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RESULTS OF PIPE BEND ANALYSIS

PART VII: STRESS DISTRIBUTIONS IN FLANGED PIPE ELBOWS FROM AN OUT-OF-PLANE FORCE

by

J.F. WHATHAM

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ABSTRACT

Graphs of outside surface stress distributions are presented and numerical values of stresses on inside and outside surfaces tabulated for a wide range of flange-ended pipe elbows subjected to an out-of-plane force applied to one flange; calculations are based on linear thin shell theory.

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ANALYTICAL SOLUTION; DEFORMATION; EXPERIMENTAL DATA; FLANGES; PIPES; STRESS ANALYSIS; STRESSES; TORQUE; TORSION

CONTENTS

1. INTRODUCTION

The objective of this report is to present the surface stress distributions for a range of flanged elbows subjected to an out-of-plane force, to assist pipework design engineers and to provide analytic solutions for checking numerical solution methods. Wall thicknesses vary from one to ten per cent of the pipe radius with bend radii two, three and five times the pipe radius.

Stresses were calculated by the thin shell theory of Novozhilov [1970] and details of the analysis have been published [Whatham 1982, 1983]. The assumptions were that:

(i) the pipe wall is thin ($t/r < 0.3$),

(ii) normal stresses through the wall are negligible,

(iii) normals through the wall remain normal to it and unchanged in length, and

(iv) the flanges are infinitely stiff.

2. STRESS DERIVATION

The flanged pipe elbow configuration is shown in Figure 1, and a segment of a curved pipe middle surface, an imaginary surface mid-way between the inner and outer surfaces, is shown in Figure 2 with one end flanged. An element of the middle surface in Figure 3 is supposed to have forces T_θ, T_η, $T_{\theta\eta}$, $T_{\eta\theta}$, N_θ, N_η and moments M_θ, M_η, $M_{\eta\theta}$, $M_{\theta\eta}$ per unit length acting on its edges and the solution was obtained by thin shell theory in terms of these forces and moments; the stresses presented in this report were then derived as follows:

$$\begin{aligned} \text{Hoop stress: } \sigma_{\theta\theta} &= T_\theta/t + 12zM_\theta/t^3 \quad , \\ \text{Axial stress: } \sigma_{\eta\eta} &= T_\eta/t + 12zM_\eta/t^3 \quad , \\ \text{Shear stress: } \sigma_{\eta\theta} &= S/t + z(12H/t^3 - S/rt) \quad , \end{aligned} \tag{1}$$

where $S = T_{\theta\eta} - M_{\eta\theta}/r_\eta = T_{\eta\theta} - M_{\theta\eta}/r$, and $H = M_{\theta\eta} = M_{\eta\theta}$.

These stresses were close to those derived from beam theory when considering a straight pipe subjected to bending or torsion; if a moment M is applied to a straight pipe, Novozhilov's theory [see Whatham 1981] gives

$$\begin{aligned} T_\eta &= \frac{12M\cos\theta}{(12+\gamma)\pi r^2} \quad , \\ M_\eta &= \frac{\gamma M\cos\theta}{(12+\gamma)\pi r} \quad , \\ T_\theta &= M_\theta = S = H = 0 \quad , \end{aligned} \tag{2}$$

where $\gamma = (t/r)^2$.

Substituting in Equations (1), the axial stress distribution approximates that from beam theory, which is

$$\sigma_{\eta\eta} = \frac{M(r+z)\cos\theta}{\pi r^3 t(1+\gamma/4)} \quad . \tag{3}$$

If torque T is applied to a straight pipe, Novozhilov's theory gives

$$\begin{aligned} S &= \frac{3T}{2(3+\gamma)\pi r^2} \\ H &= \frac{\gamma T}{4(3+\gamma)\pi r} \\ T_\eta &= M_\eta = T_\theta = M_\theta = 0 \quad . \end{aligned} \tag{4}$$

Substituting in Equations (1), the shear stress distribution approximates that from beam theory, which is

$$\sigma_{\eta\theta} = \frac{T(r+z)}{2\pi r^3 t(1+\gamma/4)} \quad . \tag{5}$$

Equations (1) assume that the strains are linearly distributed through the pipe wall; this is not true for curved shells and the stresses $\sigma'_{\theta\theta}$, $\sigma'_{\eta\eta}$, $\sigma'_{\eta\theta}$ derived by the following equations are theoretically more accurate, even though the results do not agree with beam theory in the case of straight pipes:

$$\sigma'_{\theta\theta} = \sigma_{\theta\theta} - z(A+\nu B)/(1-\nu^2) \quad ,$$

$$\sigma'_{\eta\eta} = \sigma_{\eta\eta} - z(B+\nu A)/(1-\nu^2) \quad , \tag{6}$$

$$\sigma'_{\eta\theta} = \sigma_{\eta\theta} - \frac{z}{2r}\left[(r/(r+z)+r/(r_\eta+z))\sigma_{\eta\theta} - (r_\eta-r)\bar{\sigma}_{\eta\theta}/(r_\eta+z)\right] \quad ,$$

where

$$r_\eta = r + R/\cos\theta \quad ,$$

$$A = (\sigma_{\theta\theta} - \nu\sigma_{\eta\eta})/(r+z) \quad ,$$

$$B = (\sigma_{\eta\eta} - \nu\sigma_{\theta\theta})/(r_\eta+z) \quad , \quad \text{and}$$

$$\bar{\sigma}_{\eta\theta} = \tfrac{1}{2}\sigma_{\eta\theta}(\text{inside}) + \tfrac{1}{2}\sigma_{\eta\theta}(\text{outside}).$$

3. ELBOW CONFIGURATION AND RESULTS

Stresses were calculated for one side of the bend in Figure 1 (θ = 0 to 180°), those for negative θ having the same magnitude but with the hoop and axial stress signs changed. Hoop and axial stresses on the outside surface are plotted in Appendix A, together with the stresses at ϕ = 90° on theoretically unterminated or unflanged pipe bends. The latter stresses vary as $\sin\phi$ and their maxima and minima are given by the floating numbers; note that the shear stresses on unflanged pipe bends with this loading have two components, one varying as $\cos\phi$ and the other independent of ϕ.

The two graphs for each pipe bend are accompanied by tabulated stresses from which the graphs were constructed. In addition, since shear stresses and inside surface stresses are also given and a linear variation through the wall is assumed, the complete stress state in each pipe bend is provided.

A computer program package BENDPAC, written in FORTRAN IV and ASSEMBLER for an IBM3031 computer and designed to calculate the stresses in and the flexibility of flanged pipe elbows under in-plane or out-of-plane loading, is available from the Australian Atomic Energy Commission, the Risley Nuclear Power Development Establishment, Cheshire, UK, or the National Energy Software Center, Argonne National Laboratory, USA.

4. ACKNOWLEDGEMENT

The author acknowledges the advice and encouragement of Professor J.J. Thompson of the School of Nuclear Engineering, University of New South Wales.

5. REFERENCES

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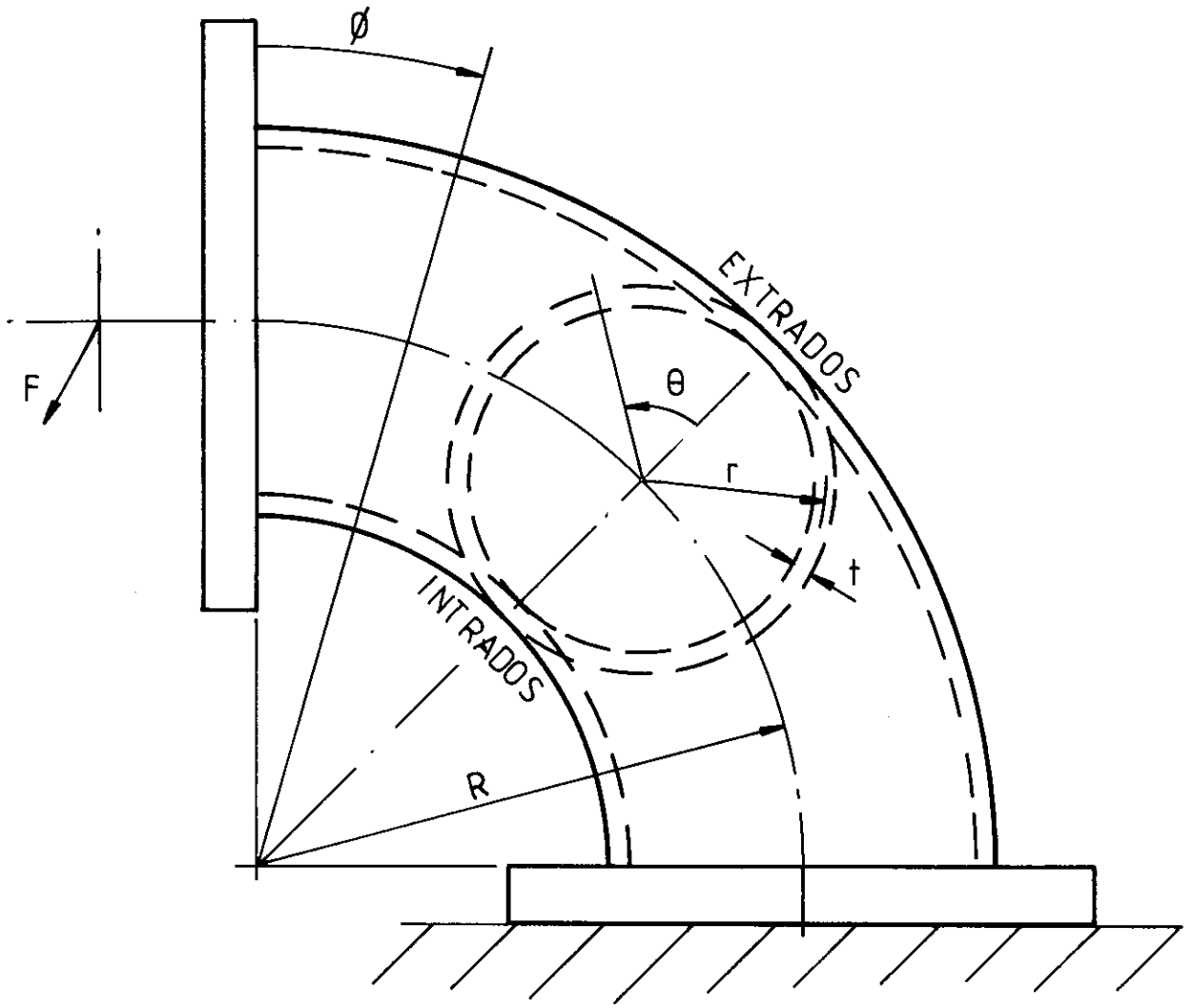


FIGURE 1. PIPE BEND CONFIGURATION

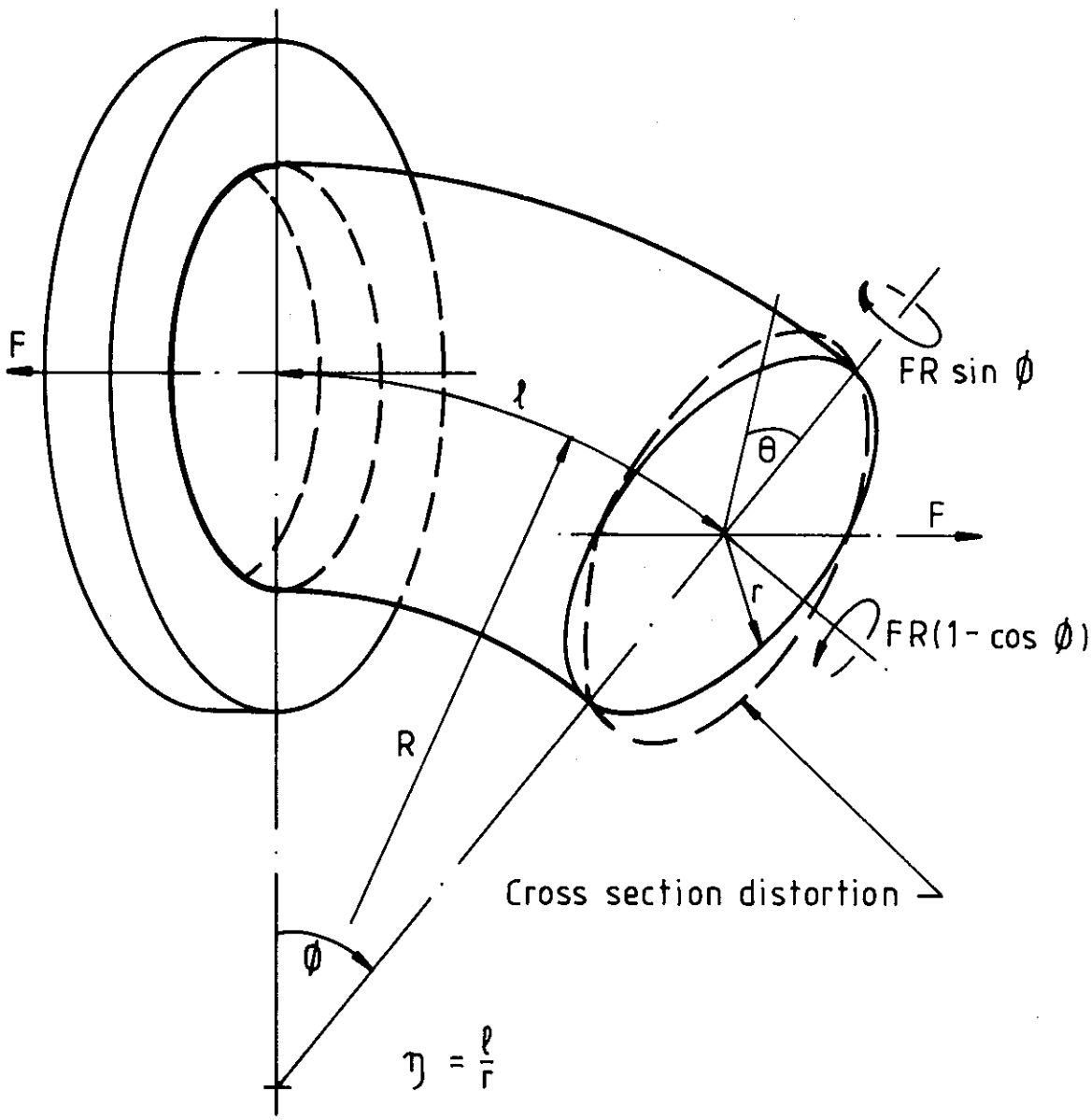


FIGURE 2. PIPE MIDDLE SURFACE

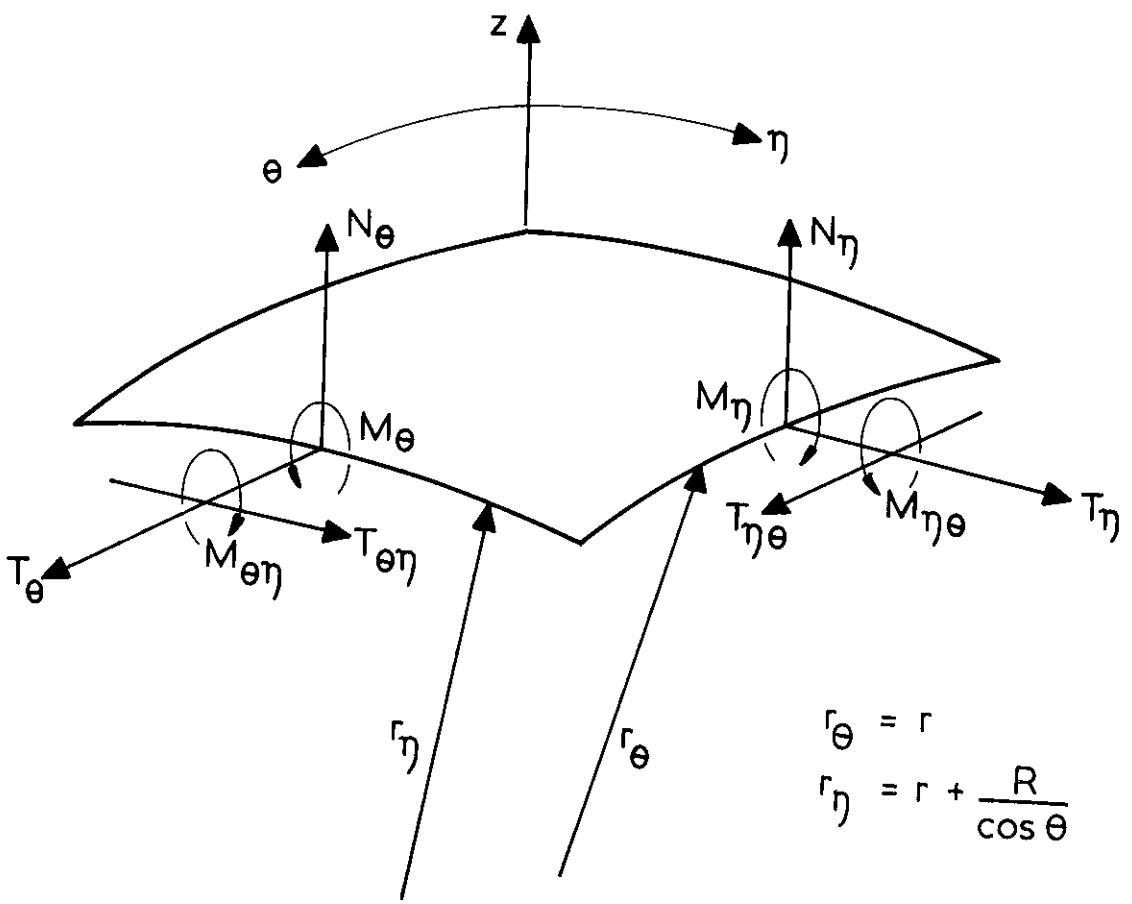


FIGURE 3. ELEMENT OF PIPE MIDDLE SURFACE

APPENDIX A
STRESSES IN FLANGED PIPE ELBOWS FROM AN OUT-OF-PLANE FORCE

Parameters of pipe elbows considered:

$R/r = 2, 3, 5$

$t/r = 0.01, 0.02, 0.05, 0.1$

$\nu = 0.3$

Stress factor (S) = stress . $\pi r^2 t/FR$

For unflanged pipe bends:

$\left.\begin{matrix} x \sin \\ x \cos \end{matrix}\right\}$ = multiply stress factors by $\left\{\begin{matrix} \sin \phi \\ \cos \phi \end{matrix}\right.$

+ const. = add constant stress factor

UF = unflanged pipe bend.

