sides of the box shaped crane girder. Smeared orthotropic material properties are used with a meridional value for the modulus of elasticity, E equal to Young's modulus factored by the ratio of the radial web thickness divided by the radial web circumferential spacing. The shear modulus is then computed to be one-half the meridional modulus of elasticity and the circumferential modulus of elasticity is zero.

MATERIAL PROPERTIES

Properties are at 320°F.

Parts 1 through 3, 5 through 10, 12, 17, and 19 through 22:

$E = 28.18 \times 10^6$ psi; $\nu = 0.3$

Part 4:

$E_\varphi = 28.18 \times 10^9$ psi; $E_\theta = \nu = 0$; $G_{\varphi\theta} = 14.09 \times 10^9$ psi

Parts 11, 13, through 16, and 18:

Combination of layers with isotropic and orthotropic properties. The layers representing the radial web plates of the crane girder use the orthotropic properties calculated using the method described earlier.

BOUNDARY CONDITIONS (for each Fourier harmonic loading)

At start of Part 1 (Base):	Fixed
At end of Part 22 (Crown):	$Q = N_{\varphi\theta} = 0$, $N_\varphi = A_n \times R_{crown} / 2$, and $M_\varphi = N_\varphi \times t / 2$, where A_n is the n^{th} coefficient of the Fourier series that represents the given pressure distribution - see page 3.
At branch ends:	Free

†Problem No. 1 was for the verification of the program for an axisymmetric uniform pressure ($n = 0$ harmonic) and was submitted to Westinghouse via CBI Letter No. CBI/NSE0029 dated February 5, 1996.

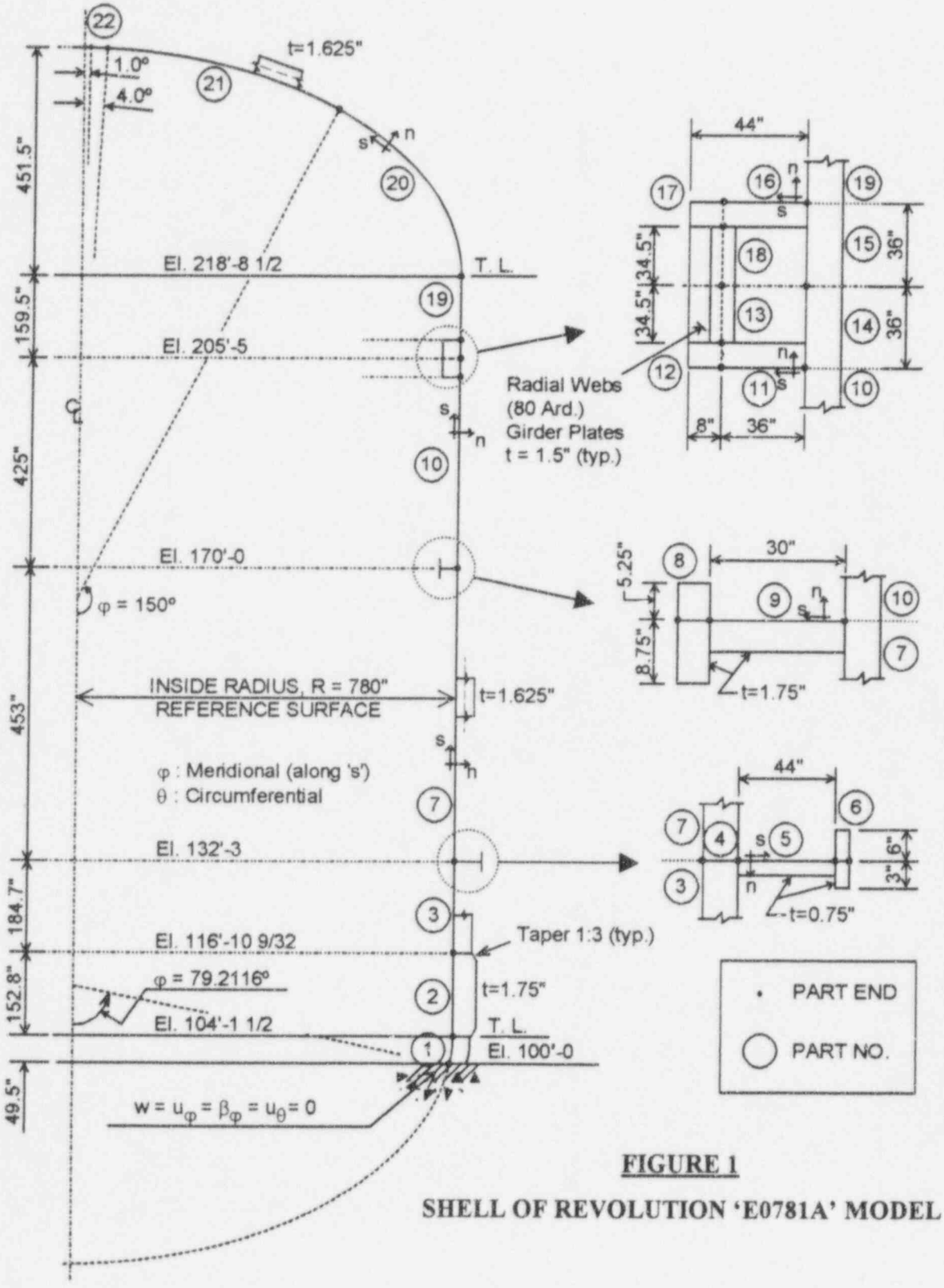


FIGURE 1

SHELL OF REVOLUTION 'E0781A' MODEL

LOADING

Non-axisymmetric normal pressure as shown in Figure 2 is applied on the shell parts above El. 132'-3" through the Fourier harmonics. The shell parts are: 1 through 3, 7, 10, 14, 15, and 19 through 22 (see Figure 1). This pressure is applied on the reference surface which is the inside surface of the containment vessel.