Diameter expansion factor = diameter expansion . $\pi rEt/FR$

E = Young's modulus

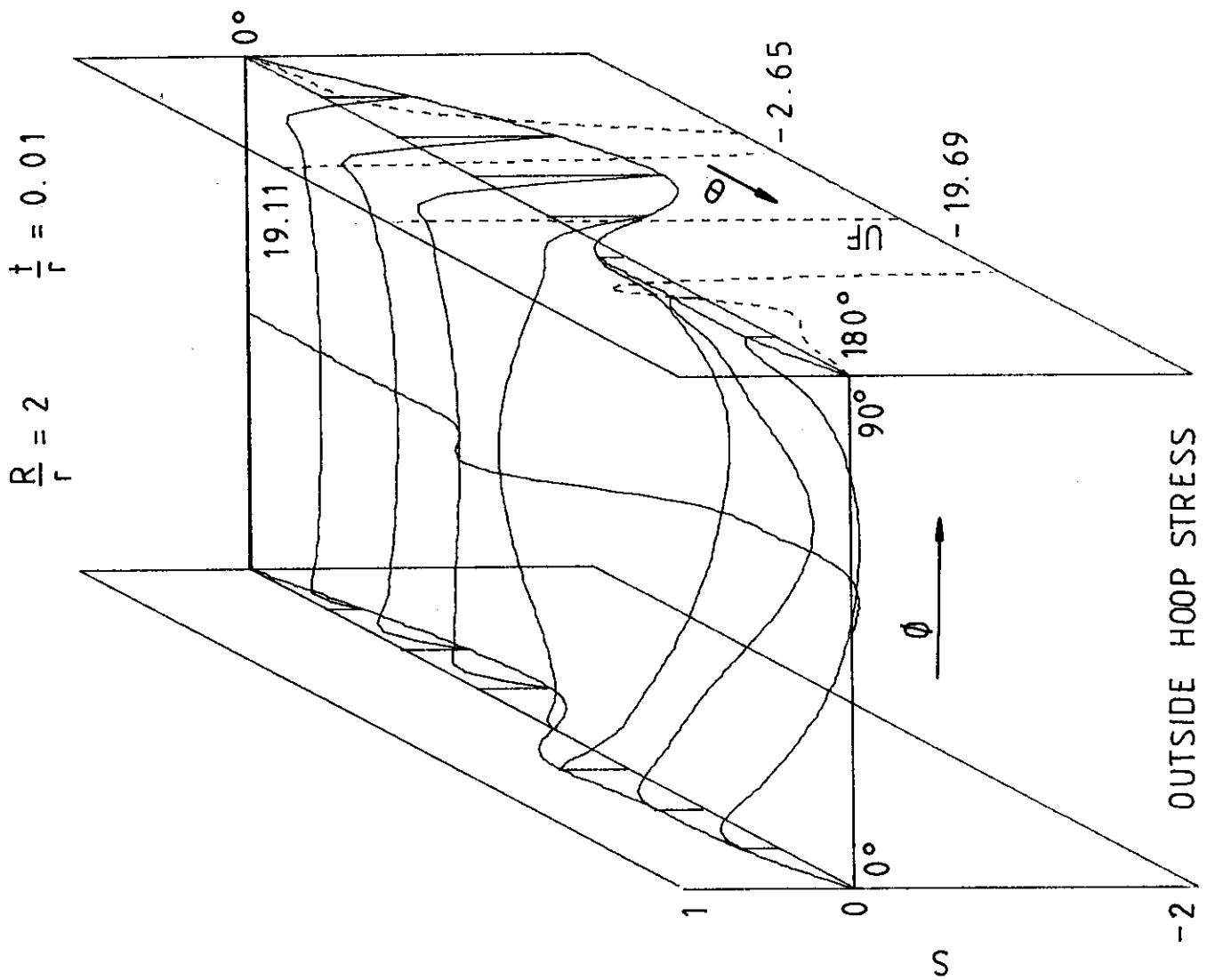

R/r = 2
t/r = 0.01
19.11
0°
-2.65
-19.69
UF
θ
180°
90°
0°
φ
1
0
-2
S
OUTSIDE HOOP STRESS

FIGURE A1

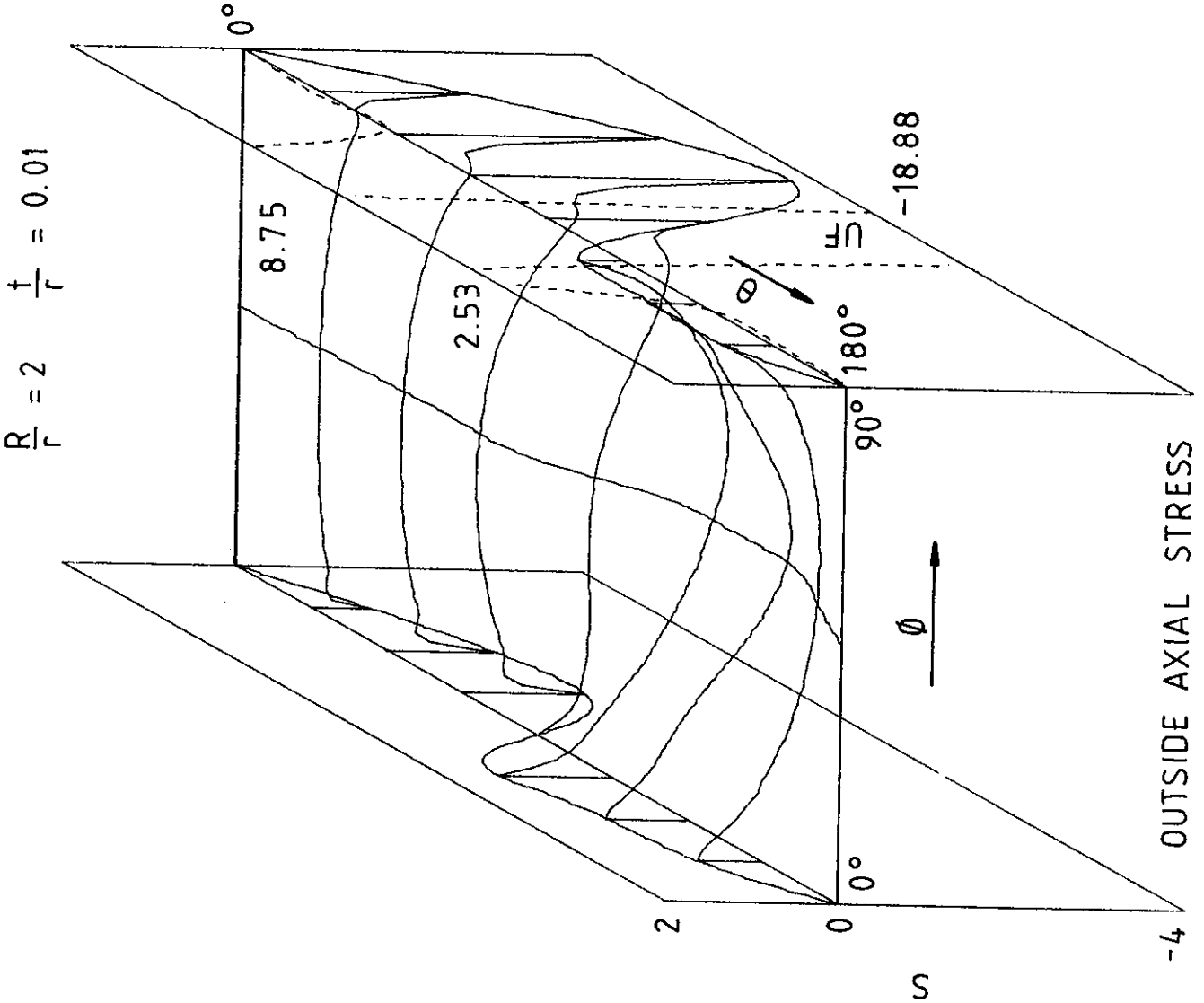


FIGURE A2

TABLE A1

R/r = 2.0 t/r = 0.01

OUTSIDE HOOP STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	-0.2119	0.0590	0.0382	0.0264	0.0202	0.0182	0.0200	0.0261	0.0375	0.0569	0.0884	0.1410	-0.5076	-0.1093
45.0	-0.3809	0.0966	0.0562	0.0321	0.0183	0.0132	0.0162	0.0278	0.0502	0.0871	0.1445	0.2384	-0.9203	-1.8290
67.5	-0.4331	0.1339	0.1240	0.1131	0.0997	0.0908	0.0918	0.1061	0.1343	0.1739	0.2188	0.2849	-1.1112	5.8631
90.0	-0.0036	-0.0218	0.0355	0.1174	0.1982	0.2608	0.2952	0.2946	0.2554	0.1798	0.0822	0.0169	-0.5833	8.9887
112.5	0.3956	0.0275	-0.1410	-0.2972	-0.4178	-0.5042	-0.5667	-0.6064	-0.6083	-0.5474	-0.4097	-0.2092	0.1475	-15.3619
135.0	0.2812	0.2910	0.1133	-0.0855	-0.3144	-0.5179	-0.6393	-0.6471	-0.5490	-0.3877	-0.2215	-0.0516	0.1696	0.2894
157.5	0.2207	0.2428	-0.0190	-0.2101	-0.3429	-0.4249	-0.4699	-0.4882	-0.4765	-0.4199	-0.3049	-0.0824	0.1729	-0.1728
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OUTSIDE AXIAL STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	-0.7064	-0.1793	-0.1142	-0.0795	-0.0621	-0.0571	-0.0630	-0.0808	-0.1143	-0.1711	-0.2652	-0.4298	-1.6919	0.1231
45.0	-1.2696	-0.3581	-0.2444	-0.1805	-0.1483	-0.1408	-0.1557	-0.1954	-0.2668	-0.3833	-0.5670	-0.8655	-3.0677	0.0894
67.5	-1.4437	-0.4785	-0.3246	-0.2185	-0.1589	-0.1418	-0.1660	-0.2350	-0.3588	-0.5534	-0.8382	-1.2276	-3.7041	8.0408
90.0	-0.0121	-0.4887	-0.5801	-0.5940	-0.5812	-0.5860	-0.6370	-0.7493	-0.9222	-1.1350	-1.3396	-1.4391	-1.9444	-12.1821
112.5	1.3185	0.2829	-0.0964	-0.4511	-0.7331	-0.9541	-1.1249	-1.2417	-1.2806	-1.2014	-0.9624	-0.5796	0.4917	-3.9445
135.0	0.9374	0.4830	0.1752	-0.1875	-0.5781	-0.9116	-1.1144	-1.1452	-1.0067	-0.7458	-0.4419	-0.1699	0.5653	0.5014
157.5	0.7356	0.3051	-0.0342	-0.2616	-0.4282	-0.5328	-0.5899	-0.6109	-0.5931	-0.5200	-0.3838	-0.1552	0.5765	-0.0751
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OUTSIDE SHEAR STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x cos + const.	
0.0	0.0220	-0.0174	-0.0639	-0.0941	-0.1158	-0.1338	-0.1518	-0.1734	-0.2031	-0.2472	-0.3155	-0.4255	-0.5197	-0.5023	0.1463
22.5	-0.0474	-0.0615	-0.0918	-0.1124	-0.1277	-0.1407	-0.1538	-0.1696	-0.1910	-0.2220	-0.2685	-0.3405	-0.3740	-0.5417	0.1539
45.0	-0.2540	-0.2036	-0.1857	-0.1749	-0.1679	-0.1626	-0.1576	-0.1517	-0.1433	-0.1299	-0.1064	-0.0656	0.0581	-0.7116	0.1795
67.5	-0.5789	-0.4825	-0.3910	-0.3202	-0.2621	-0.2095	-0.1556	-0.0924	-0.0108	0.1003	0.2555	0.4732	0.7464	-1.5310	0.2315
90.0	-0.6981	-0.6605	-0.5771	-0.4844	-0.3779	-0.2536	-0.1084	0.0601	0.2546	0.4778	0.7341	1.0306	1.2782	0.4599	0.3280
112.5	-0.2914	-0.4157	-0.4511	-0.3973	-0.2822	-0.1216	0.0737	0.2945	0.5303	0.7663	0.9781	1.1212	1.1164	1.0720	0.5004
135.0	0.2085	0.1735	0.1141	0.1002	0.1488	0.2547	0.4005	0.5612	0.7083	0.8151	0.8652	0.8620	0.8590	-0.5773	0.7806
157.5	0.9435	0.9727	1.0008	0.9963	0.9630	0.9060	0.8318	0.7461	0.6571	0.5770	0.5180	0.4908	0.4823	-1.1926	1.1233
180.0	1.4138	1.4409	1.5016	1.4918	1.4053	1.2501	1.0456	0.8224	0.6126	0.4407	0.3220	0.2729	0.2268	-1.5034	1.2990

DIAMETER EXPANSION FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
45.0	0.0	1.334	2.754	4.332	5.908	7.182	7.859	7.774	6.958	5.616	4.025	2.360	0.0	374.297

TABLE A2

R/r = 2.0 t/r = 0.01

INSIDE HOOP STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	0.0400	0.0565	0.0349	0.0246	0.0198	0.0186	0.0206	0.0259	0.0359	0.0528	0.0814	0.1358	0.0908	0.0255
45.0	0.0607	0.0995	0.0718	0.0613	0.0573	0.0577	0.0624	0.0718	0.0877	0.1130	0.1537	0.2355	0.1351	1.6232
67.5	0.0414	0.0368	-0.0102	-0.0259	-0.0264	-0.0196	-0.0109	-0.0025	0.0078	0.0265	0.0647	0.1590	0.0868	-7.1961
90.0	-0.0923	0.0321	-0.0449	-0.1417	-0.2340	-0.3043	-0.3433	-0.3442	-0.3019	-0.2166	-0.1029	0.0155	-0.1688	-10.5240
112.5	0.0033	0.1244	0.1246	0.1550	0.1654	0.1601	0.1520	0.1466	0.1343	0.0973	0.0271	-0.0188	-0.2011	17.4862
135.0	0.1162	0.2151	0.0064	-0.1662	-0.2857	-0.3617	-0.4170	-0.4623	-0.4814	-0.4405	-0.3165	-0.0938	-0.1015	0.7329
157.5	0.0432	0.2327	0.0870	-0.0958	-0.2892	-0.4601	-0.5630	-0.5713	-0.4922	-0.3610	-0.2120	-0.0351	-0.1260	0.7945
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INSIDE AXIAL STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	0.1334	-0.1768	-0.1173	-0.0822	-0.0646	-0.0596	-0.0657	-0.0840	-0.1183	-0.1762	-0.2719	-0.4239	0.3027	0.0837
45.0	0.2024	-0.3532	-0.2444	-0.1774	-0.1434	-0.1351	-0.1502	-0.1911	-0.2649	-0.3850	-0.5742	-0.8571	0.4504	0.8400
67.5	0.1379	-0.5006	-0.3704	-0.2763	-0.2199	-0.2028	-0.2277	-0.2998	-0.4281	-0.6240	-0.9004	-1.2696	0.2892	3.4320
90.0	-0.3077	-0.3567	-0.5122	-0.5948	-0.6527	-0.7127	-0.7931	-0.9022	-1.0358	-1.1758	-1.2879	-1.3294	-0.5628	-12.8991
112.5	0.0110	0.3262	-0.0045	-0.2536	-0.4656	-0.6422	-0.7796	-0.8706	-0.9055	-0.8703	-0.7442	-0.4691	-0.6702	8.4890
135.0	0.3872	0.3608	0.0702	-0.2403	-0.5036	-0.7053	-0.8381	-0.8952	-0.8641	-0.7329	-0.4989	-0.1811	-0.3384	1.5605
157.5	0.1439	0.1834	0.0863	-0.1138	-0.3162	-0.4884	-0.5927	-0.6063	-0.5335	-0.4016	-0.2335	-0.0859	-0.4201	0.8044
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INSIDE SHEAR STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x cos + const.	
0.0	0.0218	-0.0073	-0.0555	-0.0878	-0.1114	-0.1314	-0.1517	-0.1758	-0.2084	-0.2558	-0.3283	-0.4421	-0.5146	-0.0743	0.1424
22.5	-0.0469	-0.0509	-0.0825	-0.1052	-0.1227	-0.1380	-0.1538	-0.1725	-0.1971	-0.2319	-0.2829	-0.3581	-0.3703	-0.0821	0.1499
45.0	-0.2514	-0.1883	-0.1713	-0.1634	-0.1600	-0.1587	-0.1579	-0.1567	-0.1535	-0.1457	-0.1279	-0.0895	0.0575	-0.0537	0.1750
67.5	-0.5731	-0.4549	-0.3532	-0.2835	-0.2335	-0.1930	-0.1537	-0.1068	-0.0422	0.0542	0.2021	0.4266	0.7390	-0.5177	0.2261
90.0	-0.6912	-0.7929	-0.6759	-0.5456	-0.4112	-0.2740	-0.1259	0.0462	0.2571	0.5177	0.8293	1.1795	1.2655	-2.8612	0.3215
112.5	-0.2885	-0.4172	-0.5291	-0.5316	-0.4257	-0.2267	0.0404	0.3436	0.6452	0.9033	1.0776	1.1432	1.1052	-0.0824	0.4928
135.0	0.2064	0.1522	0.1194	0.1349	0.1922	0.2923	0.4221	0.5576	0.6746	0.7605	0.8194	0.8533	0.8504	-0.0503	0.7736
157.5	0.9341	1.0044	1.0505	1.0704	1.0469	0.9695	0.8483	0.7117	0.5926	0.5110	0.4675	0.4488	0.4775	-0.1743	1.1201
180.0	1.3997	1.5712	1.6112	1.5418	1.4058	1.2335	1.0441	0.8436	0.6348	0.4308	0.2573	0.1547	0.2245	-0.2245	1.2990

DIAMETER EXPANSION FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
135.0	0.0	-1.334	-2.754	-4.332	-5.908	-7.182	-7.859	-7.774	-6.958	-5.616	-4.025	-2.360	0.0	-374.297

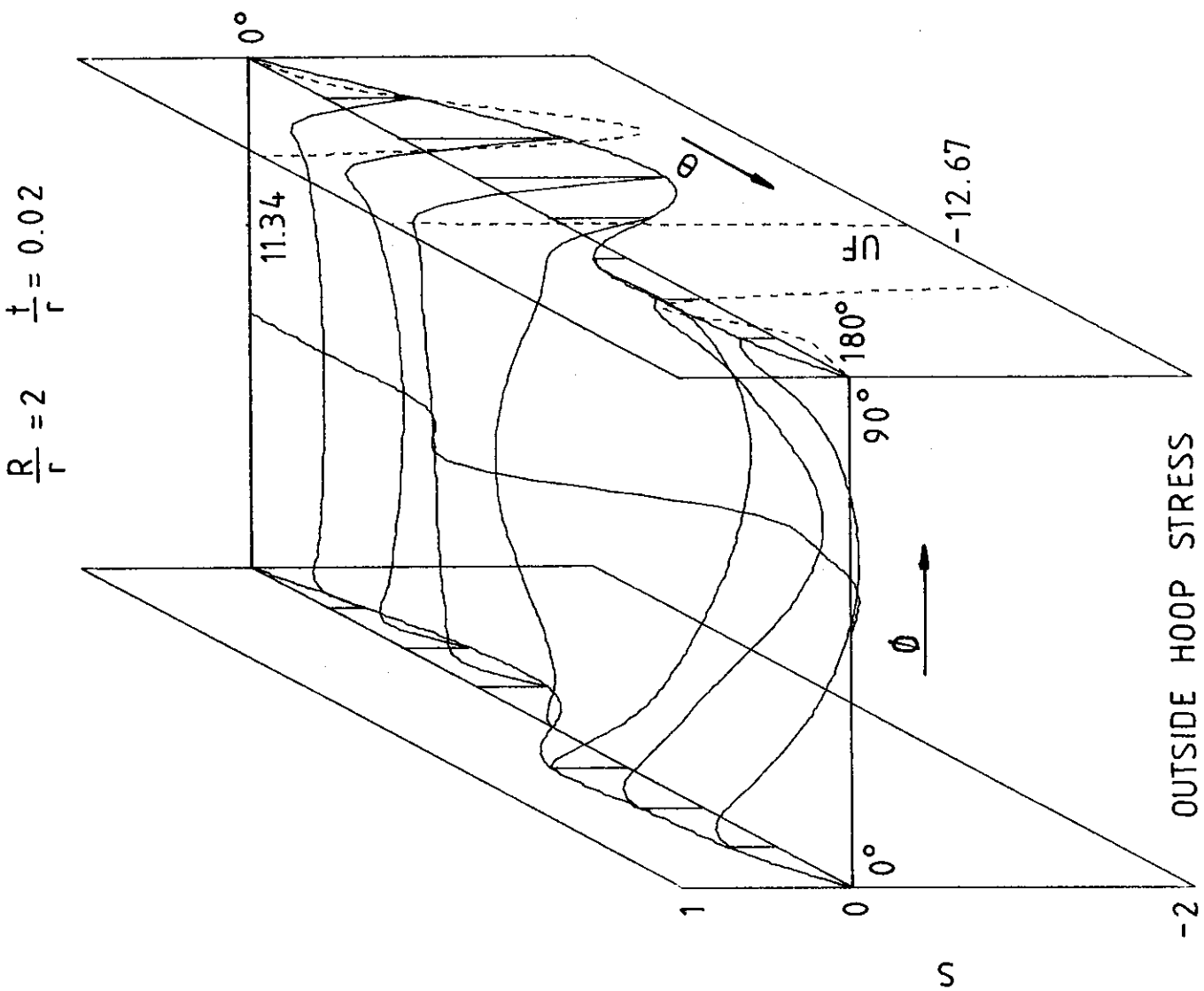


FIGURE A3

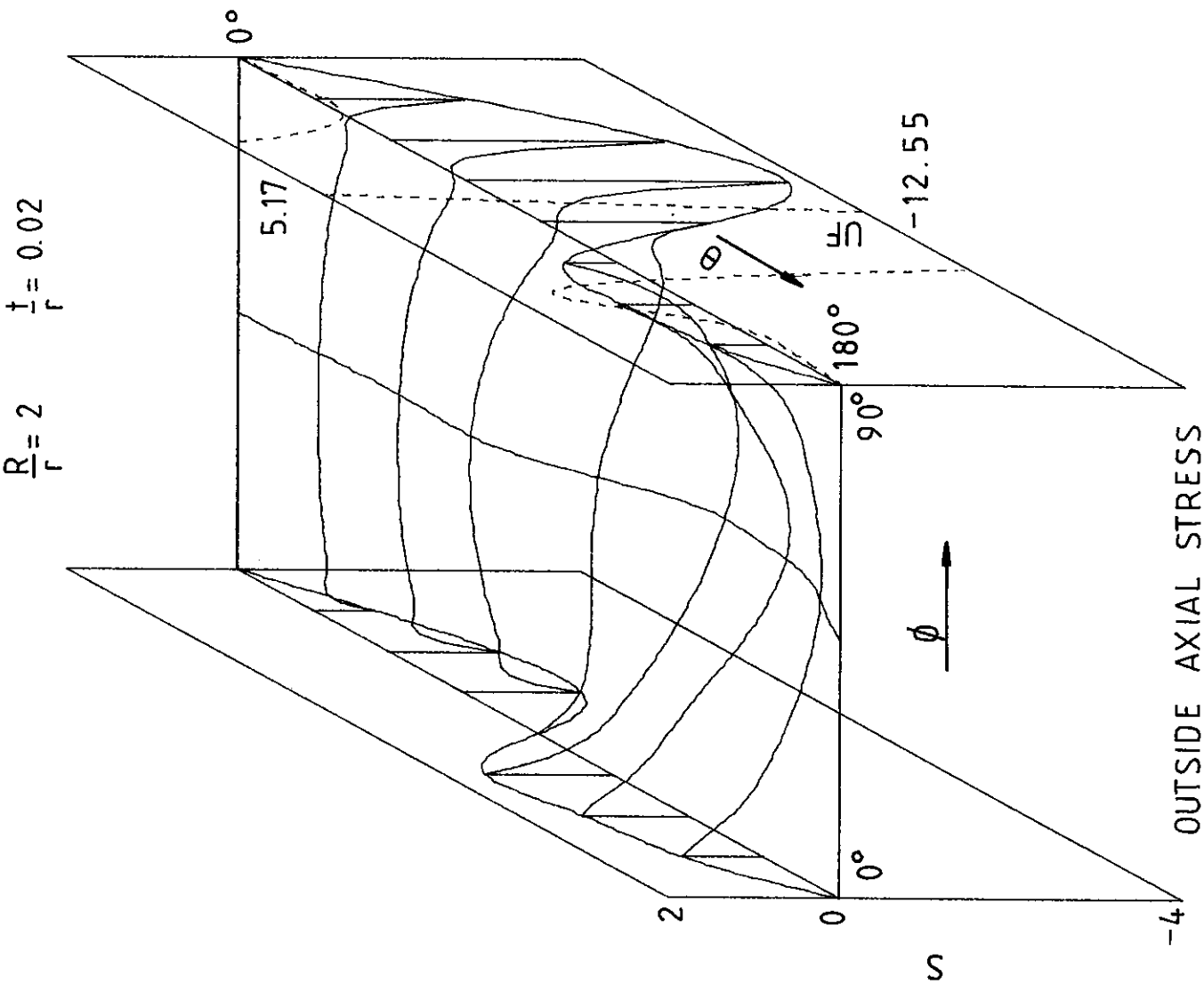


FIGURE A4

TABLE A3

R/r = 2.0 t/r = 0.02

OUTSIDE HOOP STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	-0.2153	0.0668	0.0330	0.0199	0.0126	0.0101	0.0119	0.0183	0.0306	0.0515	0.0845	0.1666	-0.5260	-0.4231
45.0	-0.3913	0.1190	0.0536	0.0207	-0.0027	-0.0151	-0.0156	-0.0027	0.0260	0.0738	0.1417	0.2943	-0.9599	-1.3965
67.5	-0.4173	0.1665	0.1896	0.2136	0.2266	0.2361	0.2483	0.2658	0.2870	0.3062	0.3136	0.3596	-1.1262	7.2402
90.0	-0.0019	-0.0169	0.0241	0.1156	0.2082	0.2825	0.3215	0.3154	0.2629	0.1727	0.0675	0.0121	-0.5995	5.0188
112.5	0.4509	0.0242	-0.2314	-0.3919	-0.5239	-0.6241	-0.6953	-0.7351	-0.7299	-0.6620	-0.5204	-0.2365	0.1771	-12.4339
135.0	0.3730	0.3683	0.1213	-0.1182	-0.3656	-0.5766	-0.7019	-0.7145	-0.6174	-0.4454	-0.2427	0.0296	0.2533	-0.3627
157.5	0.2818	0.2756	0.0152	-0.1865	-0.3299	-0.4275	-0.4799	-0.4882	-0.4560	-0.3850	-0.2558	-0.0086	0.2032	-0.1386
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OUTSIDE AXIAL STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	-0.7178	-0.1588	-0.1121	-0.0798	-0.0642	-0.0602	-0.0665	-0.0841	-0.1167	-0.1716	-0.2635	-0.3896	-1.7532	-0.0683
45.0	-1.3044	-0.2975	-0.2145	-0.1471	-0.1148	-0.1076	-0.1225	-0.1612	-0.2310	-0.3461	-0.5349	-0.7507	-3.1997	1.2836
67.5	-1.3911	-0.4247	-0.3029	-0.1796	-0.1024	-0.0699	-0.0850	-0.1536	-0.2862	-0.4967	-0.8082	-1.0880	-3.7539	5.1079
90.0	-0.0064	-0.4943	-0.5971	-0.6197	-0.6218	-0.6384	-0.6974	-0.8123	-0.9808	-1.1813	-1.3768	-1.3887	-1.9985	-8.2386
112.5	1.5031	0.1928	-0.2267	-0.5751	-0.8709	-1.1076	-1.2890	-1.4079	-1.4426	-1.3601	-1.1385	-0.7045	0.5903	-6.8733
135.0	1.2433	0.6197	0.2093	-0.1840	-0.5890	-0.9240	-1.1275	-1.1661	-1.0354	-0.7691	-0.4479	-0.0570	0.8444	1.3404
157.5	0.9392	0.3747	-0.0143	-0.2512	-0.4368	-0.5728	-0.6459	-0.6531	-0.6011	-0.5057	-0.3732	-0.0845	0.6774	-0.1306
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OUTSIDE SHEAR STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x cos + const.	
0.0	-0.0043	-0.0256	-0.0715	-0.0997	-0.1196	-0.1358	-0.1521	-0.1719	-0.1996	-0.2414	-0.3067	-0.4183	-0.4695	-0.5015	0.1481
22.5	-0.0699	-0.0692	-0.0989	-0.1175	-0.1312	-0.1425	-0.1540	-0.1679	-0.1874	-0.2162	-0.2599	-0.3323	-0.3297	-0.5371	0.1559
45.0	-0.2681	-0.2212	-0.1989	-0.1850	-0.1747	-0.1662	-0.1581	-0.1488	-0.1364	-0.1180	-0.0894	-0.0398	0.0885	-0.8059	0.1817
67.5	-0.5573	-0.4875	-0.4056	-0.3392	-0.2795	-0.2207	-0.1571	-0.0830	0.0084	0.1259	0.2797	0.4978	0.7267	-1.2764	0.2341
90.0	-0.6448	-0.5944	-0.5369	-0.4538	-0.3557	-0.2378	-0.0983	0.0630	0.2465	0.4541	0.6915	0.9539	1.1918	0.2366	0.3312
112.5	-0.2966	-0.3735	-0.3820	-0.3222	-0.2152	-0.0763	0.0883	0.2749	0.4799	0.6960	0.9044	1.0589	1.1023	1.1056	0.5041
135.0	0.2263	0.1803	0.1313	0.1173	0.1653	0.2648	0.3994	0.5504	0.6957	0.8095	0.8658	0.8680	0.8383	-0.5605	0.7841
157.5	0.9334	0.9450	0.9650	0.9488	0.9114	0.8670	0.8189	0.7633	0.6961	0.6213	0.5559	0.5277	0.5053	-1.1977	1.1248
180.0	1.3579	1.3356	1.3988	1.4179	1.3610	1.2289	1.0403	0.8290	0.6333	0.4836	0.3982	0.3741	0.3019	-1.5064	1.2989

DIAMETER EXPANSION FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
45.0	0.0	1.343	2.853	4.445	5.926	7.072	7.683	7.643	6.953	5.725	4.134	2.365	0.0	192.735

TABLE A4

R/r = 2.0 t/r = 0.02

INSIDE HOOP STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	0.0496	0.0567	0.0370	0.0294	0.0259	0.0254	0.0276	0.0326	0.0417	0.0569	0.0820	0.1370	0.1143	0.3471
45.0	0.0829	0.0810	0.0669	0.0674	0.0740	0.0826	0.0912	0.0994	0.1086	0.1223	0.1489	0.2075	0.1847	1.1333
67.5	0.0588	-0.0175	-0.0951	-0.1475	-0.1753	-0.1875	-0.1905	-0.1861	-0.1697	-0.1309	-0.0519	0.0523	0.1393	-8.5820
90.0	-0.0983	0.0657	-0.0337	-0.1457	-0.2601	-0.3510	-0.3995	-0.3943	-0.3324	-0.2230	-0.0853	0.0153	-0.1458	-6.1803
112.5	-0.0940	0.2151	0.2147	0.2627	0.2922	0.3037	0.3074	0.3052	0.2875	0.2364	0.1499	0.0832	-0.2929	14.1262
135.0	0.0393	0.1903	-0.0072	-0.1380	-0.1987	-0.2298	-0.2618	-0.3077	-0.3555	-0.3701	-0.2922	-0.0765	-0.1645	1.4920
157.5	-0.0429	0.2185	0.1245	-0.0554	-0.2486	-0.4188	-0.5260	-0.5441	-0.4736	-0.3387	-0.1670	-0.0060	-0.1695	0.7584
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INSIDE AXIAL STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	0.1654	-0.1856	-0.1142	-0.0810	-0.0647	-0.0607	-0.0675	-0.0860	-0.1200	-0.1774	-0.2718	-0.4559	0.3811	0.0789
45.0	0.2764	-0.3712	-0.2193	-0.1479	-0.1091	-0.0977	-0.1115	-0.1529	-0.2294	-0.3551	-0.5490	-0.9315	0.6158	1.6529
67.5	0.1960	-0.5231	-0.3786	-0.3017	-0.2516	-0.2367	-0.2632	-0.3380	-0.4682	-0.6616	-0.9163	-1.3846	0.4644	0.2832
90.0	-0.3276	-0.3128	-0.4711	-0.5809	-0.6675	-0.7524	-0.8452	-0.9495	-1.0613	-1.1684	-1.2393	-1.3337	-0.4858	-7.5311
112.5	-0.3134	0.2817	-0.0041	-0.2526	-0.4511	-0.6167	-0.7454	-0.8310	-0.8660	-0.8393	-0.7162	-0.5148	-0.9764	4.3033
135.0	0.1309	0.2711	0.0828	-0.1790	-0.3861	-0.5410	-0.6483	-0.7052	-0.7018	-0.6180	-0.4230	-0.2222	-0.5483	2.7382
157.5	-0.1431	0.0799	0.0876	-0.0720	-0.2524	-0.4041	-0.5002	-0.5231	-0.4699	-0.3495	-0.1905	-0.1476	-0.5650	0.7277
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INSIDE SHEAR STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x cos +	const.
0.0	-0.0043	-0.0061	-0.0553	-0.0873	-0.1110	-0.1312	-0.1519	-0.1766	-0.2098	-0.2581	-0.3317	-0.4511	-0.4602	-0.0756	0.1405
22.5	-0.0685	-0.0462	-0.0808	-0.1037	-0.1217	-0.1376	-0.1540	-0.1735	-0.1992	-0.2354	-0.2878	-0.3719	-0.3232	-0.0681	0.1479
45.0	-0.2628	-0.1764	-0.1627	-0.1553	-0.1538	-0.1550	-0.1574	-0.1598	-0.1605	-0.1564	-0.1407	-0.1146	0.0868	-0.0411	0.1727
67.5	-0.5463	-0.4725	-0.3620	-0.2881	-0.2356	-0.1949	-0.1569	-0.1113	-0.0462	0.0538	0.2088	0.4420	0.7123	-0.7768	0.2235
90.0	-0.6320	-0.8030	-0.6895	-0.5662	-0.4345	-0.2926	-0.1346	0.0495	0.2696	0.5332	0.8412	1.1980	1.1682	-2.2646	0.3182
112.5	-0.2907	-0.4530	-0.5632	-0.5484	-0.4316	-0.2291	0.0366	0.3374	0.6406	0.9094	1.1061	1.1924	1.0805	-0.5737	0.4890
135.0	0.2218	0.2065	0.1464	0.1416	0.1923	0.2924	0.4255	0.5651	0.6836	0.7630	0.7985	0.7932	0.8217	0.0864	0.7700
157.5	0.9150	1.0132	1.0732	1.0892	1.0567	0.9738	0.8527	0.7161	0.5900	0.4965	0.4437	0.4343	0.4953	-0.1750	1.1185
180.0	1.3310	1.5365	1.6022	1.5520	1.4282	1.2538	1.0474	0.8280	0.6133	0.4184	0.2615	0.1897	0.2959	-0.2184	1.2989

DIAMETER EXPANSION FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
135.0	0.0	-1.343	-2.853	-4.445	-5.926	-7.072	-7.683	-7.643	-6.953	-5.725	-4.134	-2.365	0.0	-192.735

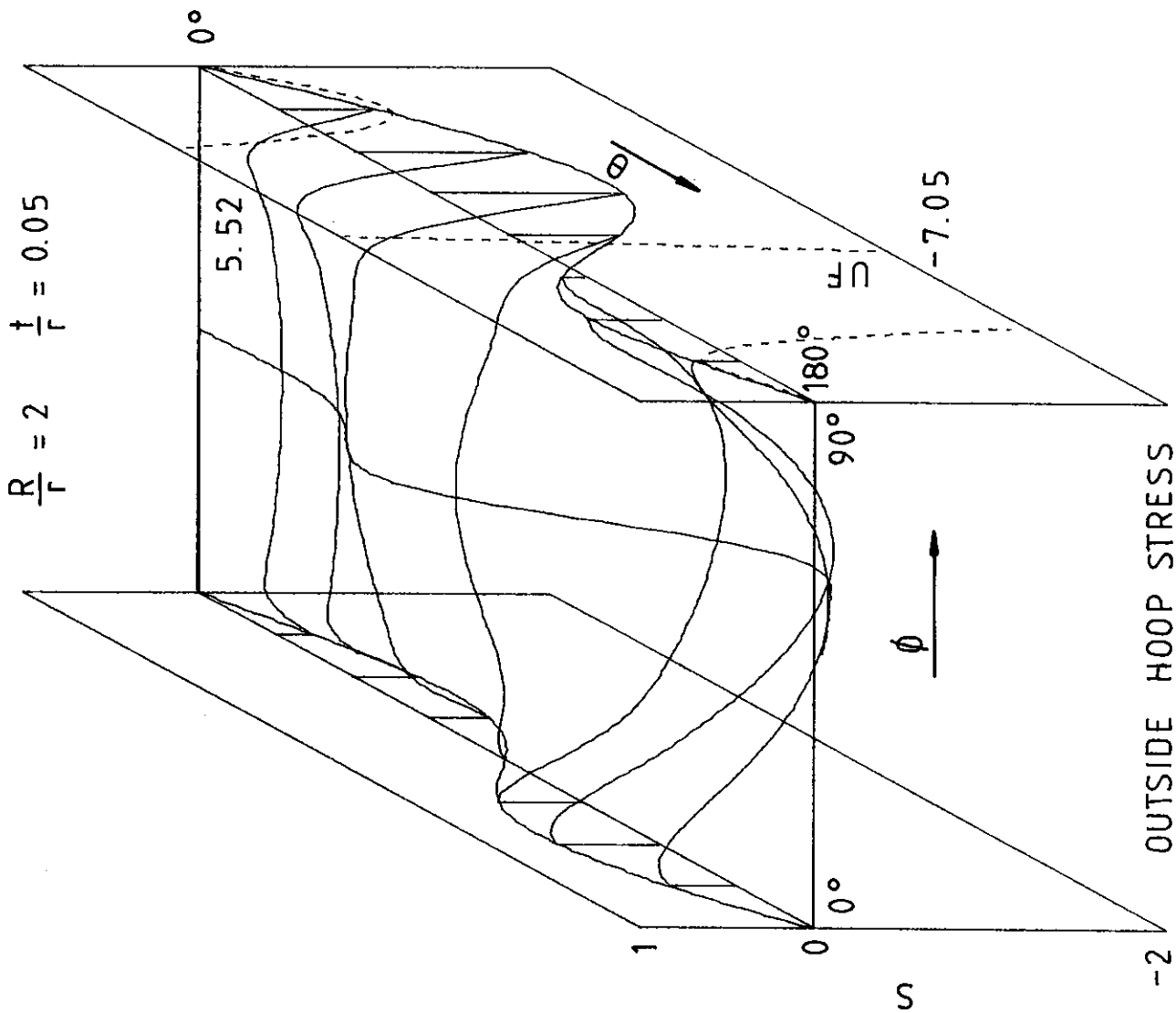

0°
5.52
-7.05
$\frac{R}{r} = 2$
$\frac{t}{r} = 0.05$
θ
180°
90°
0°
φ
1
0
S
-2
OUTSIDE HOOP STRESS