Applied normal pressure, $p_n = A_n$, where A_n is the coefficient of the n^{th} harmonic of the Fourier series representing the given pressure distribution. The distribution is symmetric about '0 - 180°' line. The Fourier series representation for such distribution is given by

$$q = \sum_{n=0,1,2,\ldots}^{\infty} A_n \cdot \cos(n\theta) \qquad (1)$$

Integrating both the sides of Eqn. (1) from 0 to 2π as follows:

$\int_0^{2\pi} q \cdot d\theta = \sum_{n=0,1,2,\ldots}^{\infty} \int_0^{2\pi} A_n \cdot \cos(n\theta) \cdot d\theta = A_0 \cdot \int_0^{2\pi} d\theta + \sum_{n=1,2,\ldots}^{\infty} \int_0^{2\pi} A_n \cdot \cos(n\theta) \cdot d\theta$, we get (noting that the second integral on the right hand side is zero)

$$A_0 \cdot 2\pi = \left[\int_0^{\pi/2} p \cdot d\theta + \int_{3\pi/2}^{2\pi} p \cdot d\theta \right] \Rightarrow A_0 = p/2 \qquad (2)$$

Multiplying both the sides of Eqn. (1) with $\cos(m\theta)$ and then integrating as follows:

$\int_0^{2\pi} q \cdot \cos(m\theta) \cdot d\theta = \sum_{n=0,1,2,\ldots}^{\infty} \int_0^{2\pi} A_n \cdot \cos(n\theta) \cdot \cos(m\theta) \cdot d\theta$, we get for $n > 0$ (noting that the integral on the right hand side is zero when $n \neq m$ and it is equal to $A_n \times \pi$ when $n = m$)

$$A_n \cdot \pi = \left[\int_0^{\pi/2} p \cdot \cos(n\theta) \cdot d\theta + \int_{3\pi/2}^{2\pi} p \cdot \cos(n\theta) \cdot d\theta \right] \Rightarrow A_n = \frac{2 \cdot p}{\pi \cdot n} \cdot \sin\left(\frac{n \cdot \pi}{2}\right) \qquad (3)$$

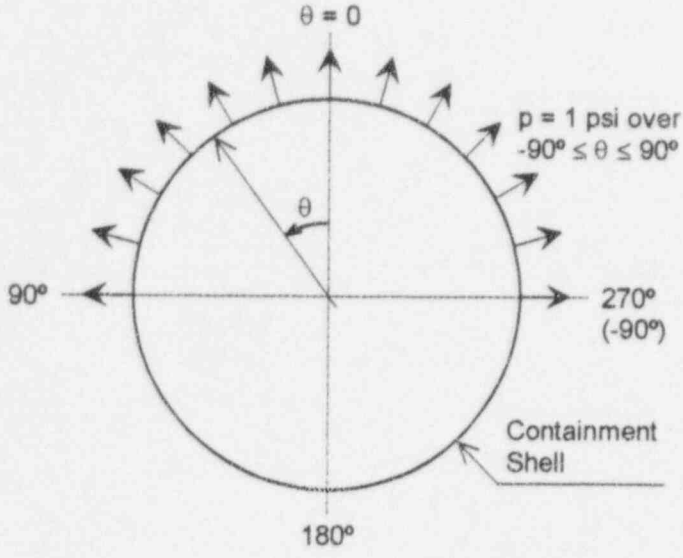
Note that for even 'n' number, $A_n = 0$.

The coefficients A_n in Eqn. (1) determined from Eqns. (2) and (3) using p = 1.0 psig are calculated in the Table 1 (page 6) using Excel 5.0. The given and Fourier distributions using Excel are shown in Figure 3. It can be seen from this figure that the sum of the first 19 terms in the Fourier series of Eqn. (1) adequately represents the given pressure. Therefore, only the first 19 harmonics (actually, 11 terms as $A_n = 0$ for even 'n' number) are used in the analysis.

For a given harmonic, 'n', apply normal pressure, $p_n = A_n$
(on shell parts 1 through 3, 7, 10, 14, 15, and 19 through 22 - see Figure 1).

RESULTS

The deflections are summarized in Table 2 and plotted in Figure 4.
The stresses are summarized in Table 3.



NOTE:

The pressure is applied above elevation 132'-3" and to the containment shell only. (See Figure 1.)