FIGURE A5

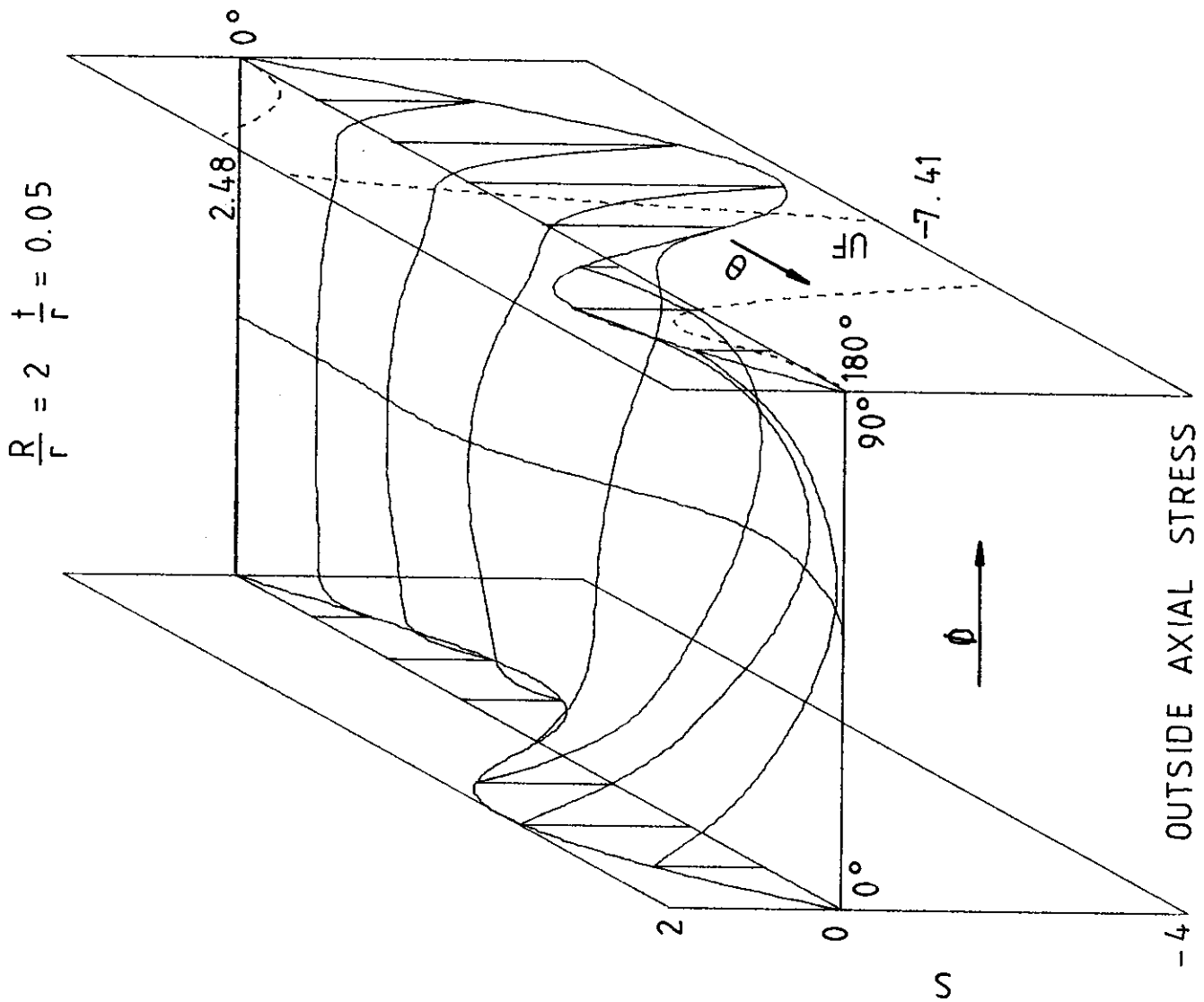


FIGURE A6

TABLE A5

R/r = 2.0 t/r = 0.05

OUTSIDE HOOP STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	-0.2120	0.0573	0.0281	-0.0031	-0.0219	-0.0331	-0.0353	-0.0270	-0.0067	0.0266	0.0900	0.1584	-0.5505	-0.6238
45.0	-0.3715	0.1117	0.1255	0.1007	0.0873	0.0810	0.0859	0.1044	0.1370	0.1821	0.2664	0.2733	-0.9879	0.9396
67.5	-0.3504	0.1136	0.2400	0.3138	0.3807	0.4321	0.4677	0.4857	0.4823	0.4562	0.4349	0.2266	-1.0973	5.0996
90.0	0.0035	0.0222	0.0239	0.1020	0.1928	0.2604	0.2911	0.2779	0.2205	0.1334	0.0588	-0.0800	-0.6326	2.1334
112.5	0.4797	0.1317	-0.2470	-0.4541	-0.5871	-0.6884	-0.7624	-0.8033	-0.8013	-0.7347	-0.5529	-0.1978	0.1297	-6.6493
135.0	0.5851	0.4500	0.0347	-0.3283	-0.6169	-0.8338	-0.9620	-0.9850	-0.8978	-0.6992	-0.3716	0.0914	0.4206	-3.3757
157.5	0.3841	0.3832	0.1375	-0.1108	-0.3064	-0.4424	-0.5137	-0.5158	-0.4501	-0.3179	-0.1144	0.1381	0.2646	0.2045
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OUTSIDE AXIAL STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	-0.7067	-0.0858	-0.0768	-0.0482	-0.0339	-0.0313	-0.0374	-0.0531	-0.0820	-0.1352	-0.2200	-0.2387	-1.8351	0.4115
45.0	-1.2385	-0.1930	-0.1303	-0.0488	0.0039	0.0261	0.0209	-0.0148	-0.0898	-0.2240	-0.4150	-0.5261	-3.2931	1.9898
67.5	-1.1679	-0.3731	-0.2925	-0.1768	-0.0894	-0.0483	-0.0591	-0.1303	-0.2720	-0.4988	-0.7702	-0.9704	-3.6575	1.5867
90.0	0.0117	-0.4170	-0.6058	-0.6485	-0.6779	-0.7271	-0.8069	-0.9239	-1.0780	-1.2584	-1.3842	-1.3266	-2.1087	-4.9780
112.5	1.5989	0.1923	-0.4301	-0.7835	-1.0704	-1.3140	-1.5035	-1.6271	-1.6716	-1.6164	-1.3898	-0.7968	0.4322	-6.3998
135.0	1.9502	0.8656	0.1435	-0.3512	-0.7625	-1.0923	-1.3015	-1.3615	-1.2666	-1.0268	-0.6202	0.1101	1.4020	-0.2702
157.5	1.2803	0.6342	0.1372	-0.2065	-0.4750	-0.6777	-0.7876	-0.7869	-0.6848	-0.5056	-0.2428	0.1934	0.8819	0.3056
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OUTSIDE SHEAR STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x cos + const.	
0.0	-0.0634	-0.0659	-0.0893	-0.1134	-0.1283	-0.1402	-0.1523	-0.1679	-0.1906	-0.2261	-0.2892	-0.3552	-0.3577	-0.5022	0.1537
22.5	-0.1226	-0.1184	-0.1241	-0.1372	-0.1444	-0.1497	-0.1552	-0.1627	-0.1745	-0.1943	-0.2323	-0.2510	-0.2273	-0.5921	0.1617
45.0	-0.2901	-0.2702	-0.2414	-0.2227	-0.2038	-0.1836	-0.1614	-0.1363	-0.1071	-0.0737	-0.0333	0.0593	0.1470	-0.8515	0.1882
67.5	-0.4929	-0.4372	-0.4038	-0.3517	-0.2935	-0.2274	-0.1514	-0.0638	0.0374	0.1547	0.2999	0.4731	0.6568	-0.8903	0.2418
90.0	-0.5399	-0.4389	-0.4263	-0.3706	-0.2899	-0.1901	-0.0725	0.0631	0.2169	0.3904	0.5859	0.7524	1.0271	0.0071	0.3406
112.5	-0.2743	-0.2401	-0.2132	-0.1676	-0.0940	0.0014	0.1146	0.2461	0.3965	0.5632	0.7337	0.8726	1.0376	0.7478	0.5152
135.0	0.2388	0.1791	0.1893	0.2063	0.2473	0.3171	0.4102	0.5188	0.6329	0.7388	0.8238	0.8787	0.8311	-0.2596	0.7942
157.5	0.8879	0.8210	0.8208	0.8185	0.8085	0.7992	0.7920	0.7817	0.7623	0.7337	0.7048	0.6756	0.5813	-1.2487	1.1290
180.0	1.2494	1.1453	1.1661	1.1872	1.1656	1.0994	0.9992	0.8795	0.7584	0.6583	0.5968	0.5576	0.4437	-1.5163	1.2982

DIAMETER EXPANSION FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
45.0	0.0	1.149	2.706	4.222	5.539	6.512	7.035	7.035	6.489	5.421	3.927	2.019	0.0	78.887

TABLE A6

R/r = 2.0 t/r = 0.05

INSIDE HOOP STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	0.0660	0.0042	0.0401	0.0454	0.0558	0.0655	0.0722	0.0755	0.0756	0.0760	0.0906	0.0175	0.1573	0.5407
45.0	0.1098	-0.0438	-0.0218	-0.0388	-0.0395	-0.0354	-0.0319	-0.0302	-0.0278	-0.0142	0.0331	-0.0660	0.2607	-1.3483
67.5	0.0713	-0.0809	-0.1702	-0.2914	-0.3795	-0.4391	-0.4702	-0.4687	-0.4283	-0.3358	-0.1822	-0.1831	0.2058	-6.1898
90.0	-0.0958	0.0902	-0.0014	-0.1492	-0.2786	-0.3744	-0.4209	-0.4070	-0.3313	-0.1983	-0.0363	-0.0424	-0.0894	-2.9106
112.5	-0.2308	0.2638	0.3248	0.3500	0.3820	0.4081	0.4245	0.4287	0.4137	0.3753	0.3083	0.1324	-0.3828	7.6378
135.0	-0.1971	0.1759	0.1644	0.1458	0.1741	0.2080	0.2113	0.1696	0.0917	0.0138	-0.0137	-0.0216	-0.3601	4.6581
157.5	-0.1723	0.1177	0.0870	-0.0359	-0.1555	-0.2525	-0.3247	-0.3652	-0.3594	-0.2901	-0.1606	-0.0562	-0.2243	0.4339
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INSIDE AXIAL STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	0.2202	-0.2051	-0.0860	-0.0456	-0.0252	-0.0178	-0.0228	-0.0415	-0.0786	-0.1395	-0.2450	-0.5580	0.5244	0.6278
45.0	0.3658	-0.3871	-0.1997	-0.1195	-0.0765	-0.0596	-0.0715	-0.1160	-0.2006	-0.3313	-0.5529	-1.0830	0.8691	0.9977
67.5	0.2378	-0.4635	-0.3746	-0.3426	-0.3350	-0.3484	-0.3914	-0.4692	-0.5856	-0.7388	-0.9823	-1.4233	0.6861	-1.2823
90.0	-0.3192	-0.2768	-0.3727	-0.5219	-0.6491	-0.7587	-0.8604	-0.9550	-1.0369	-1.0949	-1.1622	-1.2653	-0.2980	-3.5224
112.5	-0.7692	0.0168	-0.0042	-0.2223	-0.4159	-0.5644	-0.6761	-0.7505	-0.7772	-0.7410	-0.6661	-0.7152	-1.2760	1.1265
135.0	-0.6571	-0.0503	0.1107	0.0185	-0.1065	-0.2049	-0.2773	-0.3252	-0.3374	-0.3021	-0.2660	-0.4528	-1.2003	3.3502
157.5	-0.5743	-0.2060	-0.0201	-0.0166	-0.0771	-0.1402	-0.1894	-0.2189	-0.2202	-0.1946	-0.1922	-0.3449	-0.7477	0.9204
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INSIDE SHEAR STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x cos + const.	
0.0	-0.0603	0.0104	-0.0531	-0.0846	-0.1084	-0.1296	-0.1516	-0.1783	-0.2142	-0.2651	-0.3419	-0.5085	-0.3403	-0.0397	0.1345
22.5	-0.1166	-0.0288	-0.0715	-0.0949	-0.1142	-0.1330	-0.1533	-0.1776	-0.2086	-0.2493	-0.3082	-0.4283	-0.2163	-0.0356	0.1417
45.0	-0.2759	-0.1828	-0.1570	-0.1477	-0.1466	-0.1516	-0.1598	-0.1687	-0.1749	-0.1729	-0.1622	-0.1271	0.1398	-0.1897	0.1658
67.5	-0.4689	-0.5013	-0.3935	-0.3181	-0.2627	-0.2168	-0.1711	-0.1159	-0.0398	0.0708	0.2304	0.4929	0.6248	-0.8841	0.2152
90.0	-0.5135	-0.7721	-0.7085	-0.5940	-0.4636	-0.3166	-0.1478	0.0482	0.2770	0.5423	0.8478	1.1763	0.9770	-1.6513	0.3082
112.5	-0.2610	-0.4977	-0.6030	-0.5685	-0.4344	-0.2286	0.0297	0.3211	0.6230	0.9066	1.1346	1.2332	0.9869	-0.9664	0.4773
135.0	0.2271	0.2474	0.1704	0.1373	0.1794	0.2826	0.4227	0.5723	0.7017	0.7822	0.7946	0.7580	0.7906	0.0475	0.7590
157.5	0.8446	1.0339	1.1239	1.1256	1.0722	0.9816	0.8644	0.7318	0.5969	0.4761	0.3964	0.4064	0.5530	-0.0906	1.1131
180.0	1.1884	1.4593	1.5970	1.5984	1.4922	1.3049	1.0647	0.8047	0.5603	0.3647	0.2516	0.2617	0.4221	-0.2137	1.2982

DIAMETER EXPANSION FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
135.0	0.0	-1.149	-2.706	-4.222	-5.539	-6.512	-7.035	-7.035	-6.489	-5.421	-3.927	-2.019	0.0	-78.887

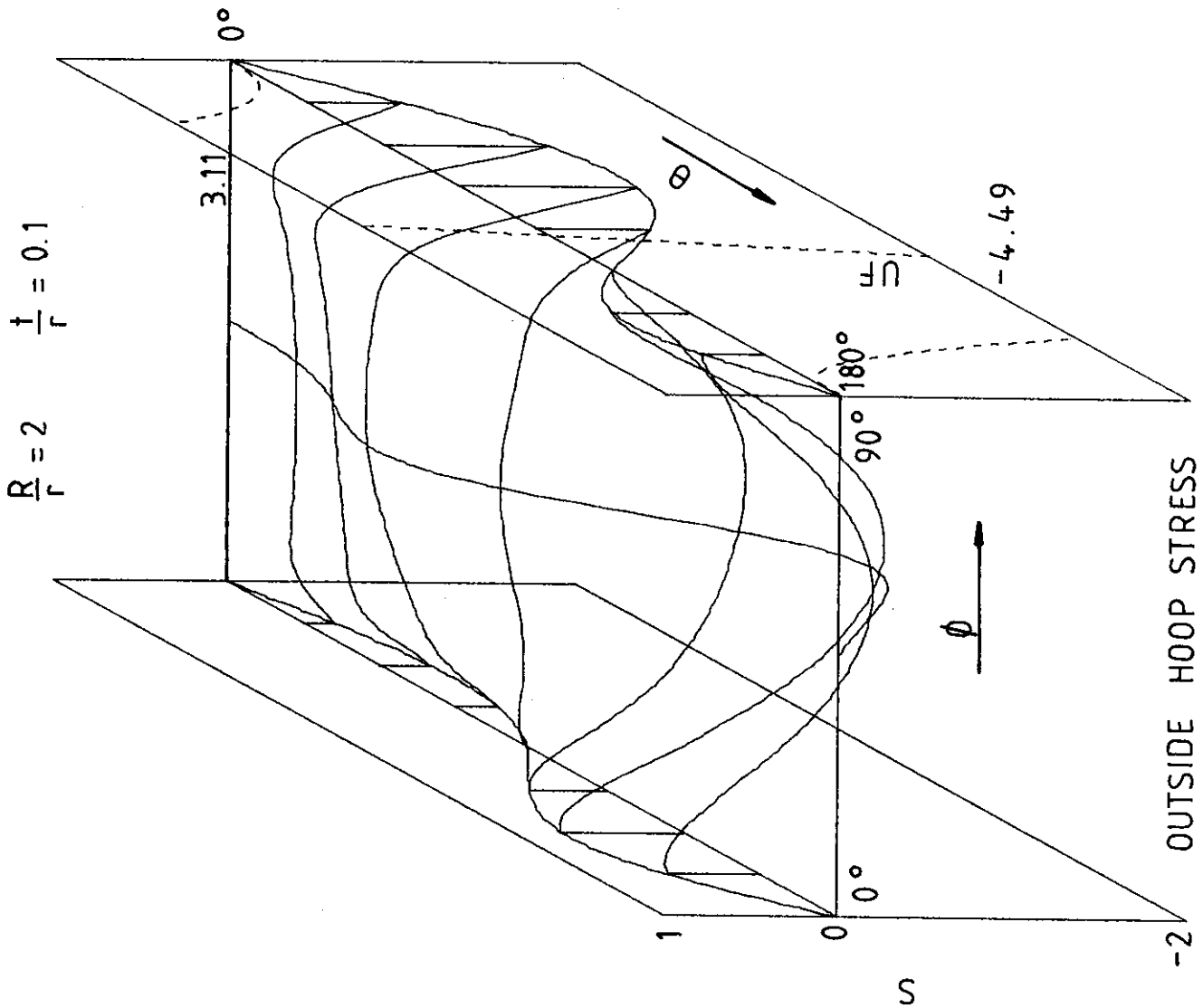


FIGURE A7

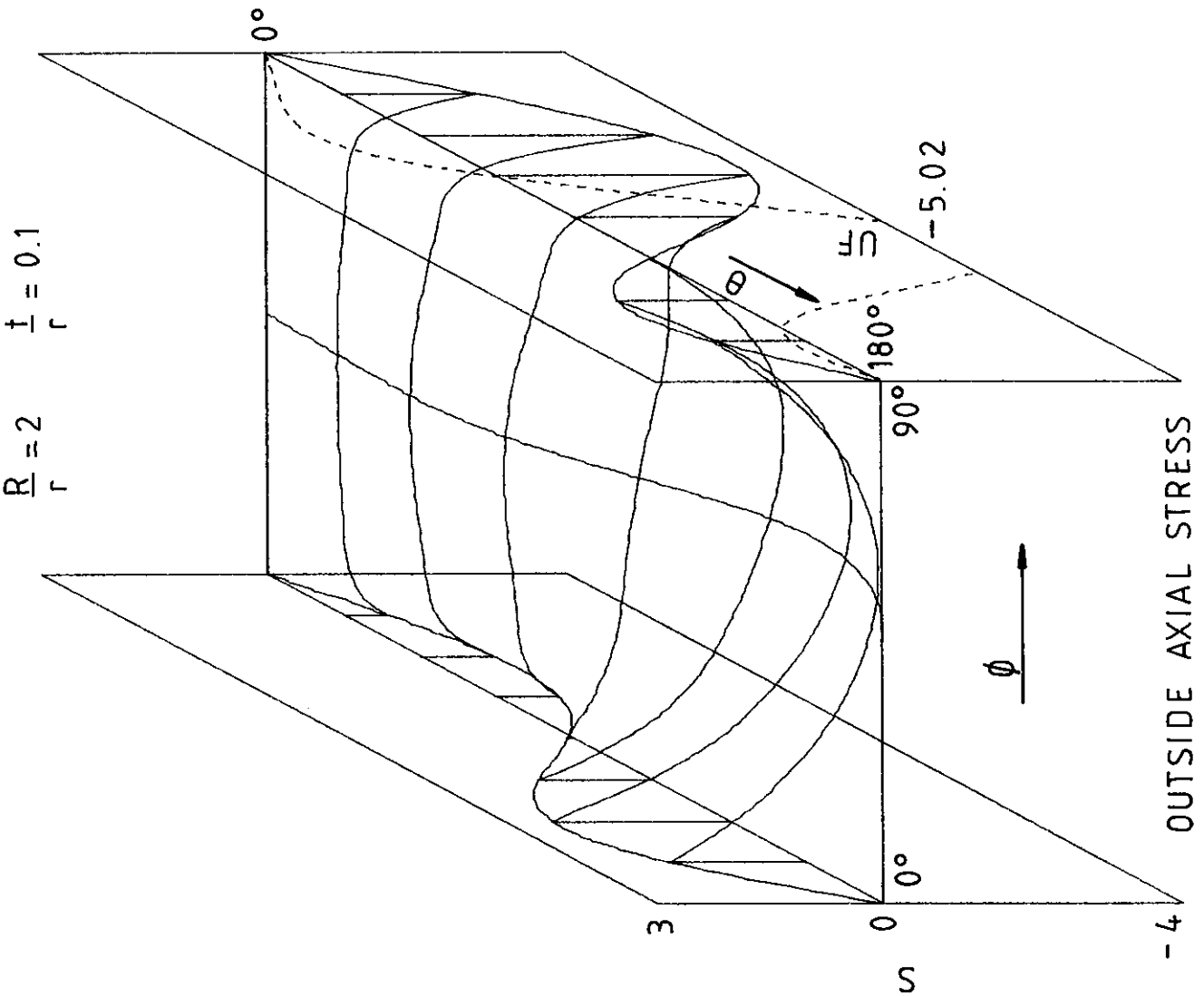


FIGURE A8

TABLE A7

R/r = 2.0 t/r = 0.1

OUTSIDE HOOP STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	-0.1802	0.0286	0.0751	0.0613	0.0507	0.0473	0.0514	0.0642	0.0870	0.1280	0.1879	0.0778	-0.5413	0.3227
45.0	-0.2941	0.0493	0.1781	0.2077	0.2311	0.2550	0.2781	0.3000	0.3226	0.3575	0.3877	0.0917	-0.9391	1.7440
67.5	-0.2513	0.0484	0.2138	0.3142	0.4037	0.4759	0.5211	0.5350	0.5202	0.4896	0.4086	-0.0242	-1.0210	3.1096
90.0	0.0249	0.0662	0.0462	0.0708	0.1244	0.1711	0.1892	0.1726	0.1298	0.0804	0.0113	-0.2114	-0.6583	0.9763
112.5	0.4512	0.2332	-0.1282	-0.3905	-0.5580	-0.6685	-0.7421	-0.7789	-0.7630	-0.6676	-0.4724	-0.1976	-0.0017	-3.6251
135.0	0.7076	0.4928	0.0209	-0.4189	-0.7567	-0.9892	-1.1185	-1.1384	-1.0365	-0.7973	-0.4132	0.0734	0.4413	-3.7593
157.5	0.5340	0.4524	0.1705	-0.1283	-0.3721	-0.5399	-0.6258	-0.6263	-0.5382	-0.3609	-0.1048	0.1815	0.3644	-0.7491
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OUTSIDE AXIAL STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	-0.6008	-0.0769	-0.0075	0.0247	0.0531	0.0689	0.0712	0.0579	0.0230	-0.0340	-0.0840	-0.2376	-1.8043	0.8353
45.0	-0.9803	-0.1959	-0.0656	0.0096	0.0762	0.1142	0.1177	0.0811	-0.0052	-0.1365	-0.2620	-0.5922	-3.1304	1.4152
67.5	-0.8378	-0.3349	-0.2639	-0.2022	-0.1390	-0.1105	-0.1308	-0.2083	-0.3488	-0.5322	-0.6949	-1.0724	-3.4035	0.1419
90.0	0.0831	-0.2733	-0.5244	-0.6451	-0.7155	-0.7903	-0.8873	-1.0100	-1.1511	-1.2705	-1.2952	-1.3461	-2.1943	-3.4377
112.5	1.5039	0.2866	-0.4385	-0.8721	-1.1746	-1.4144	-1.6050	-1.7381	-1.7917	-1.7169	-1.4318	-0.8732	-0.0055	-4.8783
135.0	2.3588	0.9983	0.0473	-0.5866	-1.0376	-1.3666	-1.5799	-1.6626	-1.5923	-1.3328	-0.8159	0.0738	1.4709	-1.8125
157.5	1.7799	0.9114	0.2320	-0.2549	-0.6045	-0.8456	-0.9782	-0.9924	-0.8804	-0.6327	-0.2247	0.3882	1.2148	0.2133
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OUTSIDE SHEAR STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x cos + const.	
0.0	-0.1358	-0.1552	-0.1390	-0.1468	-0.1521	-0.1542	-0.1561	-0.1602	-0.1704	-0.1951	-0.2296	-0.1827	-0.2140	-0.5818	0.1626
22.5	-0.1792	-0.1941	-0.1770	-0.1767	-0.1738	-0.1671	-0.1589	-0.1513	-0.1476	-0.1537	-0.1603	-0.0946	-0.1062	-0.6461	0.1709
45.0	-0.2923	-0.2842	-0.2721	-0.2546	-0.2299	-0.1978	-0.1598	-0.1177	-0.0738	-0.0283	0.0331	0.1307	0.1874	-0.7599	0.1985
67.5	-0.4130	-0.3448	-0.3456	-0.3186	-0.2715	-0.2088	-0.1333	-0.0477	0.0463	0.1523	0.2756	0.3800	0.5658	-0.6625	0.2541
90.0	-0.4267	-0.2853	-0.2746	-0.2487	-0.1985	-0.1278	-0.0403	0.0612	0.1765	0.3079	0.4454	0.5494	0.8605	-0.1240	0.3558
112.5	-0.2186	-0.0956	-0.0404	-0.0052	0.0332	0.0824	0.1449	0.2227	0.3187	0.4341	0.5584	0.6826	0.9386	0.3756	0.5328
135.0	0.2328	0.2159	0.2621	0.3039	0.3393	0.3775	0.4255	0.4870	0.5635	0.6531	0.7476	0.8285	0.8400	-0.1195	0.8102
157.5	0.8080	0.6528	0.6338	0.6574	0.6896	0.7238	0.7599	0.7966	0.8316	0.8616	0.8779	0.8504	0.6964	-1.1652	1.1347
180.0	1.1139	0.8975	0.8519	0.8687	0.8970	0.9195	0.9321	0.9339	0.9259	0.9095	0.8796	0.8079	0.6212	-1.5872	1.2955

DIAMETER EXPANSION FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
45.0	0.0	0.759	2.019	3.271	4.354	5.151	5.579	5.587	5.154	4.297	3.050	1.378	0.0	36.739

TABLE A8

R/r = 2.0 t/r = 0.1

INSIDE HOOP STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	0.0702	-0.0559	-0.0358	-0.0325	-0.0298	-0.0260	-0.0251	-0.0281	-0.0316	-0.0297	-0.0428	-0.1416	0.1862	-0.4459
45.0	0.1073	-0.1026	-0.1290	-0.1801	-0.2226	-0.2504	-0.2672	-0.2725	-0.2584	-0.2159	-0.1832	-0.2711	0.2967	-2.1875
67.5	0.0644	-0.0744	-0.1757	-0.3237	-0.4533	-0.5434	-0.5896	-0.5861	-0.5233	-0.3988	-0.2735	-0.2796	0.2417	-3.9364
90.0	-0.0928	0.0747	0.0329	-0.1020	-0.2328	-0.3225	-0.3589	-0.3354	-0.2493	-0.1169	-0.0183	-0.0882	-0.0256	-1.5186
112.5	-0.3081	0.1887	0.3409	0.3838	0.4081	0.4335	0.4574	0.4745	0.4785	0.4521	0.3439	0.0718	-0.3701	4.2175
135.0	-0.4355	0.1032	0.3045	0.4141	0.5078	0.5806	0.6094	0.5801	0.4953	0.3688	0.2063	-0.0327	-0.5047	4.9145
157.5	-0.3548	-0.0002	0.0996	0.1107	0.1045	0.0919	0.0651	0.0220	-0.0252	-0.0572	-0.0701	-0.1144	-0.3378	1.4382
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INSIDE AXIAL STRESS FACTORS

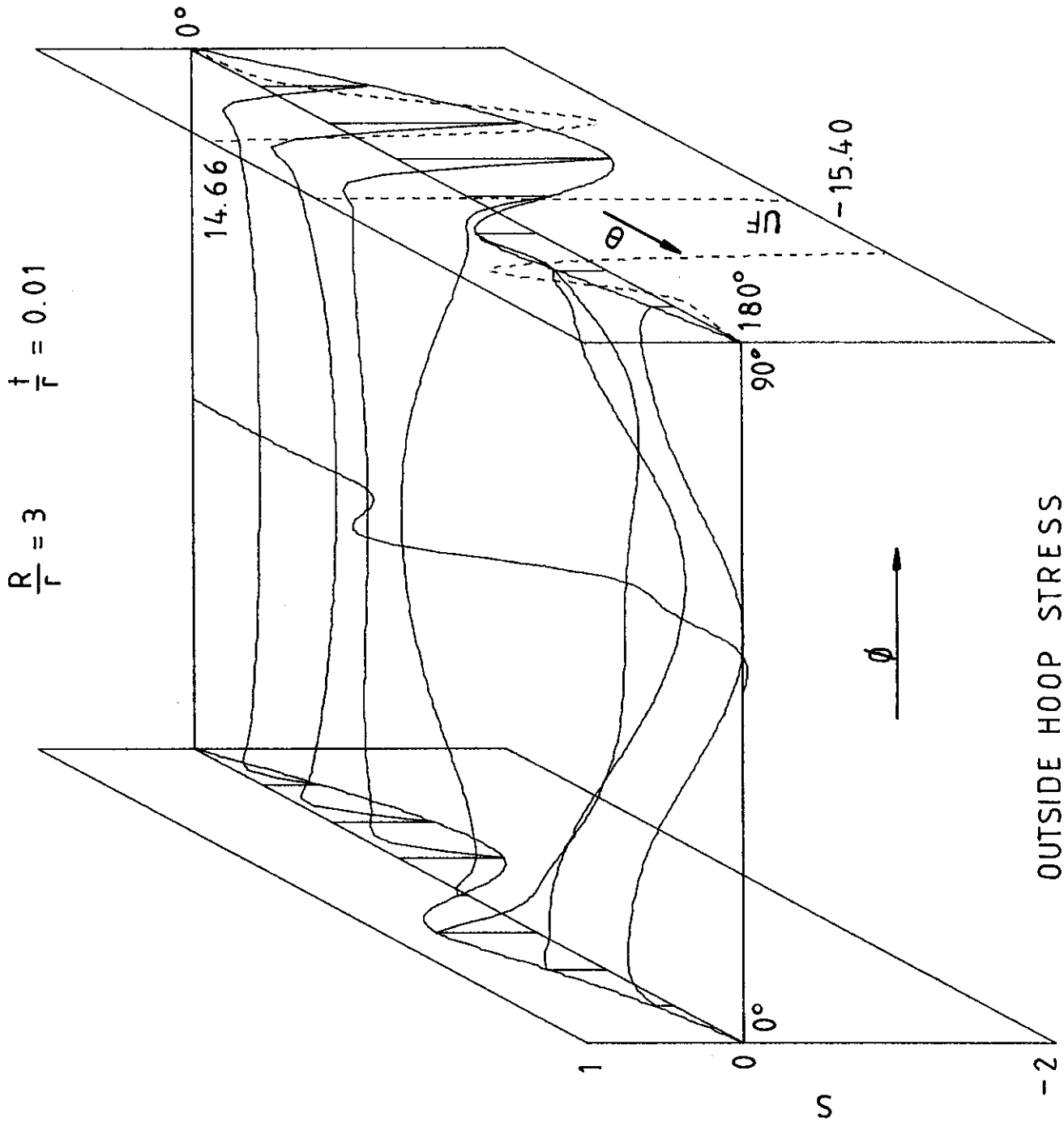
Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	0.2340	-0.1513	-0.0876	-0.0306	-0.0044	0.0061	0.0019	-0.0192	-0.0598	-0.1343	-0.3055	-0.5152	0.6207	0.4515
45.0	0.3576	-0.2661	-0.2081	-0.1390	-0.1131	-0.1110	-0.1318	-0.1795	-0.2580	-0.3944	-0.6804	-0.9398	0.9890	0.1310
67.5	0.2146	-0.3026	-0.3260	-0.3343	-0.3721	-0.4215	-0.4815	-0.5552	-0.6466	-0.7869	-1.0466	-1.1471	0.8057	-1.2383
90.0	-0.3092	-0.2653	-0.2969	-0.4131	-0.5510	-0.6744	-0.7760	-0.8558	-0.9168	-0.9847	-1.0953	-1.0591	-0.0855	-1.8553
112.5	-1.0269	-0.3004	-0.1030	-0.1713	-0.3114	-0.4410	-0.5368	-0.5948	-0.6193	-0.6334	-0.6881	-0.8440	-1.2335	0.3228
135.0	-1.4518	-0.5204	-0.0536	0.0852	0.0814	0.0390	-0.0034	-0.0373	-0.0690	-0.1290	-0.2993	-0.7440	-1.6823	2.3904
157.5	-1.1828	-0.5580	-0.1464	0.0592	0.1419	0.1662	0.1627	0.1407	0.0958	0.0053	-0.1833	-0.5485	-1.1259	1.4732
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INSIDE SHEAR STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x cos + const.	
0.0	-0.1229	0.0084	-0.0350	-0.0701	-0.0954	-0.1207	-0.1494	-0.1840	-0.2272	-0.2869	-0.3949	-0.5504	-0.1936	-0.0075	0.1242
22.5	-0.1622	-0.0438	-0.0647	-0.0880	-0.1074	-0.1290	-0.1544	-0.1845	-0.2203	-0.2676	-0.3485	-0.4406	-0.0961	-0.0659	0.1311
45.0	-0.2645	-0.2117	-0.1820	-0.1686	-0.1638	-0.1654	-0.1704	-0.1751	-0.1760	-0.1722	-0.1608	-0.0883	0.1696	-0.3136	0.1539
67.5	-0.3737	-0.4767	-0.4240	-0.3602	-0.3027	-0.2476	-0.1886	-0.1182	-0.0290	0.0871	0.2529	0.4895	0.5119	-0.8253	0.2011
90.0	-0.3860	-0.6661	-0.6779	-0.5964	-0.4762	-0.3299	-0.1590	0.0382	0.2632	0.5179	0.8054	1.0469	0.7785	-1.2883	0.2910
112.5	-0.1978	-0.4690	-0.5746	-0.5449	-0.4178	-0.2220	0.0219	0.2965	0.5834	0.8597	1.0875	1.1615	0.8492	-1.0205	0.4572
135.0	0.2106	0.2007	0.1483	0.1306	0.1755	0.2766	0.4137	0.5621	0.6958	0.7898	0.8248	0.7985	0.7600	-0.2154	0.7400
157.5	0.7310	1.0013	1.1250	1.1366	1.0821	0.9904	0.8755	0.7457	0.6105	0.4880	0.4122	0.4390	0.6301	0.0074	1.1032
180.0	1.0078	1.3871	1.5928	1.6283	1.5309	1.3398	1.0907	0.8181	0.5593	0.3575	0.2623	0.3234	0.5621	-0.1239	1.2956

DIAMETER EXPANSION FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
135.0	0.0	-0.759	-2.019	-3.271	-4.354	-5.151	-5.579	-5.587	-5.154	-4.297	-3.050	-1.378	0.0	-36.739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$\frac{t}{r} = 0.01$
0°
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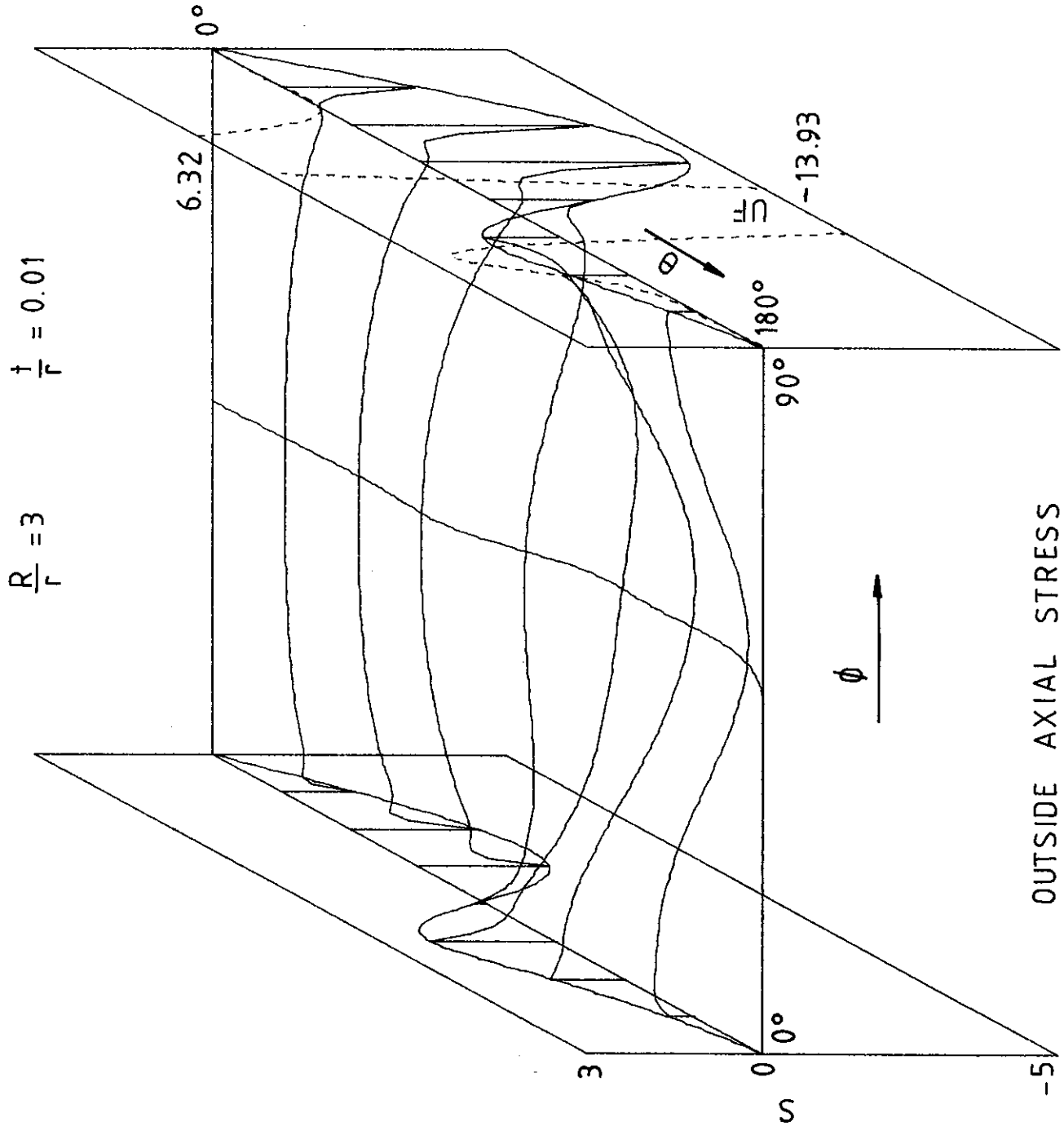
-15.40
UF
θ
180°
90°
0°
φ
1
0
-2
S
OUTSIDE HOOP STRESS