FIGURE 2: PRESSURE DISTRIBUTION

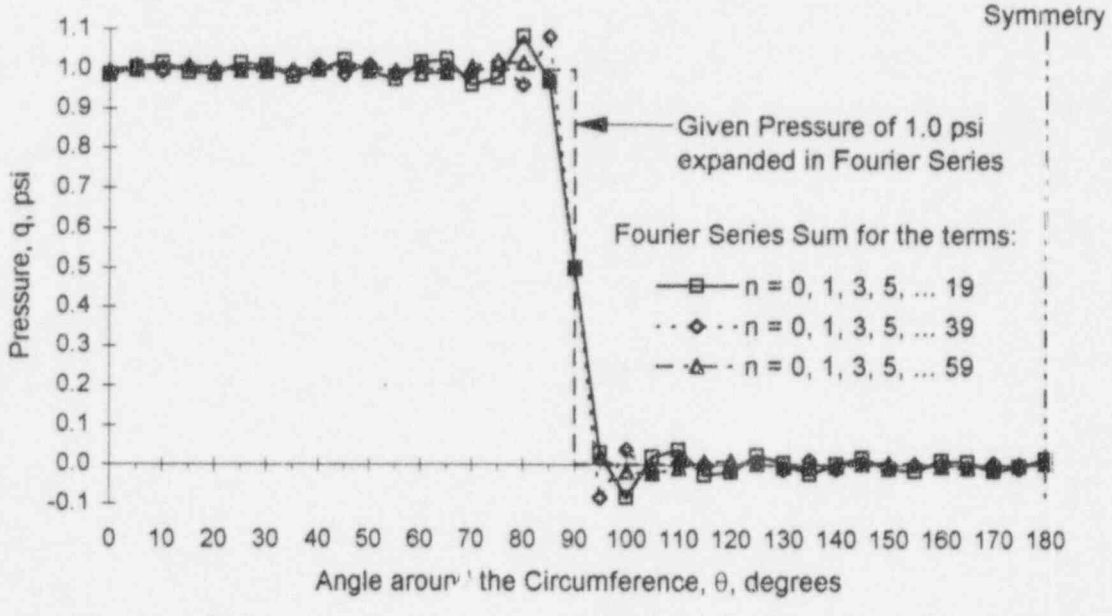


FIGURE 3

GIVEN PRESSURE DISTRIBUTION Vs FOURIER SERIES DISTRIBUTION

TABLE 1: FOURIER COEFFICIENTS†

As the coefficients for the harmonics "n = 2, 4, 6, ..." are zero, only the harmonics "n = 0, 1, 3, 5, ... 19" need to be used in the analysis.
Units: psi.

n	A_n	n	A_n	n	A_n
0	0.500	21	0.030	41	0.016
1	0.637	23	-0.028	43	-0.015
3	-0.212	25	0.025	45	0.014
5	0.127	27	-0.024	47	-0.014
7	-0.091	29	0.022	49	0.013
9	0.071	31	-0.021	51	-0.012
11	-0.058	33	0.019	53	0.012
13	0.049	35	-0.018	55	-0.012
15	-0.042	37	0.017	57	0.011
17	0.037	39	-0.016	59	-0.011
19	-0.034				

†In the Fourier series equation: $q = \sum_{n=0,1,3,5...}^{\infty} A_n \cdot \cos(n\theta)$ - see page 4 and Figure 3.

TABLE 2: DEFLECTIONS OF THE CONTAINMENT VESSEL

w: Normal (radial) displacement, '+' is in the direction of 'n' in Fig. 1;
u_φ: Meridional displacement, '+' is in the direction of 's' in Fig. 1;
u_θ: Circumferential (hoop) displacement, '+' is in the direction of 'θ' in Fig. 2.
Due to the symmetry of load at θ = 0 and 180°, u_θ = 0 at these locations.

Shl Prt	Coord.	Elev.	At θ = 0°		At θ = ±90°			At θ = 180°	
start/end (Fig. 1)	(Fig. 1) ° or in	(Fig. 1) ft	w in	u_φ in	w in	u_φ in	u_θ in	w in	u_φ in
1s[a]	79.2116°	100.000[a]	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
(s: start)	81.4	100.844	0.00303	0.00024	-0.00095	-0.00007	-0.00088	-0.00492	-0.00039
	83.5	101.649	0.00858	-0.00008	-0.00268	0.00003	-0.00177	-0.01394	0.00014
	85.7	102.489	0.01320	-0.00082	-0.00410	0.00026	-0.00268	-0.02140	0.00134
	87.8	103.289	0.01531	-0.00176	-0.00472	0.00056	-0.00360	-0.02474	0.00288
1e, 2s[b]	90.0	104.125[b]	0.01479	-0.00269	-0.00449	0.00085	-0.00453	-0.02378	0.00439
(e: end)	1280.1"	106.675	0.00800	-0.00319	-0.00214	0.00101	-0.00721	-0.01228	0.00521
	1310.6	109.217	0.00466	-0.00343	-0.00091	0.00109	-0.00991	-0.00647	0.00562
	1341.2	111.767	0.00478	-0.00373	-0.00079	0.00119	-0.01269	-0.00637	0.00612
	1371.7	114.308	0.00573	-0.00408	-0.00094	0.00131	-0.01555	-0.00761	0.00670
2e, 3s	1402.3	116.858	0.00633	-0.00444	-0.00095	0.00144	-0.01847	-0.00824	0.00733
	1433.1	119.425	0.00687	-0.00479	-0.00093	0.00157	-0.02164	-0.00872	0.00792
	1463.9	121.992	0.00757	-0.00515	-0.00098	0.00170	-0.02489	-0.00954	0.00854
	1494.7	124.558	0.00806	-0.00551	-0.00109	0.00183	-0.02821	-0.01024	0.00916
	1525.4	127.117	0.00824	-0.00585	-0.00123	0.00196	-0.03159	-0.01070	0.00977
	1556.2	129.683	0.00896	-0.00612	-0.00081	0.00213	-0.03505	-0.01058	0.01038
3e, 7s[c]	1587.0	132.250[c]	0.01352	-0.00630	0.00165	0.00231	-0.03892	-0.01023	0.01092
	1617.2	134.767	0.02081	-0.00677	0.00482	0.00235	-0.04330	-0.01116	0.01146
	1647.4	137.283	0.02348	-0.00734	0.00584	0.00235	-0.04788	-0.01180	0.01204
	1677.6	139.800	0.02366	-0.00782	0.00580	0.00239	-0.05213	-0.01206	0.01260
	1707.8	142.317	0.02368	-0.00827	0.00567	0.00244	-0.05597	-0.01234	0.01315
	1738.0	144.833	0.02406	-0.00870	0.00564	0.00249	-0.05940	-0.01278	0.01369
	1768.2	147.350	0.02468	-0.00913	0.00564	0.00255	-0.06239	-0.01338	0.01423
	1798.4	149.867	0.02541	-0.00956	0.00565	0.00260	-0.06495	-0.01411	0.01475
	1828.6	152.383	0.02626	-0.00998	0.00565	0.00265	-0.06705	-0.01497	0.01527
	1858.8	154.900	0.02723	-0.01038	0.00564	0.00270	-0.06871	-0.01594	0.01578
	1889.0	157.417	0.02835	-0.01078	0.00565	0.00275	-0.06994	-0.01705	0.01629
	1919.2	159.933	0.02972	-0.01117	0.00569	0.00281	-0.07076	-0.01833	0.01678
	1949.4	162.450	0.03130	-0.01155	0.00576	0.00285	-0.07120	-0.01978	0.01726

[a]BASE [b]Bottom T. L. [c]Stiffener Continued on page 7...