FIGURE A9



OUTSIDE AXIAL STRESS

FIGURE A10

TABLE A9

R/r = 3.0 t/r = 0.01

OUTSIDE HOOP STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	-0.3812	0.0774	0.0459	0.0274	0.0172	0.0127	0.0129	0.0178	0.0288	0.0485	0.0825	0.1395	-0.6862	-0.1702
45.0	-0.6640	0.1134	0.0495	0.0048	-0.0226	-0.0363	-0.0383	-0.0287	-0.0049	0.0385	0.1092	0.2135	-1.2193	-1.7189
67.5	-0.6662	0.1877	0.2213	0.2251	0.2144	0.2025	0.1983	0.2066	0.2281	0.2580	0.2840	0.2860	-1.3670	8.7159
90.0	0.0689	-0.0389	0.0585	0.1876	0.2985	0.3744	0.4144	0.4173	0.3744	0.2763	0.1325	-0.0037	-0.5434	4.4266
112.5	0.6464	-0.0653	-0.3233	-0.4929	-0.5568	-0.5667	-0.5776	-0.6139	-0.6568	-0.6464	-0.5113	-0.2417	0.3834	-13.4215
135.0	0.3775	0.3541	0.2625	0.0583	-0.1828	-0.3831	-0.4983	-0.5066	-0.3991	-0.1975	0.0248	0.1708	0.3203	0.7076
157.5	0.1334	0.3017	0.2450	0.1058	-0.1065	-0.3213	-0.4419	-0.4141	-0.2654	-0.0787	0.0742	0.1732	0.1409	-0.1053
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OUTSIDE AXIAL STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	-1.2707	-0.3114	-0.1811	-0.1119	-0.0765	-0.0621	-0.0638	-0.0819	-0.1215	-0.1946	-0.3256	-0.5640	-2.2872	0.0396
45.0	-2.2133	-0.6023	-0.3656	-0.2342	-0.1655	-0.1385	-0.1448	-0.1852	-0.2693	-0.4189	-0.6752	-1.1166	-4.0642	0.8418
67.5	-2.2208	-0.7582	-0.4416	-0.2264	-0.0979	-0.0410	-0.0465	-0.1160	-0.2643	-0.5205	-0.9243	-1.5240	-4.5566	6.3149
90.0	0.2296	-0.6688	-0.7989	-0.7603	-0.6804	-0.6301	-0.6474	-0.7523	-0.9503	-1.2228	-1.5043	-1.6501	-1.8114	-10.5093
112.5	2.1548	0.4751	-0.1733	-0.6000	-0.8426	-0.9891	-1.1137	-1.2443	-1.3481	-1.3318	-1.0647	-0.4462	1.2780	-3.9508
135.0	1.2583	0.9855	0.6092	0.0755	-0.4568	-0.8751	-1.1238	-1.1721	-0.9959	-0.6012	-0.0707	0.4266	1.0677	1.6324
157.5	0.4447	0.6516	0.5186	0.2125	-0.2240	-0.6479	-0.8896	-0.8542	-0.5776	-0.1969	0.1435	0.3729	0.4695	0.1177
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OUTSIDE SHEAR STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x cos + const.	
0.0	0.2006	0.1200	0.0425	-0.0025	-0.0304	-0.0500	-0.0674	-0.0878	-0.1173	-0.1648	-0.2449	-0.3845	-0.5292	-0.5154	0.2379
22.5	0.0870	0.0557	0.0072	-0.0224	-0.0411	-0.0545	-0.0664	-0.0804	-0.1008	-0.1331	-0.1864	-0.2748	-0.3317	-0.5420	0.2472
45.0	-0.2345	-0.1461	-0.1103	-0.0905	-0.0783	-0.0693	-0.0613	-0.0524	-0.0407	-0.0224	0.0096	0.0700	0.2335	-0.7079	0.2768
67.5	-0.6549	-0.4870	-0.3435	-0.2418	-0.1664	-0.1054	-0.0480	0.0171	0.1030	0.2258	0.4068	0.6761	1.0340	-1.0807	0.3322
90.0	-0.6359	-0.5989	-0.4890	-0.3787	-0.2636	-0.1406	-0.0044	0.1528	0.3392	0.5626	0.8302	1.1504	1.4193	0.2661	0.4219
112.5	0.0154	-0.2277	-0.3131	-0.2967	-0.2083	-0.0627	0.1265	0.3432	0.5695	0.7857	0.9662	1.0628	0.9461	0.4008	0.5535
135.0	0.4470	0.3227	0.1640	0.0812	0.0932	0.1858	0.3324	0.4999	0.6505	0.7431	0.7400	0.6343	0.5118	-0.6680	0.7200
157.5	0.5809	0.6728	0.7294	0.7292	0.6909	0.6381	0.5794	0.5124	0.4331	0.3486	0.2871	0.2819	0.3275	-0.9159	0.8770
180.0	0.5896	0.7658	0.9421	1.0538	1.0547	0.9286	0.7057	0.4483	0.2295	0.1073	0.0968	0.1736	0.2878	-1.0295	0.9446

DIAMETER EXPANSION FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
45.0	0.0	2.314	5.123	8.693	12.295	15.135	16.626	16.451	14.584	11.363	7.508	3.867	0.0	378.281

TABLE A10

R/r = 3.0 t/r = 0.01

INSIDE HOOP STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	0.0475	0.0684	0.0394	0.0250	0.0182	0.0158	0.0164	0.0201	0.0281	0.0433	0.0717	0.1251	0.0830	0.0963
45.0	0.0620	0.1163	0.0925	0.0860	0.0860	0.0884	0.0924	0.0983	0.1074	0.1227	0.1514	0.2113	0.1080	1.5154
67.5	0.0078	-0.0193	-0.1138	-0.1578	-0.1705	-0.1680	-0.1608	-0.1528	-0.1422	-0.1188	-0.0624	0.0571	0.0202	-9.7353
90.0	-0.1415	0.0403	-0.0726	-0.2180	-0.3387	-0.4196	-0.4625	-0.4669	-0.4227	-0.3173	-0.1566	0.0037	-0.2322	-5.0099
112.5	0.0421	0.2076	0.3448	0.4198	0.4174	0.3788	0.3507	0.3556	0.3802	0.3782	0.2964	0.1374	-0.1423	14.7163
135.0	0.2739	0.1899	0.0351	-0.0556	-0.0894	-0.1033	-0.1185	-0.1418	-0.1715	-0.1845	-0.1277	0.0319	0.1194	-0.1539
157.5	0.2287	0.2348	0.1620	0.0407	-0.0860	-0.1832	-0.2425	-0.2599	-0.2204	-0.1179	0.0159	0.1263	0.1375	0.3776
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INSIDE AXIAL STRESS FACTORS

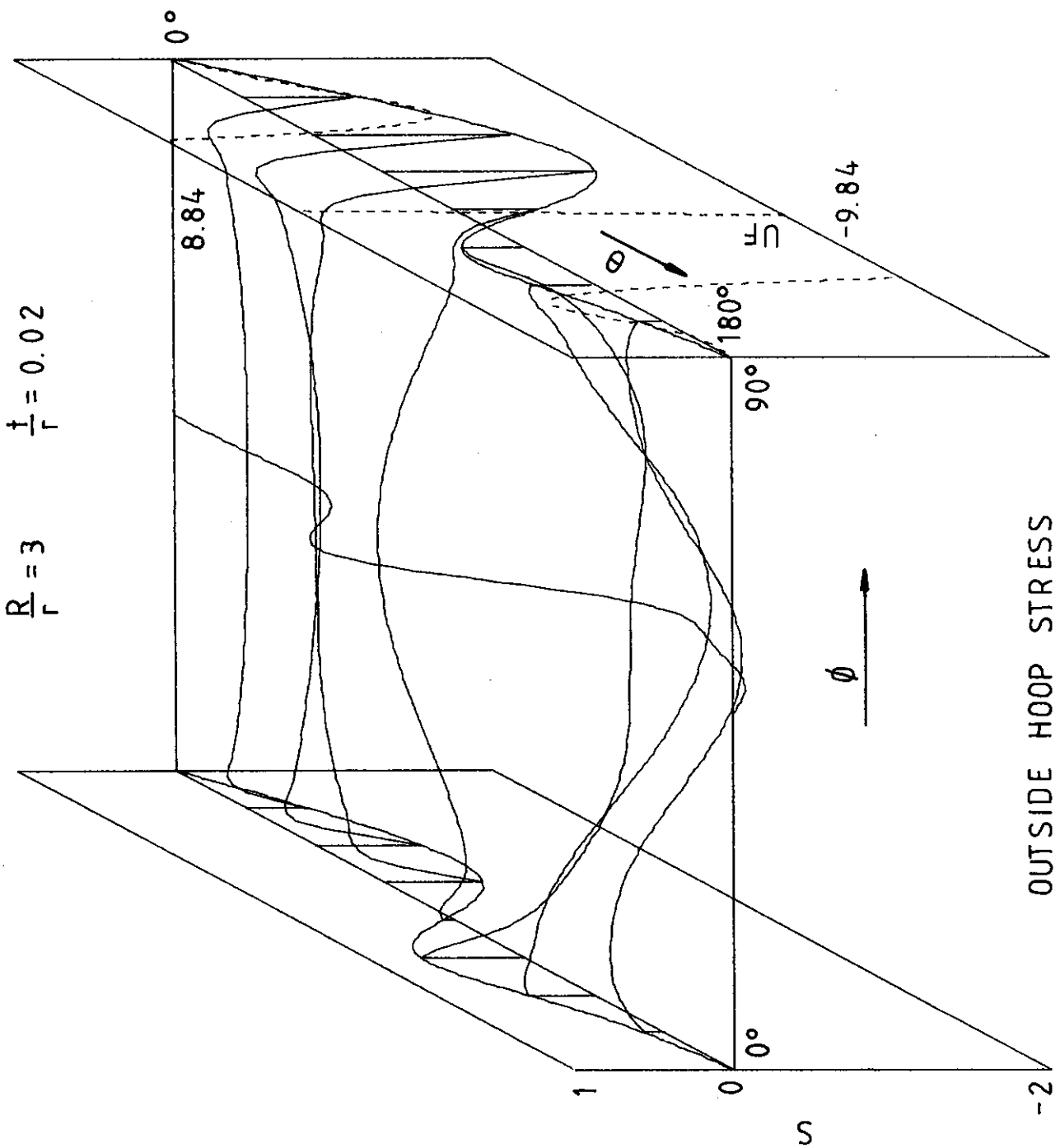
Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	0.1582	-0.3145	-0.1849	-0.1149	-0.0788	-0.0642	-0.0661	-0.0847	-0.1253	-0.1999	-0.3329	-0.5704	0.2768	0.0752
45.0	0.2065	-0.5975	-0.3576	-0.2176	-0.1426	-0.1121	-0.1174	-0.1591	-0.2474	-0.4047	-0.6717	-1.1144	0.3601	1.5993
67.5	0.0258	-0.7868	-0.5414	-0.3553	-0.2357	-0.1792	-0.1840	-0.2549	-0.4055	-0.6577	-1.0373	-1.5553	0.0673	0.7907
90.0	-0.4716	-0.5267	-0.7249	-0.7863	-0.7942	-0.8047	-0.8543	-0.9609	-1.1224	-1.3128	-1.4740	-1.4965	-0.7741	-10.1122
112.5	0.1403	0.5348	0.0944	-0.2189	-0.4422	-0.6096	-0.7430	-0.8468	-0.9041	-0.8759	-0.7015	-0.3006	-0.4744	5.9333
135.0	0.9130	0.8189	0.4320	0.0076	-0.3735	-0.6682	-0.8512	-0.9041	-0.8122	-0.5667	-0.1792	0.2902	0.3981	1.5898
157.5	0.7622	0.5452	0.3959	0.1211	-0.2064	-0.4938	-0.6623	-0.6678	-0.5104	-0.2394	0.0575	0.2940	0.4582	0.4209
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INSIDE SHEAR STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x cos + const.	
0.0	0.1986	0.1375	0.0559	0.0076	-0.0234	-0.0463	-0.0673	-0.0915	-0.1252	-0.1775	-0.2636	-0.4115	-0.5239	-0.1920	0.2335
22.5	0.0861	0.0735	0.0218	-0.0110	-0.0332	-0.0503	-0.0663	-0.0847	-0.1098	-0.1475	-0.2068	-0.3025	-0.3284	-0.2025	0.2427
45.0	-0.2321	-0.1185	-0.0841	-0.0698	-0.0642	-0.0621	-0.0612	-0.0599	-0.0564	-0.0471	-0.0240	0.0316	0.2311	-0.1988	0.2720
67.5	-0.6484	-0.4643	-0.2972	-0.1945	-0.1295	-0.0837	-0.0438	0.0018	0.0669	0.1710	0.3444	0.6344	1.0237	-0.7607	0.3269
90.0	-0.6296	-0.7673	-0.6120	-0.4409	-0.2846	-0.1458	-0.0109	0.1428	0.3407	0.6047	0.9427	1.3305	1.4052	-1.7926	0.4161
112.5	0.0152	-0.2356	-0.4265	-0.4533	-0.3499	-0.1578	0.0926	0.3795	0.6778	0.9445	1.1135	1.1124	0.9367	-0.2307	0.5475
135.0	0.4425	0.3956	0.2213	0.0700	0.0281	0.1250	0.3256	0.5528	0.7196	0.7644	0.6857	0.5523	0.5067	-0.1647	0.7146
157.5	0.5751	0.6920	0.7792	0.8139	0.7824	0.7034	0.5995	0.4800	0.3561	0.2582	0.2197	0.2426	0.3243	-0.3418	0.8728
180.0	0.5837	0.7799	1.0102	1.1698	1.1916	1.0337	0.7277	0.3811	0.1154	-0.0051	0.0128	0.1295	0.2849	-0.3836	0.9410

DIAMETER EXPANSION FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
135.0	0.0	-2.314	-5.123	-8.693	-12.295	-15.135	-16.626	-16.451	-14.584	-11.363	-7.508	-3.867	0.0	-378.281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$\frac{t}{r} = 0.02$
0°
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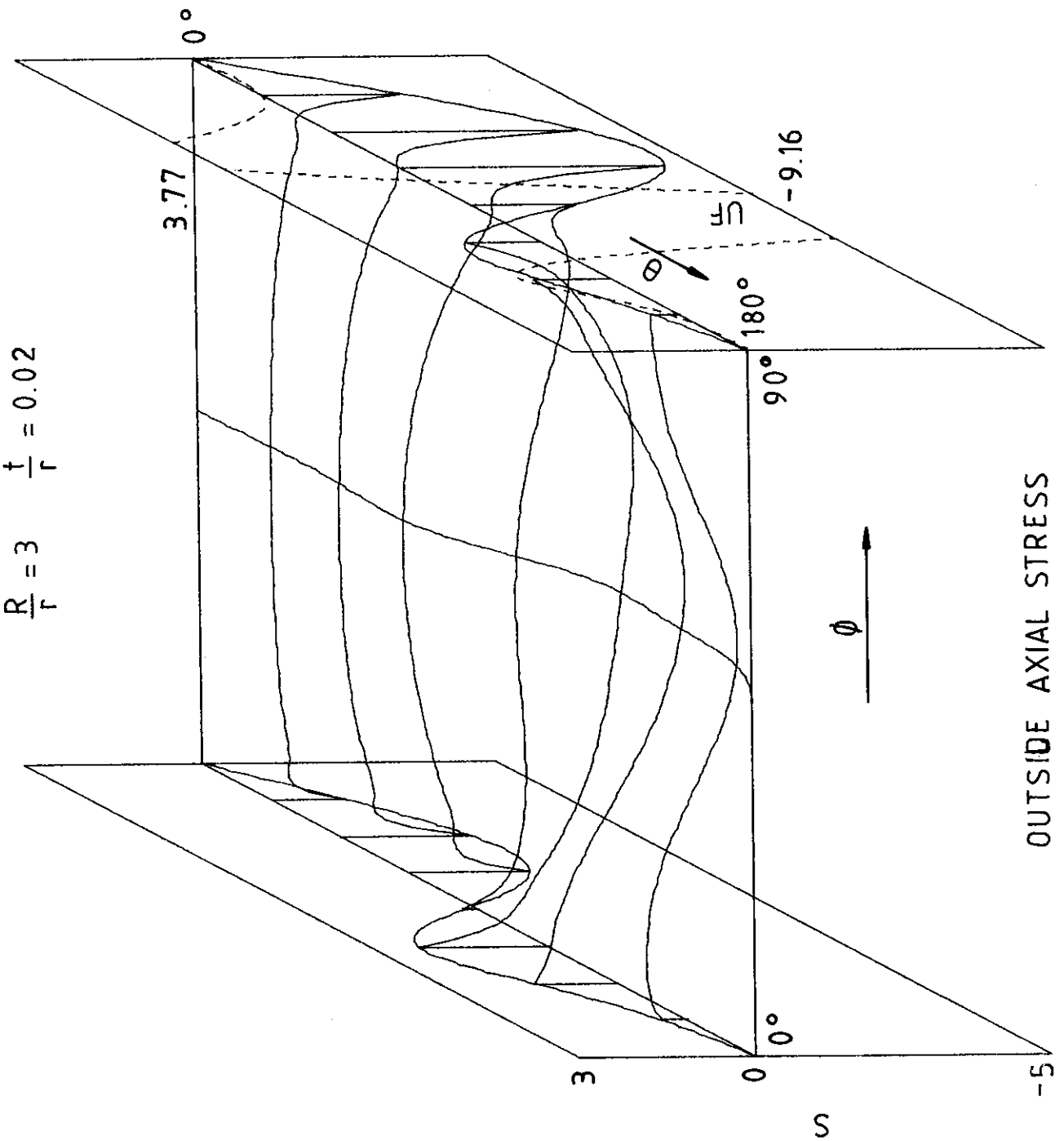
-9.84
UF
θ
180°
90°
0°
φ
1
0
-2
S
OUTSIDE HOOP STRESS

FIGURE A11



OUTSIDE AXIAL STRESS

FIGURE A12

TABLE A11

R/r = 3.0 t/r = 0.02

OUTSIDE HOOP STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	-0.3831	0.0729	0.0270	-0.0000	-0.0156	-0.0229	-0.0237	-0.0180	-0.0044	0.0208	0.0641	0.1398	-0.7030	-0.6920
45.0	-0.6689	0.1491	0.0793	0.0269	-0.0120	-0.0357	-0.0432	-0.0331	-0.0022	0.0533	0.1364	0.2622	-1.2545	-0.0363
67.5	-0.6127	0.2375	0.3296	0.3902	0.4170	0.4268	0.4340	0.4456	0.4583	0.4588	0.4276	0.3767	-1.3433	7.5629
90.0	0.0803	-0.0692	0.0239	0.1680	0.3097	0.4162	0.4723	0.4698	0.4023	0.2721	0.1060	-0.0164	-0.5431	2.4541
112.5	0.6612	-0.1537	-0.4294	-0.6042	-0.6675	-0.6752	-0.6850	-0.7232	-0.7694	-0.7617	-0.6257	-0.3350	0.3836	-9.8090
135.0	0.4234	0.3656	0.2136	-0.0607	-0.3545	-0.5896	-0.7238	-0.7353	-0.6134	-0.3729	-0.0799	0.1518	0.3841	-1.3379
157.5	0.1328	0.3290	0.3122	0.1679	-0.0859	-0.3485	-0.4957	-0.4595	-0.2702	-0.0347	0.1367	0.2071	0.1482	0.2965
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OUTSIDE AXIAL STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	-1.2769	-0.2986	-0.1739	-0.1114	-0.0804	-0.0687	-0.0717	-0.0895	-0.1270	-0.1958	-0.3194	-0.5541	-2.3434	0.0152
45.0	-2.2297	-0.5420	-0.2884	-0.1481	-0.0757	-0.0478	-0.0538	-0.0933	-0.1766	-0.3279	-0.5914	-1.0522	-4.1815	1.9981
67.5	-2.0425	-0.7214	-0.4169	-0.1908	-0.0448	0.0279	0.0326	-0.0345	-0.1895	-0.4600	-0.8787	-1.4677	-4.4776	3.1057
90.0	0.2675	-0.6879	-0.8216	-0.8068	-0.7387	-0.6912	-0.7095	-0.8168	-1.0152	-1.2783	-1.5355	-1.6529	-1.8103	-6.9813
112.5	2.2042	0.2978	-0.3072	-0.7428	-1.0075	-1.1765	-1.3133	-1.4420	-1.5314	-1.4986	-1.2271	-0.6505	1.2788	-5.4215
135.0	1.4112	1.0341	0.6380	0.0828	-0.4593	-0.8890	-1.1483	-1.2019	-1.0290	-0.6365	-0.0874	0.4371	1.2805	1.5641
157.5	0.4426	0.6751	0.5711	0.2594	-0.2026	-0.6488	-0.9031	-0.8693	-0.5766	-0.1641	0.1957	0.3959	0.4940	0.2618
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OUTSIDE SHEAR STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x cos + const.	
0.0	0.1535	0.1033	0.0296	-0.0117	-0.0364	-0.0530	-0.0673	-0.0845	-0.1106	-0.1541	-0.2295	-0.3649	-0.4564	-0.5112	0.2401
22.5	0.0479	0.0397	-0.0059	-0.0316	-0.0470	-0.0572	-0.0660	-0.0769	-0.0938	-0.1222	-0.1707	-0.2561	-0.2696	-0.5537	0.2494
45.0	-0.2532	-0.1726	-0.1348	-0.1088	-0.0900	-0.0752	-0.0617	-0.0471	-0.0286	-0.0021	0.0388	0.1026	0.2695	-0.7704	0.2792
67.5	-0.6001	-0.4770	-0.3533	-0.2614	-0.1858	-0.1183	-0.0508	0.0260	0.1225	0.2510	0.4274	0.6785	0.9822	-0.8647	0.3348
90.0	-0.5490	-0.5161	-0.4300	-0.3461	-0.2500	-0.1354	0.0000	0.1565	0.3346	0.5372	0.7723	1.0604	1.3019	0.0796	0.4247
112.5	-0.0062	-0.1850	-0.2307	-0.2075	-0.1351	-0.0174	0.1387	0.3194	0.5092	0.6964	0.8698	0.9986	0.9445	0.3675	0.5564
135.0	0.4179	0.2740	0.1615	0.1305	0.1656	0.2421	0.3437	0.4614	0.5836	0.6867	0.7308	0.6769	0.5347	-0.5865	0.7227
157.5	0.5677	0.6443	0.6706	0.6625	0.6415	0.6113	0.5708	0.5232	0.4715	0.4147	0.3569	0.3270	0.3525	-0.9399	0.8791
180.0	0.5968	0.7512	0.8908	0.9514	0.9206	0.8227	0.6840	0.5204	0.3520	0.2183	0.1666	0.2133	0.3040	-1.0314	0.9462

DIAMETER EXPANSION FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
45.0	0.0	2.430	5.370	8.851	12.191	14.763	16.114	15.990	14.355	11.429	7.727	3.991	0.0	197.272

TABLE A12

R/r = 3.0 t/r = 0.02

INSIDE HOOP STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	0.0649	0.0760	0.0542	0.0495	0.0488	0.0495	0.0513	0.0543	0.0594	0.0685	0.0865	0.1365	0.1153	0.6230
45.0	0.0981	0.0839	0.0494	0.0530	0.0660	0.0794	0.0894	0.0948	0.0964	0.0981	0.1119	0.1857	0.1735	-0.2434
67.5	0.0269	-0.0751	-0.2497	-0.3519	-0.4021	-0.4210	-0.4252	-0.4214	-0.4034	-0.3518	-0.2379	-0.0158	0.0759	-8.4746
90.0	-0.1601	0.0865	-0.0347	-0.2062	-0.3676	-0.4859	-0.5485	-0.5479	-0.4753	-0.3290	-0.1338	0.0521	-0.2229	-2.8933
112.5	-0.0630	0.3020	0.4760	0.5633	0.5517	0.4989	0.4637	0.4743	0.5139	0.5253	0.4384	0.2516	-0.2489	10.8135
135.0	0.2306	0.1430	0.0566	0.0760	0.1297	0.1698	0.1812	0.1612	0.1042	0.0190	-0.0426	0.0248	0.0529	1.9971
157.5	0.2130	0.1715	0.0536	-0.0565	-0.0972	-0.0882	-0.0897	-0.1341	-0.1888	-0.1834	-0.0815	0.0719	0.1123	-0.0281
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INSIDE AXIAL STRESS FACTORS

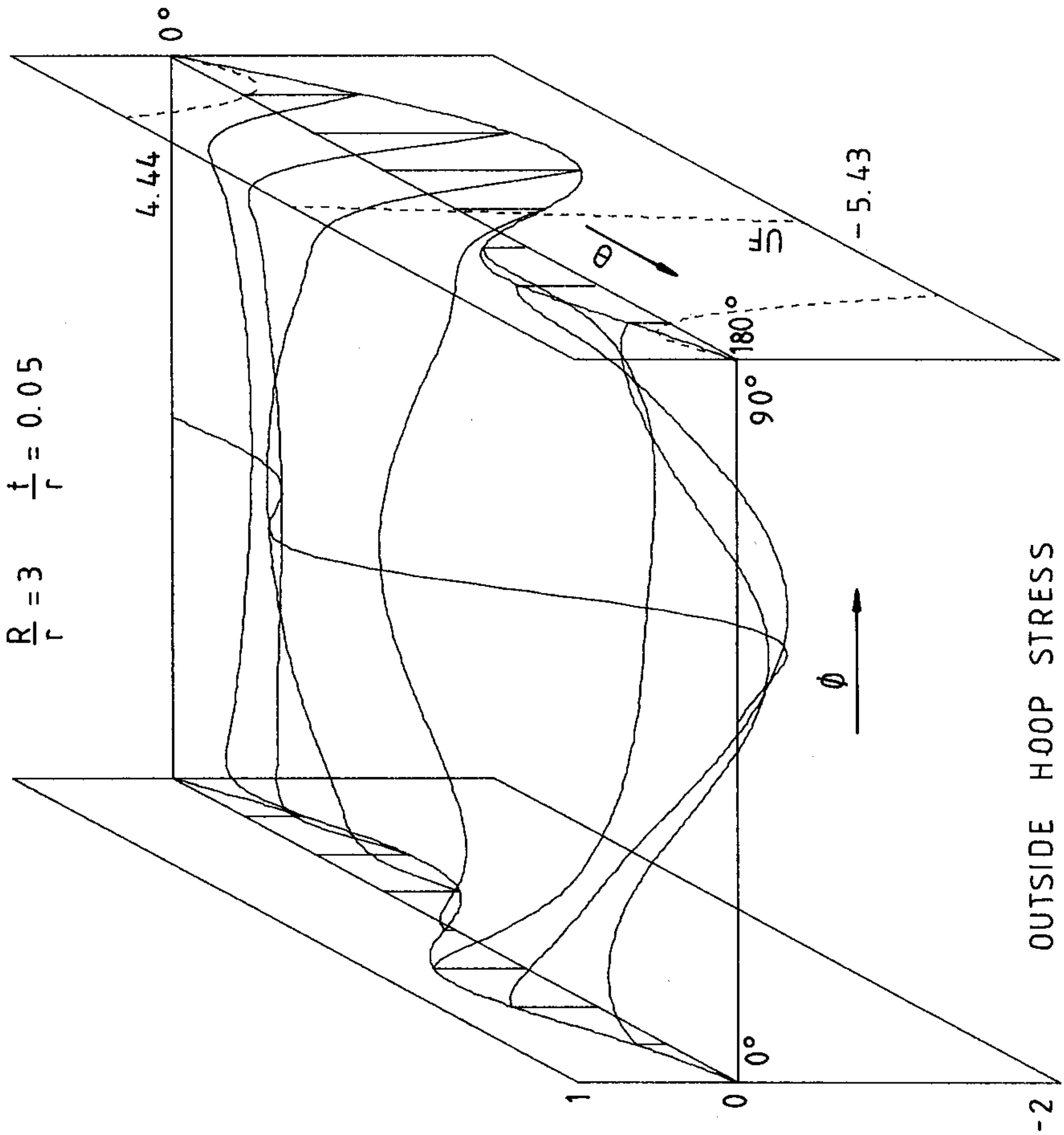
Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	0.2162	-0.2942	-0.1699	-0.1014	-0.0668	-0.0535	-0.0563	-0.0751	-0.1153	-0.1891	-0.3211	-0.5507	0.3842	0.3491
45.0	0.3269	-0.5567	-0.3102	-0.1598	-0.0760	-0.0396	-0.0419	-0.0838	-0.1760	-0.3418	-0.6219	-1.0743	0.5782	1.7025
67.5	0.0898	-0.7528	-0.5666	-0.4148	-0.3085	-0.2547	-0.2596	-0.3316	-0.4820	-0.7245	-1.0724	-1.5367	0.2531	-1.3163
90.0	-0.5336	-0.4344	-0.6611	-0.7628	-0.8149	-0.8591	-0.9253	-1.0279	-1.1633	-1.3075	-1.4150	-1.4062	-0.7429	-6.0262
112.5	-0.2100	0.5075	0.0881	-0.2072	-0.4465	-0.6380	-0.7829	-0.8763	-0.9072	-0.8563	-0.6921	-0.3206	-0.8297	2.5050
135.0	0.7686	0.7595	0.4224	0.0969	-0.1991	-0.4386	-0.5955	-0.6498	-0.5925	-0.4227	-0.1433	0.2587	0.1765	2.8067
157.5	0.7101	0.4536	0.2876	0.0497	-0.1796	-0.3570	-0.4661	-0.4963	-0.4316	-0.2645	-0.0236	0.2201	0.3744	0.3097
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INSIDE SHEAR STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x cos + const.	
0.0	0.1504	0.1327	0.0541	0.0071	-0.0233	-0.0460	-0.0671	-0.0917	-0.1257	-0.1783	-0.2646	-0.4109	-0.4473	-0.1895	0.2312
22.5	0.0469	0.0751	0.0245	-0.0085	-0.0313	-0.0491	-0.0660	-0.0855	-0.1119	-0.1512	-0.2124	-0.3089	-0.2642	-0.1801	0.2404
45.0	-0.2482	-0.1118	-0.0743	-0.0598	-0.0561	-0.0570	-0.0597	-0.0625	-0.0637	-0.0590	-0.0386	0.0172	0.2641	-0.2421	0.2695
67.5	-0.5882	-0.4838	-0.3114	-0.2009	-0.1305	-0.0833	-0.0451	-0.0015	0.0639	0.1726	0.3550	0.6522	0.9628	-0.8576	0.3242
90.0	-0.5382	-0.7601	-0.6176	-0.4582	-0.3043	-0.1613	-0.0185	0.1445	0.3506	0.6177	0.9492	1.3262	1.2761	-1.4623	0.4132
112.5	-0.0061	-0.2599	-0.4406	-0.4657	-0.3645	-0.1712	0.0851	0.3790	0.6810	0.9494	1.1255	1.1447	0.9258	-0.5080	0.5445
135.0	0.4096	0.4334	0.2316	0.0751	0.0339	0.1287	0.3243	0.5473	0.7139	0.7619	0.6792	0.5154	0.5241	-0.0927	0.7118
157.5	0.5565	0.6946	0.7956	0.8270	0.7912	0.7111	0.6048	0.4826	0.3562	0.2498	0.2001	0.2281	0.3455	-0.3319	0.8706
180.0	0.5850	0.7598	1.0001	1.1778	1.2073	1.0468	0.7365	0.3822	0.1053	-0.0160	0.0181	0.1465	0.2980	-0.3800	0.9392

DIAMETER EXPANSION FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
135.0	0.0	-2.430	-5.370	-8.851	-12.191	-14.763	-16.114	-15.990	-14.355	-11.429	-7.727	-3.991	0.0	-197.272



OUTSIDE HOOP STRESS

FIGURE A13

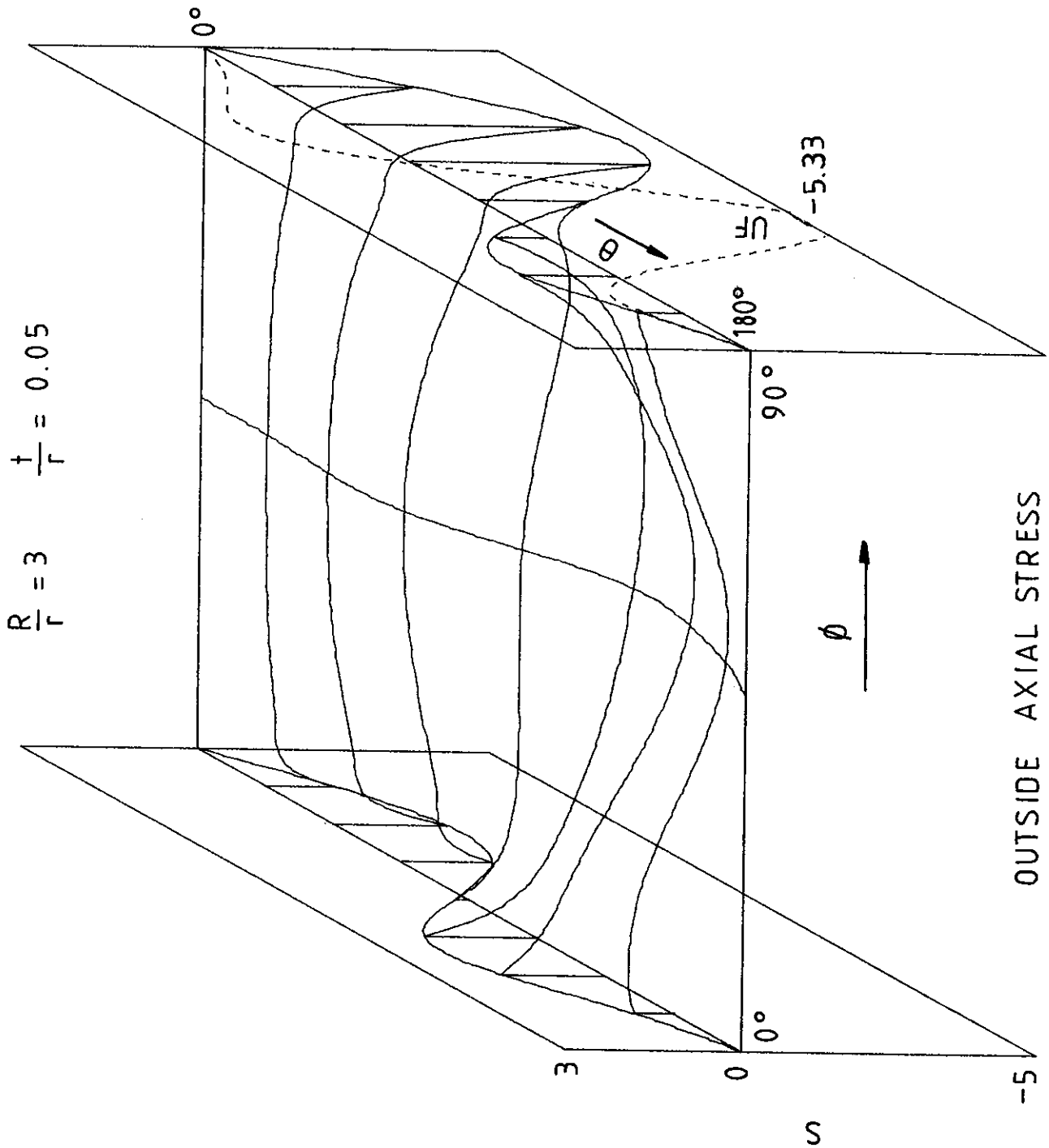

$\frac{R}{r} = 3$
$\frac{t}{r} = 0.05$
0°
-5.33
θ
180°
90°
0°
ϕ
3
0
-5
S
OUTSIDE AXIAL STRESS

FIGURE A14

TABLE A13

R/r = 3.0 t/r = 0.05

OUTSIDE HOOP STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	-0.3665	0.1105	0.0482	0.0078	-0.0251	-0.0472	-0.0559	-0.0489	-0.0242	0.0197	0.0820	0.2031	-0.7155	-0.0802
45.0	-0.5902	0.2304	0.2285	0.2261	0.2132	0.2008	0.1988	0.2127	0.2425	0.2824	0.3221	0.4019	-1.2230	1.9281
67.5	-0.4659	0.2111	0.3562	0.4948	0.6012	0.6749	0.7178	0.7296	0.7054	0.6365	0.5198	0.3928	-1.2261	4.4222
90.0	0.0718	-0.0552	-0.0303	0.1070	0.2619	0.3919	0.4614	0.4509	0.3604	0.2111	0.0492	-0.0240	-0.5673	1.0233
112.5	0.5781	-0.1024	-0.4380	-0.6008	-0.6897	-0.7323	-0.7618	-0.7934	-0.8133	-0.7826	-0.6523	-0.2991	0.2585	-5.0286
135.0	0.5327	0.2797	-0.0339	-0.3729	-0.7230	-1.0086	-1.1739	-1.1866	-1.0402	-0.7602	-0.4048	0.0342	0.4859	-3.4837
157.5	0.2042	0.3646	0.3039	0.0961	-0.1984	-0.4728	-0.6290	-0.6140	-0.4384	-0.1755	0.0681	0.2365	0.2363	-0.0922
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OUTSIDE AXIAL STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	-1.2215	-0.1757	-0.0854	-0.0145	0.0181	0.0295	0.0267	0.0108	-0.0237	-0.0906	-0.2228	-0.3737	-2.3849	0.7824
45.0	-1.9675	-0.3654	-0.1670	0.0032	0.1026	0.1523	0.1598	0.1240	0.0330	-0.1374	-0.4378	-0.7633	-4.0768	1.8182
67.5	-1.5531	-0.6090	-0.4352	-0.2357	-0.0860	0.0046	0.0228	-0.0440	-0.2086	-0.4830	-0.8878	-1.2438	-4.0870	0.4362
90.0	0.2393	-0.6226	-0.7943	-0.8269	-0.8132	-0.8028	-0.8391	-0.9447	-1.1187	-1.3331	-1.5399	-1.5152	-1.8909	-4.1297
112.5	1.9271	0.0874	-0.4507	-0.8550	-1.1637	-1.3932	-1.5650	-1.6824	-1.7267	-1.6555	-1.4181	-0.8644	0.8616	-4.5894
135.0	1.7757	0.9093	0.4463	-0.0956	-0.6374	-1.0803	-1.3582	-1.4271	-1.2700	-0.9013	-0.3876	0.2379	1.6196	-0.4152
157.5	0.6808	0.7858	0.6254	0.2657	-0.1851	-0.5826	-0.8155	-0.8217	-0.5996	-0.2173	0.1844	0.4892	0.7878	0.7363
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OUTSIDE SHEAR STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x cos + const.	
0.0	0.0478	0.0451	-0.0094	-0.0372	-0.0513	-0.0592	-0.0658	-0.0752	-0.0922	-0.1240	-0.1834	-0.2961	-0.2935	-0.5451	0.2465
22.5	-0.0418	-0.0297	-0.0560	-0.0672	-0.0695	-0.0682	-0.0661	-0.0657	-0.0694	-0.0815	-0.1107	-0.1679	-0.1257	-0.6116	0.2559
45.0	-0.2665	-0.2219	-0.1884	-0.1594	-0.1298	-0.0989	-0.0659	-0.0297	0.0109	0.0577	0.1113	0.1892	0.3228	-0.7361	0.2861
67.5	-0.4640	-0.3859	-0.3254	-0.2667	-0.2056	-0.1344	-0.0511	0.0443	0.1516	0.2739	0.4204	0.6142	0.8417	-0.6284	0.3424
90.0	-0.3984	-0.3320	-0.2990	-0.2469	-0.1824	-0.0948	0.0171	0.1484	0.2933	0.4522	0.6369	0.8435	1.0885	-0.1126	0.4330
112.5	-0.0382	-0.0996	-0.0863	-0.0420	0.0157	0.0843	0.1663	0.2651	0.3844	0.5278	0.6943	0.8467	0.9208	0.1426	0.5650
135.0	0.3382	0.1932	0.1958	0.2326	0.2851	0.3291	0.3646	0.4073	0.4752	0.5713	0.6703	0.7307	0.6094	-0.3942	0.7304
157.5	0.5441	0.5360	0.5396	0.5322	0.5334	0.5411	0.5507	0.5579	0.5580	0.5442	0.5123	0.4843	0.4114	-0.9429	0.8850
180.0	0.6051	0.7047	0.7281	0.6959	0.6553	0.6357	0.6344	0.6256	0.5805	0.4906	0.3866	0.3384	0.3487	-1.0816	0.9510

DIAMETER EXPANSION FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
45.0	0.0	2.157	4.852	7.756	10.463	12.546	13.669	13.627	12.379	10.063	6.992	3.564	0.0	78.281

TABLE A14

R/r = 3.0 t/r = 0.05

INSIDE HOOP STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	0.0942	0.0109	0.0158	0.0292	0.0494	0.0670	0.0776	0.0791	0.0718	0.0589	0.0532	0.0511	0.1738	-0.0109
45.0	0.1313	-0.0692	-0.1464	-0.1888	-0.1971	-0.1919	-0.1862	-0.1858	-0.1869	-0.1758	-0.1216	-0.0416	0.2596	-2.2847
67.5	0.0359	-0.1001	-0.3192	-0.5073	-0.6433	-0.7310	-0.7745	-0.7735	-0.7192	-0.5965	-0.3828	-0.1441	0.1419	-5.0923
90.0	-0.1578	0.1633	0.0378	-0.1425	-0.3423	-0.5075	-0.5962	-0.5854	-0.4733	-0.2840	-0.0603	0.0865	-0.1715	-1.3145
112.5	-0.1844	0.3785	0.5136	0.6103	0.6176	0.5833	0.5593	0.5702	0.6019	0.6031	0.5176	0.3400	-0.3486	5.6401
135.0	0.0456	0.1946	0.2260	0.4013	0.5988	0.7549	0.8303	0.8033	0.6732	0.4631	0.2396	0.1441	-0.1642	4.1906
157.5	0.1566	0.0443	-0.0894	-0.0717	0.0600	0.2105	0.2845	0.2335	0.0809	-0.0852	-0.1466	-0.0220	0.0274	0.3942
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INSIDE AXIAL STRESS FACTORS