TABLE 2 (Continued)

Shl Prt start/end (Fig. 1)	Coord. (Fig. 1) ° or in	Elev. (Fig. 1) ft	At θ = 0°		At θ = 90°			At θ = 180°	
			w in	u_φ in	w in	u_φ in	u_θ in	w in	u_φ in
	1979.6[a]	164.967	0.03222	-0.01197	0.00555	0.00289	-0.07128	-0.02111	0.01775
	2009.8	167.483	0.03046	-0.01240	0.00438	0.00292	-0.07111	-0.02170	0.01823
7e, 10s[c]	2040.0	170.000[c]	0.02794	-0.01254	0.00299	0.00305	-0.07118	-0.02196	0.01863
	2072.4	172.700	0.03348	-0.01274	0.00463	0.00316	-0.07365	-0.02422	0.01906
	2104.8	175.400	0.03718	-0.01317	0.00566	0.00319	-0.07630	-0.02587	0.01955
	2137.2	178.100	0.03833	-0.01355	0.00575	0.00323	-0.07864	-0.02683	0.02002
	2169.7	180.808	0.03919	-0.01389	0.00567	0.00329	-0.08057	-0.02785	0.02046
	2202.1	183.508	0.04039	-0.01421	0.00564	0.00334	-0.08205	-0.02910	0.02090
	2234.5	186.208	0.04187	-0.01453	0.00564	0.00340	-0.08305	-0.03059	0.02132
	2266.9	188.908	0.04358	-0.01483	0.00564	0.00345	-0.08358	-0.03229	0.02173
	2299.3	191.608	0.04559	-0.01511	0.00568	0.00351	-0.08361	-0.03423	0.02213
	2331.8	194.317	0.04799	-0.01539	0.00577	0.00356	-0.08317	-0.03645	0.02251
	2364.2	197.017	0.05011	-0.01569	0.00563	0.00360	-0.08227	-0.03885	0.02289
	2396.6	199.717	0.04941	-0.01603	0.00436	0.00363	-0.08101	-0.04070	0.02328
10e, 14s[d]	2429.0	202.417[d]	0.04625	-0.01609	0.00255	0.00377	-0.07981	-0.04116	0.02362
	2447.0	203.917	0.04654	-0.01614	0.00261	0.00381	-0.07977	-0.04133	0.02376
14e, 15s[e]	2465.0	205.417[e]	0.04683	-0.01618	0.00263	0.00386	-0.07976	-0.04157	0.02390
	2483.0	206.917	0.04709	-0.01621	0.00262	0.00391	-0.07977	-0.04186	0.02402
15e, 19s[f]	2501.0	208.417[f]	0.04734	-0.01624	0.00257	0.00395	-0.07977	-0.04220	0.02414
	2525.7	210.475	0.05404	-0.01597	0.00394	0.00408	-0.08026	-0.04616	0.02414
	2550.4	212.533	0.06214	-0.01614	0.00552	0.00411	-0.08066	-0.05109	0.02436
	2575.1	214.592	0.06663	-0.01636	0.00591	0.00410	-0.08085	-0.05482	0.02455
	2599.8	216.650	0.06831	-0.01653	0.00448	0.00407	-0.08079	-0.05935	0.02466
19e,20s[g]	2624.5	218.708[g]	0.06789	-0.01664	0.00074	0.00408	-0.08050	-0.06641	0.02479
	95.0°	220.611	0.06535	-0.02243	-0.00236	0.00432	-0.08030	-0.07007	0.03107
	100.0	222.529	0.06336	-0.02798	-0.00339	0.00478	-0.08029	-0.07014	0.03753
	105.0	224.475	0.06184	-0.03336	-0.00294	0.00522	-0.08043	-0.06772	0.04381
	110.0	226.465	0.06038	-0.03861	-0.00193	0.00558	-0.08069	-0.06424	0.04978
	115.0	228.513	0.05876	-0.04372	-0.00081	0.00585	-0.08106	-0.06038	0.05541
	120.0	230.634	0.05697	-0.04866	0.00034	0.00602	-0.08152	-0.05629	0.06070
	125.0	232.841	0.05508	-0.05341	0.00159	0.00611	-0.08211	-0.05191	0.06563
	130.0	235.147	0.05318	-0.05798	0.00297	0.00610	-0.08281	-0.04724	0.07017
	135.0	237.557	0.05132	-0.06235	0.00450	0.00598	-0.08366	-0.04233	0.07430

[c]Stiffener [d, e, f]Crane Girder Bottom, C. L., and Top [g]Top T. L. Continued on page 8...

TABLE 2 (Continued)

Shl Prt start/end (Fig. 1)	Coord. (Fig. 1) deg	Elev. (Fig. 1) ft	At θ = 0°		At θ = 90°			At θ = 180°	
			w in	u_φ in	w in	u_φ in	u_θ in	w in	u_φ in
	140.0°	240.073	0.04958	-0.06654	0.00617	0.00574	-0.08467	-0.03725	0.07802
	145.0	242.681	0.04799	-0.07054	0.00795	0.00539	-0.08586	-0.03209	0.08132
20e, 21s	150.0	245.348	0.04657	-0.07437	0.00983	0.00492	-0.08723	-0.02691	0.08421
	152.0	246.418	0.04606	-0.07586	0.01061	0.00470	-0.08783	-0.02484	0.08525
	154.0	247.481	0.04557	-0.07732	0.01139	0.00446	-0.08845	-0.02280	0.08623
	156.0	248.532	0.04510	-0.07875	0.01216	0.00420	-0.08910	-0.02078	0.08715
	158.0	249.561	0.04465	-0.08017	0.01293	0.00392	-0.08975	-0.01880	0.08801
	160.0	250.560	0.04421	-0.08156	0.01368	0.00362	-0.09042	-0.01685	0.08881
	162.0	251.518	0.04375	-0.08293	0.01441	0.00331	-0.09108	-0.01494	0.08955
	164.0	252.423	0.04328	-0.08427	0.01510	0.00299	-0.09173	-0.01308	0.09025
	166.0	253.264	0.04275	-0.08560	0.01575	0.00265	-0.09234	-0.01125	0.09089
	168.0	254.027	0.04214	-0.08690	0.01635	0.00229	-0.09290	-0.00944	0.09149
	170.0	254.700	0.04139	-0.08819	0.01688	0.00193	-0.09340	-0.00764	0.09204
	172.0	255.271	0.04051	-0.08944	0.01733	0.00155	-0.09381	-0.00586	0.09255
	174.0	255.728	0.03965	-0.09066	0.01769	0.00117	-0.09411	-0.00427	0.09301
21e, 22s	176.0	256.062	0.03872	-0.09189	0.01796	0.00079	-0.09430	-0.00281	0.09346
	176.2	256.088	0.03864	-0.09200	0.01798	0.00075	-0.09428	-0.00269	0.09349
	176.4	256.113	0.03845	-0.09213	0.01800	0.00071	-0.09429	-0.00246	0.09354
	176.6	256.137	0.03822	-0.09225	0.01801	0.00067	-0.09429	-0.00219	0.09359
	176.8	256.159	0.03794	-0.09237	0.01803	0.00063	-0.09429	-0.00187	0.09363
	177.0	256.180	0.03759	-0.09250	0.01805	0.00059	-0.09429	-0.00149	0.09368
	177.2	256.200	0.03718	-0.09262	0.01807	0.00055	-0.09429	-0.00105	0.09372
	177.4	256.218	0.03669	-0.09274	0.01808	0.00051	-0.09428	-0.00052	0.09377
	177.6	256.235	0.03610	-0.09286	0.01810	0.00047	-0.09428	0.00009	0.09381
	177.8	256.251	0.03542	-0.09298	0.01811	0.00043	-0.09427	0.00080	0.09385
	178.0	256.265	0.03463	-0.09310	0.01812	0.00039	-0.09425	0.00161	0.09388
	178.2	256.278	0.03373	-0.09321	0.01813	0.00035	-0.09424	0.00254	0.09392
	178.4	256.290	0.03271	-0.09331	0.01815	0.00032	-0.09423	0.00358	0.09394
	178.6	256.300	0.03159	-0.09340	0.01816	0.00028	-0.09421	0.00473	0.09395
	178.8	256.309	0.03037	-0.09348	0.01817	0.00024	-0.09420	0.00597	0.09395
22e[h]	179.0	256.316[h]	0.02910	-0.09354	0.01818	0.00020	-0.09417	0.00726	0.09394

[h]Pole (just 1° off)

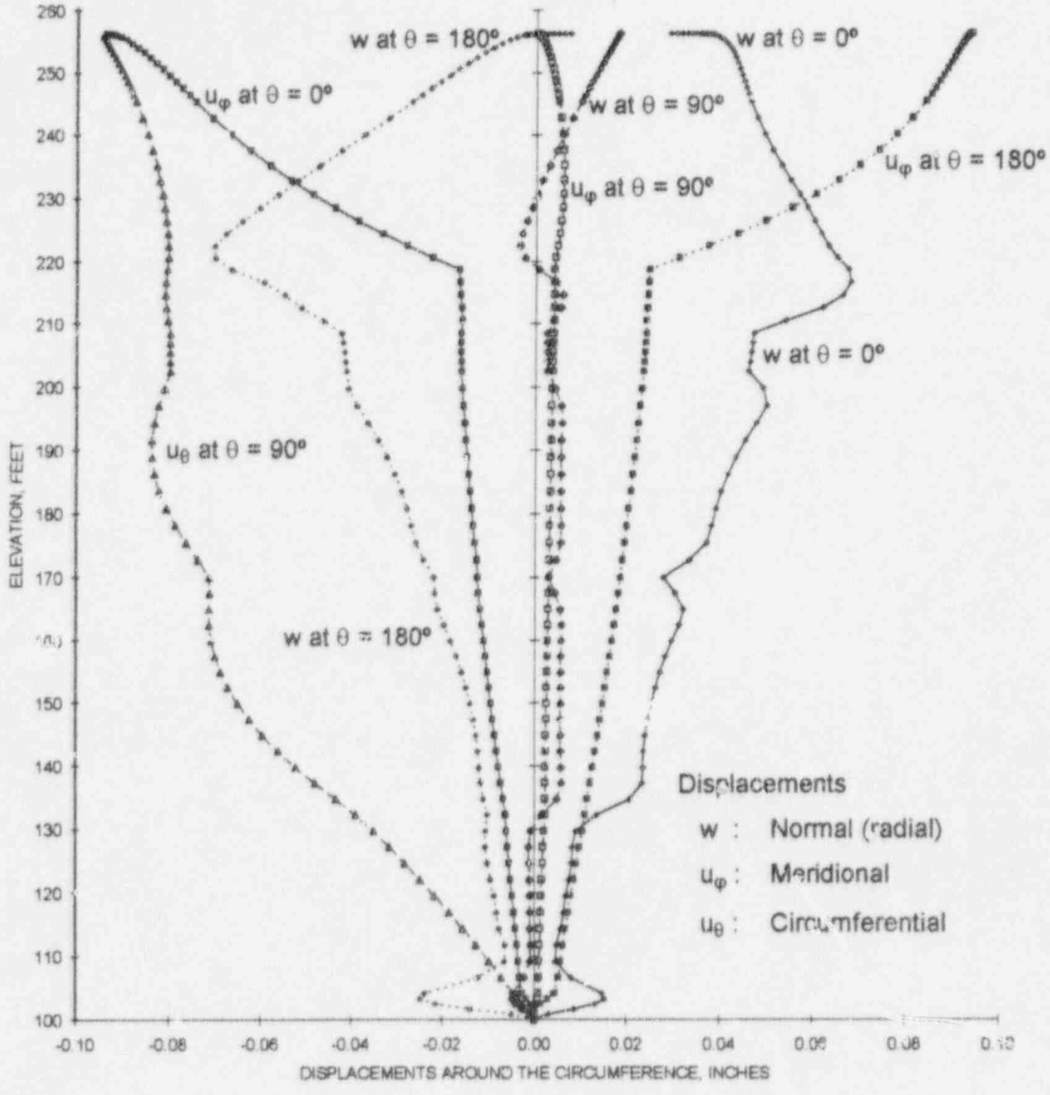


FIGURE 4: DISPLACEMENTS OF THE CONTAINMENT VESSEL

TABLE 3: SURFACE STRESSES IN THE CONTAINMENT VESSEL

σ_φ: Meridional stresses;

σ_θ: Circumferential (hoop) stresses;

$\tau_{\varphi\theta}$: Shear (tangential) stresses.

Due to the symmetry of load at $\theta = 0$ and 180°, $\tau_{\varphi\theta} = 0$ at these locations.

Shl Prt start/end (Fig. 1)	Coord. (Fig. 1) ° or in	Elev. (Fig. 1) ft	Face	At $\theta = 0°$		At $\theta = \pm 90°$			At $\theta = 180°$	
				σ_φ psi	σ_θ psi	σ_φ psi	σ_θ psi	$\tau_{\varphi\theta}$ psi	σ_φ psi	σ_θ psi
1s[a]	79.2116°	100.000[a]	Inside	1616	485	-507	-152	-910	-2629	-789
(s: start)			Outside	-2383	715	747	224	-912	3877	1163
	81.4	100.844	Inside	210	166	-63	-53	-976	-335	-273
			Outside	-973	-193	304	58	-852	1580	309
	83.5	101.649	Inside	-640	104	206	-34	-976	1052	-172
			Outside	-[illegible]	257	35	-85	-837	189	-426
	85.7	102.489	Inside	-1038	143	333	-47	-936	1703	-238
			Outside	284	539	-92	-174	-841	-468	-887
	87.8	103.289	Inside	-1068	204	343	-67	-879	1754	-337
			Outside	321	621	-103	-200	-848	-526	-1022
1e, 2s[b]	90.0	104.125[b]	Inside	-772	270	248	-88	-828	1269	-446
(e: end)			Outside	30	512	-8	-165	-848	-47	-842
	1280.1"	106.675	Inside	-190	180	63	-58	-709	317	-97
			Outside	-486	92	160	-29	-742	806	-151
	1310.6	109.217	Inside	-231	28	79	-9	-717	388	-46
			Outside	-433	-32	144	10	-711	722	52
	1341.2	111.767	Inside	-307	-11	105	3	-728	518	17
			Outside	-345	-20	118	7	-702	580	33
	1371.7	114.308	Inside	-330	-4	115	1	-730	561	5
			Outside	-309	5	108	-2	-699	524	-9
[illegible], 3s	1402.3	116.858	Inside	-305	4	109	-2	-781	522	-8
			Outside	-370	-12	131	5	-753	632	22
	1433.1	119.425	Inside	-328	-7	119	2	-788	566	11
			Outside	-332	-4	121	3	-744	575	9
	1463.9	121.992	Inside	-330	-6	119	0	-792	567	6
			Outside	-316	4	121	1	-733	558	-2
	1494.7	124.558	Inside	-328	-10	118	-4	-787	561	2
			Outside	-304	2	122	-3	-722	549	-7

[a]BASE [b]Bottom T. L.

Continued on page 11...

TABLE 3 (Continued)

Shl Prt start/end (Fig. 1)	Coord. (Fig. 1) in	Elev. (Fig. 1) ft	Face	At θ = 0°		At θ = ±90°			At θ = 180°	
				σ_φ psi	σ_θ psi	σ_φ psi	σ_θ psi	$\tau_{\varphi\theta}$ psi	σ_φ psi	σ_θ psi
	1525.4[a]	127.117	Inside	-300	-19	132	-5	-766	564	9
			Outside	-314	-18	108	-12	-733	530	-6
	1556.2	129.683	Inside	-199	17	178	24	-778	555	31
			Outside	-398	-40	62	-11	-822	523	19
3e, 7s[c]	1587.0	132.250[a]	Inside	-102	195	165	109	-1097	431	22
			Outside	-480	81	76	82	-898	631	83
	1617.2	134.767	Inside	-441	360	49	189	-1323	539	18
			Outside	-132	433	191	232	-787	515	30
	1647.4	137.283	Inside	-342	494	93	239	-1218	527	-16
			Outside	-225	487	147	255	-847	520	23
	1677.6	139.800	Inside	-269	524	120	245	-1061	508	-33
			Outside	-289	459	120	246	-808	530	32
	1707.8	142.317	Inside	-251	524	123	242	-931	496	-40
			Outside	-295	439	117	240	-739	530	41
	1738.0	144.833	Inside	-247	525	121	240	-814	489	-45
			Outside	-286	433	119	239	-676	524	46
	1768.2	147.350	Inside	-241	528	120	240	-699	431	-48
			Outside	-277	431	120	240	-619	517	49
	1798.4	149.867	Inside	-234	529	120	240	-585	474	-49
			Outside	-269	431	120	240	-566	510	50
	1828.6	152.383	Inside	-227	529	120	240	-471	467	-49
			Outside	-262	431	120	240	-512	502	49
	1858.8	154.900	Inside	-219	526	120	240	-357	459	-47
			Outside	-254	432	120	240	-457	494	48
	1889.0	157.417	Inside	-209	524	121	240	-243	451	-43
			Outside	-248	435	119	240	-396	486	44
	1919.2	159.933	Inside	-201	522	121	242	-127	444	-38
			Outside	-238	444	119	241	-328	476	38
	1949.4	162.450	Inside	-215	515	114	242	-1	443	-30
			Outside	-205	464	126	246	-254	457	28
	1979.6	164.967	Inside	-271	464	92	228	138	454	-7
			Outside	-126	471	148	245	-201	422	19

[c]Stiffener

Continued on page 12...

TABLE 3 (Continued)

Shl Prt start/end (Fig. 1)	Coord. (Fig. 1) in	Elev. (Fig. 1) ft	Face	At θ = 0°		At θ = ±90°			At θ = 180°	
				σ_φ psi	σ_θ psi	σ_φ psi	σ_θ psi	$\tau_{\varphi\theta}$ psi	σ_φ psi	σ_θ psi
	2009.8"	167.483	Inside	-250	334	97	187	215	445	40
			Outside	-121	360	143	201	-212	406	42
7e, 10s[c]	2040.0	170.000[c]	Inside	327	358	309	201	-96	290	43
			Outside	-678	61	-68	88	-122	541	114
	2072.4	172.700	Inside	-253	355	90	194	-882	432	33
			Outside	-83	390	151	212	-542	384	35
	2104.8	175.400	Inside	-218	482	97	234	-777	413	-15
			Outside	-108	474	143	247	-543	394	20
	2137.2	178.100	Inside	-150	519	117	243	-628	385	-34
			Outside	-164	457	123	244	-476	409	32
	2169.7	180.808	Inside	-127	523	122	241	-493	370	-40
			Outside	-170	439	119	240	-395	407	41
	2202.1	183.508	Inside	-119	524	121	240	-366	360	-44
			Outside	-159	433	120	240	-320	398	46
	2234.5	186.208	Inside	-110	525	120	240	-239	350	-46
			Outside	-147	432	120	240	-252	387	48
	2266.9	188.908	Inside	-97	525	121	240	-111	338	-45
			Outside	-138	432	119	240	-185	377	47
	2299.3	191.608	Inside	-83	526	122	242	19	326	-43
			Outside	-129	437	118	241	-115	366	44
	2331.8	194.317	Inside	-84	525	116	243	156	317	-38
			Outside	-102	455	124	246	-41	350	36
	2364.2	197.017	Inside	-139	486	92	231	306	322	-24
			Outside	-19	474	148	240	18	316	22
	2396.6	199.717	Inside	-165	345	87	184	406	340	22
			Outside	39	380	153	203	23	266	26
10e[d]	2429.0	202.417[d]	Inside	410	300	331	191	156	251	83
			Outside	-507	15	-91	65	149	326	114
14s[d]	2429.0	202.417[d]	Inside	-41	164	110	125	-91	260	86
			Outside	-51	152	113	126	-99	277	100
	2447.0	203.917	Inside	-31	134	111	128	-111	254	121
			Outside	-33	125	117	129	-117	267	134

[c]Stiffener [d]Bottom of the Crane Girder

Continued on page 13...

TABLE 3 (Continued)

Shl Prt start/end (Fig. 1)	Coord. (Fig. 1) ° or in	Elev. (Fig. 1) ft	Face	At θ = 0°		At θ = ±90°			At θ = 180°	
				σ_φ psi	σ_θ psi	σ_φ psi	σ_θ psi	$\tau_{\varphi\theta}$ psi	σ_φ psi	σ_θ psi
14e, 15s[e]	2465.0"	205.417[e]	Inside	-25	104	112	129	-114	249	153
			Outside	-24	95	118	131	-119	260	166
	2483.0	206.917	Inside	-22	71	111	123	-106	245	185
			Outside	-22	62	117	130	-110	256	198
15e[f]	2501.0	208.417[f]	Inside	-23	36	110	126	-91	242	215
			Outside	-30	24	113	127	-92	256	229
19s[f]	2501.0	208.417[f]	Inside	919	319	338	194	-306	-244	70
			Outside	-945	-250	-98	63	-308	750	377
	2525.7	210.475	Inside	-4	206	114	177	-324	232	147
			Outside	7	195	126	180	-224	245	166
	2550.4	212.533	Inside	-143	378	69	220	-239	281	62
			Outside	178	452	171	251	-182	165	50
	2575.1	214.592	Inside	-75	474	47	228	-119	169	-19
			Outside	143	515	193	271	-136	243	28
	2599.8	216.650	Inside	-34	451	14	166	1	62	-119
			Outside	138	481	226	230	-98	314	-22
19e, 20s[g]	2624.5	218.708[g]	Inside	54	358	124	64	75	194	-230
			Outside	88	356	116	62	-74	144	-233
	95.0°	220.611	Inside	145	264	230	-29	54	315	-323
			Outside	30	224	10	-96	-40	-10	-417
	100.0	222.529	Inside	146	190	187	-95	2	229	-380
			Outside	60	162	55	-135	-31	49	-432
	105.0	224.475	Inside	135	151	142	-111	-39	149	-372
			Outside	98	138	103	-122	-44	109	-382
	110.0	226.465	Inside	136	135	125	-100	-65	115	-335
			Outside	123	130	125	-100	-65	126	-329
	115.0	228.513	Inside	146	132	126	-82	-83	107	-296
			Outside	138	128	129	-81	-83	121	-289
	120.0	230.634	Inside	157	137	132	-64	-99	107	-264
			Outside	150	133	131	-64	-98	112	-260
	125.0	232.841	Inside	169	148	137	-45	-114	105	-238
			Outside	164	145	135	-45	-110	106	-234

[e]Crane Girder C. L. [f]Top of the Crane Girder [g]Top T. L. Continued on page 14...

TABLE 3 (Continued)

Shl Prt start/end (Fig. 1)	Coord. (Fig. 1) deg	Elev. (Fig. 1) ft	Face	At θ = 0°		At θ = ±90°			At θ = 180°	
				σ_φ psi	σ_θ psi	σ_φ psi	σ_θ psi	$\tau_{\varphi\theta}$ psi	σ_φ psi	σ_θ psi
	130.0°	235.147	Inside	181	168	141	-24	-128	102	-215
			Outside	178	165	140	-23	-121	103	-211
	135.0	237.557	Inside	194	196	147	0	-141	100	-195
			Outside	192	193	147	2	-130	102	-189
	140.0	240.073	Inside	207	231	153	27	-151	99	-177
			Outside	207	228	154	29	-137	102	-171
	145.0	242.681	Inside	221	273	160	55	-159	100	-163
			Outside	221	268	162	57	-140	103	-154
20e, 21s	150.0	245.348	Inside	235	321	168	84	-162	102	-153
			Outside	236	314	171	86	-137	106	-141
	152.0	246.418	Inside	241	341	172	96	-162	103	-149
			Outside	241	333	174	98	-134	107	-136
	154.0	247.481	Inside	246	362	175	108	-160	104	-147
			Outside	247	352	178	110	-130	109	-132
	156.0	248.532	Inside	252	384	179	120	-157	105	-144
			Outside	252	372	181	122	-125	110	-128
	158.0	249.561	Inside	257	405	182	131	-152	107	-143
			Outside	257	392	185	134	-118	113	-125
	160.0	250.560	Inside	262	426	186	142	-145	109	-142
			Outside	261	413	188	145	-110	115	-124
	162.0	251.518	Inside	267	447	189	153	-136	111	-141
			Outside	265	434	191	155	-101	118	-123
	164.0	252.423	Inside	270	467	192	163	-124	114	-141
			Outside	268	455	195	166	-91	121	-124
	166.0	253.264	Inside	271	485	195	172	-111	119	-141
			Outside	272	475	198	175	-80	123	-126
	168.0	254.027	Inside	271	502	198	181	-95	124	-141
			Outside	274	496	200	183	-68	127	-129
	170.0	254.700	Inside	271	518	200	188	-77	129	-142
			Outside	274	514	203	191	-54	131	-132
	172.0	255.271	Inside	272	534	202	194	-56	132	-145
			Outside	271	529	205	197	-39	139	-135

Continued on page 15...

TABLE 3 (Continued)

Shl Prt start/end (Fig. 1)	Coord. (Fig. 1) deg	Elev. (Fig. 1) ft	Face	At θ = 0°		At θ = ±90°			At θ = 180°	
				σ_φ psi	σ_θ psi	σ_φ psi	σ_θ psi	$\tau_{\varphi\theta}$ psi	σ_φ psi	σ_θ psi
	174.0°	255.728	Inside	270	557	204	199	-36	138	-158
			Outside	270	543	207	202	-16	143	-139
21e, 22s	176.0	256.062	Inside	246	571	205	203	1	164	-166
			Outside	301	567	208	206	-7	114	-155
	176.2	256.088	Inside	240	570	205	203	5	170	-164
			Outside	310	568	208	206	-6	105	-156
	176.4	256.113	Inside	233	569	205	203	8	177	-162
			Outside	321	568	208	206	-4	95	-156
	176.6	256.137	Inside	226	565	205	204	12	184	-158
			Outside	333	568	208	207	-3	83	-155
	176.8	256.159	Inside	219	561	205	204	15	192	-153
			Outside	346	566	208	207	-1	70	-153
	177.0	256.180	Inside	212	555	206	204	18	199	-147
			Outside	360	564	208	207	0	56	-150
	177.2	256.200	Inside	205	547	206	204	22	206	-138
			Outside	376	559	208	207	2	40	-145
	177.4	256.218	Inside	200	537	206	205	24	212	-128
			Outside	393	553	208	207	4	24	-139
	177.6	256.235	Inside	197	525	206	205	27	215	-115
			Outside	410	545	208	208	7	6	-130
	177.8	256.251	Inside	197	510	206	205	28	215	-101
			Outside	427	534	208	208	10	-11	-119
	178.0	256.265	Inside	202	493	206	205	27	210	-83
			Outside	445	521	208	208	14	-28	-105
	178.2	256.278	Inside	215	474	206	205	23	198	-63
			Outside	461	506	208	208	18	-45	-90
	178.4	256.290	Inside	238	452	207	205	13	175	-41
			Outside	474	491	208	209	23	-58	-74
	178.6	256.300	Inside	276	430	207	205	-11	137	-19
			Outside	481	480	208	209	27	-66	-82
	178.8	256.309	Inside	335	414	207	205	-67	79	-3
			Outside	472	487	208	209	23	-57	-68
22e[h]	179.0	256.316[h]	Inside	408	424	207	205	-95	7	-14
			Outside	408	552	207	210	95	7	-132

[h]Pole (just 1° off)