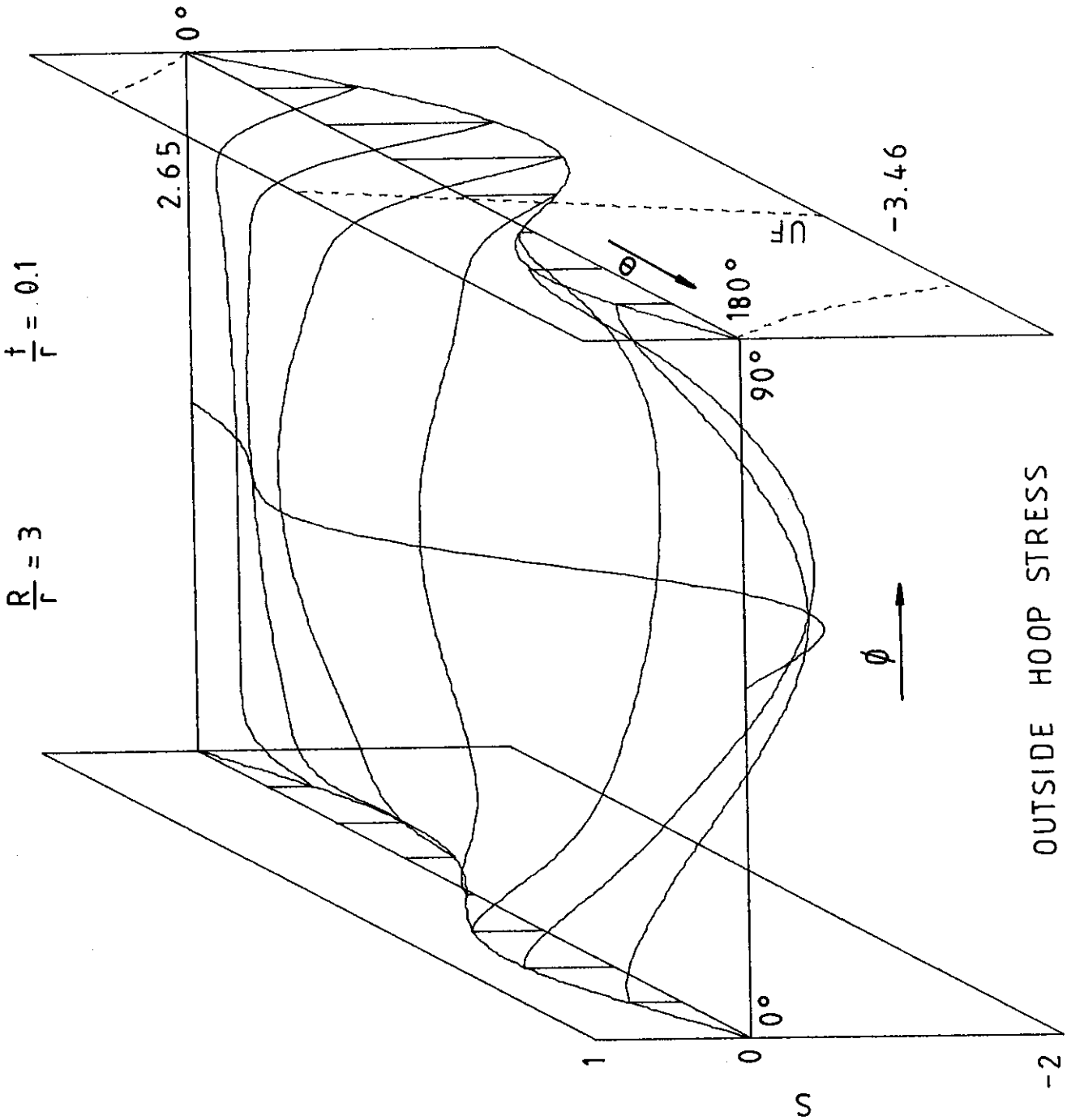
Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	0.3141	-0.2894	-0.1065	-0.0272	0.0193	0.0411	0.0429	0.0239	-0.0217	-0.1072	-0.2506	-0.5966	0.5792	0.7086
45.0	0.4375	-0.5546	-0.2816	-0.1498	-0.0631	-0.0183	-0.0151	-0.0582	-0.1574	-0.3295	-0.5928	-1.1760	0.8654	0.4770
67.5	0.1198	-0.6488	-0.5330	-0.4778	-0.4354	-0.4206	-0.4444	-0.5163	-0.6430	-0.8290	-1.0682	-1.5520	0.4731	-1.7656
90.0	-0.5260	-0.2916	-0.4918	-0.6453	-0.7653	-0.8713	-0.9683	-1.0582	-1.1397	-1.2065	-1.2326	-1.2998	-0.5717	-2.9510
112.5	-0.6146	0.3477	0.0511	-0.2067	-0.4253	-0.6133	-0.7547	-0.8368	-0.8546	-0.8061	-0.6652	-0.4691	-1.1619	0.3277
135.0	0.1519	0.5601	0.3562	0.1633	0.0138	-0.1094	-0.2054	-0.2693	-0.2910	-0.2538	-0.1172	0.0710	-0.5473	2.4311
157.5	0.5219	0.3089	0.1723	0.0665	0.0120	-0.0172	-0.0477	-0.0905	-0.1316	-0.1345	-0.0522	0.0848	0.0914	1.0080
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INSIDE SHEAR STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x cos + const.	
0.0	0.0455	0.1453	0.0583	0.0133	-0.0177	-0.0421	-0.0653	-0.0926	-0.1301	-0.1870	-0.2761	-0.4521	-0.2791	-0.1435	0.2244
22.5	-0.0398	0.0832	0.0311	0.0022	-0.0209	-0.0417	-0.0632	-0.0884	-0.1210	-0.1657	-0.2284	-0.3474	-0.1196	-0.1772	0.2333
45.0	-0.2535	-0.1370	-0.0851	-0.0591	-0.0498	-0.0512	-0.0589	-0.0682	-0.0736	-0.0678	-0.0388	0.0203	0.3071	-0.3760	0.2621
67.5	-0.4414	-0.5050	-0.3418	-0.2351	-0.1593	-0.1035	-0.0558	-0.0018	0.0755	0.1957	0.3826	0.6803	0.8006	-0.8302	0.3160
90.0	-0.3789	-0.6997	-0.5952	-0.4751	-0.3426	-0.1975	-0.0358	0.1496	0.3671	0.6240	0.9234	1.2754	1.0354	-1.1230	0.4042
112.5	-0.0363	-0.2977	-0.4380	-0.4514	-0.3589	-0.1767	0.0727	0.3607	0.6540	0.9159	1.1067	1.1830	0.8759	-0.7053	0.5352
135.0	0.3217	0.3893	0.1999	0.0854	0.0758	0.1644	0.3223	0.5051	0.6608	0.7397	0.7069	0.5685	0.5796	-0.1959	0.7032
157.5	0.5176	0.7331	0.8135	0.8315	0.7990	0.7236	0.6167	0.4923	0.3665	0.2577	0.1848	0.1818	0.3913	-0.2404	0.8638
180.0	0.5756	0.7890	1.0384	1.1828	1.1753	1.0179	0.7519	0.4430	0.1681	-0.0009	-0.0219	0.1049	0.3317	-0.3540	0.9334

DIAMETER EXPANSION FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
135.0	0.0	-2.157	-4.852	-7.756	-10.463	-12.546	-13.669	-13.627	-12.379	-10.063	-6.992	-3.564	0.0	-78.281



OUTSIDE HOOP STRESS

FIGURE A15

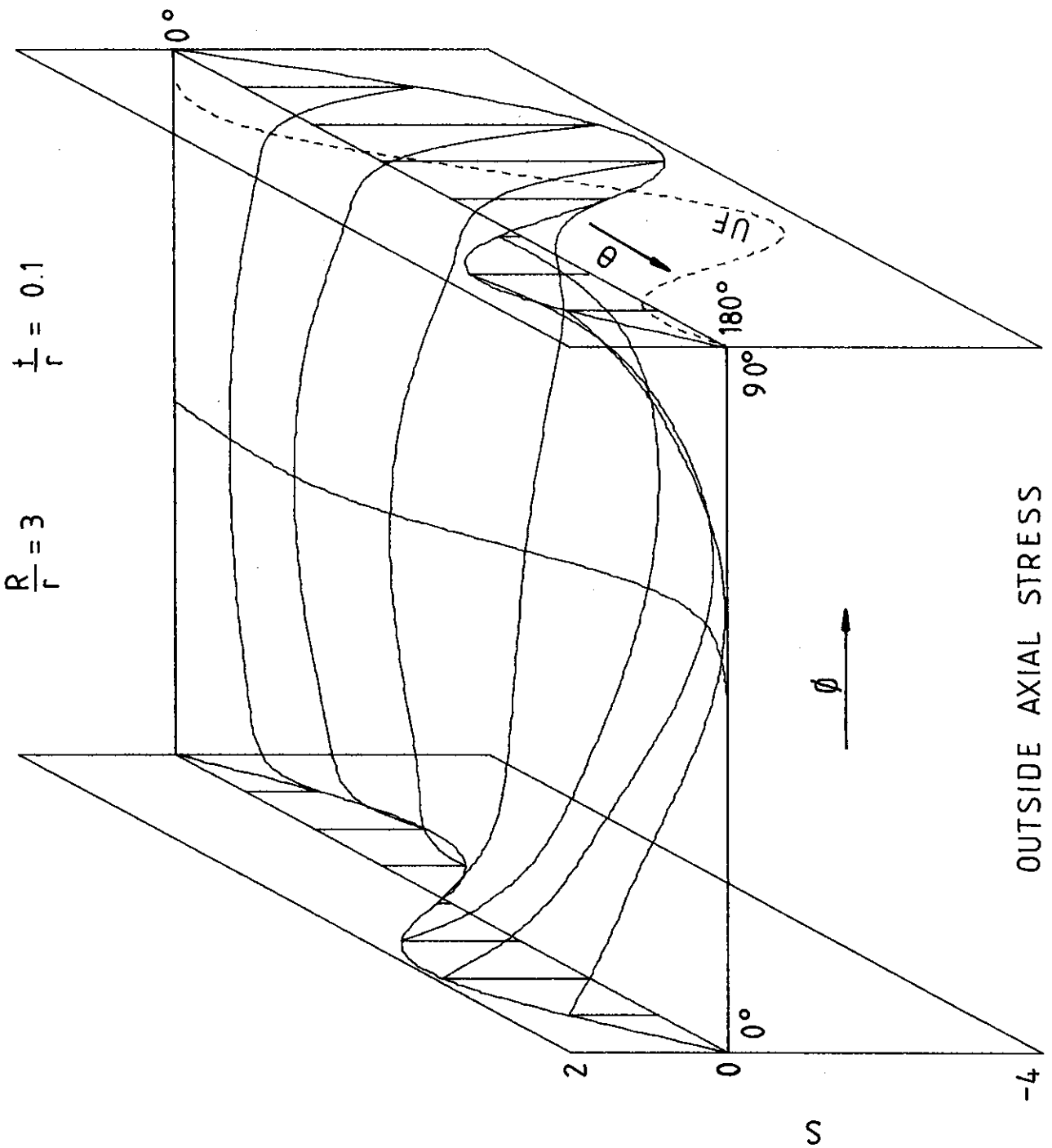


FIGURE A16

TABLE A15

R/r = 3.0 t/r = 0.1

OUTSIDE HOOP STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	-0.2860	0.1142	0.1583	0.1601	0.1600	0.1592	0.1622	0.1721	0.1888	0.2098	0.2450	0.2078	-0.6561	0.8542
45.0	-0.4308	0.1779	0.3119	0.3800	0.4366	0.4779	0.5065	0.5228	0.5249	0.5090	0.4938	0.3209	-1.0846	2.1075
67.5	-0.3170	0.1280	0.2961	0.4486	0.5904	0.6993	0.7638	0.7753	0.7293	0.6291	0.5083	0.2178	-1.0825	2.5708
90.0	0.0546	0.0085	-0.0204	0.0633	0.1721	0.2623	0.3103	0.3022	0.2363	0.1303	0.0389	-0.0715	-0.6007	0.4712
112.5	0.4566	0.0306	-0.3239	-0.5033	-0.6214	-0.7074	-0.7644	-0.7913	-0.7819	-0.7188	-0.5533	-0.2211	0.0774	-2.7379
135.0	0.5658	0.2334	-0.1980	-0.5591	-0.8841	-1.1472	-1.3057	-1.3305	-1.2137	-0.9646	-0.5848	-0.0397	0.4562	-3.1872
157.5	0.3394	0.2769	0.0541	-0.2047	-0.4720	-0.6993	-0.8341	-0.8439	-0.7259	-0.5055	-0.2157	0.1230	0.3490	-1.2881
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OUTSIDE AXIAL STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	-0.9533	-0.1146	-0.0112	0.0754	0.1343	0.1684	0.1801	0.1673	0.1239	0.0356	-0.1041	-0.2597	-2.1871	0.8181
45.0	-1.4360	-0.2892	-0.1236	0.0331	0.1491	0.2200	0.2432	0.2110	0.1122	-0.0738	-0.3438	-0.6325	-3.6154	0.9854
67.5	-1.0567	-0.4832	-0.4095	-0.2829	-0.1787	-0.1170	-0.1106	-0.1732	-0.3166	-0.5535	-0.8506	-1.1048	-3.6082	-0.3937
90.0	0.1821	-0.4446	-0.6790	-0.7592	-0.8186	-0.8802	-0.9552	-1.0529	-1.1770	-1.3245	-1.4334	-1.3448	-2.0022	-2.7771
112.5	1.5219	0.0747	-0.4882	-0.8499	-1.1667	-1.4316	-1.6278	-1.7436	-1.7693	-1.6958	-1.4710	-0.9020	0.2579	-3.3896
135.0	1.8860	0.7305	0.1290	-0.3606	-0.8290	-1.2214	-1.4839	-1.5807	-1.4935	-1.2254	-0.7762	-0.0123	1.5207	-1.4047
157.5	1.1315	0.7415	0.4032	0.0553	-0.3041	-0.6094	-0.8043	-0.8533	-0.7420	-0.4851	-0.1190	0.3829	1.1633	0.1614
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OUTSIDE SHEAR STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x cos + const.	
0.0	-0.0739	-0.0896	-0.0915	-0.0988	-0.0931	-0.0820	-0.0693	-0.0579	-0.0512	-0.0557	-0.0881	-0.0934	-0.0918	-0.6185	0.2566
22.5	-0.1262	-0.1324	-0.1284	-0.1270	-0.1136	-0.0936	-0.0703	-0.0464	-0.0251	-0.0121	-0.0196	0.0041	0.0303	-0.6404	0.2663
45.0	-0.2467	-0.2200	-0.2103	-0.1907	-0.1595	-0.1176	-0.0669	-0.0103	0.0487	0.1062	0.1602	0.2431	0.3437	-0.6494	0.2972
67.5	-0.3343	-0.2541	-0.2513	-0.2199	-0.1745	-0.1137	-0.0380	0.0499	0.1462	0.2493	0.3652	0.4858	0.6970	-0.5179	0.3545
90.0	-0.2732	-0.1658	-0.1599	-0.1244	-0.0784	-0.0223	0.0462	0.1287	0.2269	0.3447	0.4888	0.6169	0.8990	-0.2264	0.4462
112.5	-0.0351	0.0017	0.0422	0.0902	0.1326	0.1652	0.1946	0.2335	0.2964	0.3963	0.5355	0.6667	0.8573	-0.0669	0.5785
135.0	0.2687	0.1901	0.2425	0.2935	0.3338	0.3588	0.3738	0.3930	0.4328	0.5046	0.6048	0.6990	0.6713	-0.3595	0.7424
157.5	0.4955	0.4027	0.4084	0.4154	0.4354	0.4744	0.5265	0.5820	0.6294	0.6592	0.6707	0.6632	0.5086	-0.8685	0.8937
180.0	0.5767	0.5169	0.4905	0.4619	0.4631	0.5098	0.5895	0.6729	0.7267	0.7277	0.6819	0.6152	0.4495	-1.0955	0.9579

DIAMETER EXPANSION FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
45.0	0.0	1.423	3.502	5.624	7.560	9.054	9.891	9.925	9.107	7.492	5.244	2.484	0.0	34.391

TABLE A16

R/r = 3.0 t/r = 0.1

INSIDE HOOP STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	0.0911	-0.0983	-0.1235	-0.1507	-0.1590	-0.1598	-0.1600	-0.1626	-0.1661	-0.1614	-0.1311	-0.1556	0.1977	-0.9811
45.0	0.1168	-0.1600	-0.2725	-0.3896	-0.4681	-0.5189	-0.5466	-0.5512	-0.5279	-0.4622	-0.3323	-0.2858	0.2865	-2.4476
67.5	0.0321	-0.0844	-0.2700	-0.4899	-0.6738	-0.8101	-0.8847	-0.8857	-0.8059	-0.6387	-0.3864	-0.2513	0.1816	-3.0490
90.0	-0.1303	0.1508	0.0699	-0.0918	-0.2586	-0.3969	-0.4725	-0.4640	-0.3689	-0.2014	-0.0008	0.0228	-0.0957	-0.6645
112.5	-0.2274	0.3130	0.4421	0.5283	0.5861	0.6154	0.6297	0.6361	0.6282	0.5914	0.5045	0.2637	-0.3451	3.1348
135.0	-0.1514	0.2103	0.3536	0.5888	0.8533	1.0662	1.1768	1.1578	1.0054	0.7489	0.4585	0.1830	-0.3482	3.7918
157.5	-0.0243	0.0448	0.0566	0.2000	0.4175	0.6128	0.7129	0.6807	0.5215	0.2914	0.0939	0.0089	-0.1670	1.6142
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INSIDE AXIAL STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	0.3035	-0.2541	-0.1146	-0.0445	-0.0012	0.0235	0.0275	0.0075	-0.0417	-0.1259	-0.2766	-0.6171	0.6590	0.1827
45.0	0.3892	-0.4418	-0.2800	-0.2025	-0.1580	-0.1378	-0.1467	-0.1905	-0.2764	-0.4111	-0.6454	-1.1357	0.9552	-0.3178
67.5	0.1070	-0.4571	-0.4211	-0.4410	-0.4716	-0.5104	-0.5621	-0.6304	-0.7197	-0.8318	-1.0170	-1.3772	0.6053	-1.3931
90.0	-0.4343	-0.2323	-0.3311	-0.4933	-0.6341	-0.7561	-0.8600	-0.9426	-1.0015	-1.0320	-1.0668	-1.1780	-0.3189	-1.6429
112.5	-0.7581	0.0854	0.0136	-0.1843	-0.3477	-0.4816	-0.5901	-0.6683	-0.7079	-0.6943	-0.6375	-0.6723	-1.1504	-0.1249
135.0	-0.5045	0.2162	0.2509	0.1536	0.0868	0.0380	-0.0138	-0.0734	-0.1302	-0.1569	-0.1433	-0.2649	-1.1608	1.4240
157.5	-0.0811	0.1297	0.1745	0.1673	0.1821	0.2019	0.2007	0.1675	0.1100	0.0548	0.0189	-0.0994	-0.5568	1.2064
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INSIDE SHEAR STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x cos + const.	
0.0	-0.0668	0.1291	0.0603	0.0258	-0.0013	-0.0288	-0.0598	-0.0971	-0.1442	-0.2057	-0.2986	-0.4927	-0.0831	-0.1568	0.2125
22.5	-0.1142	0.0519	0.0186	0.0011	-0.0159	-0.0363	-0.0614	-0.0919	-0.1287	-0.1730	-0.2355	-0.3581	0.0274	-0.2222	0.2212
45.0	-0.2232	-0.1709	-0.1219	-0.0925	-0.0767	-0.0697	-0.0678	-0.0670	-0.0624	-0.0469	-0.0155	0.0481	0.3109	-0.4292	0.2491
67.5	-0.3025	-0.4582	-0.3562	-0.2740	-0.2066	-0.1426	-0.0751	0.0021	0.0969	0.2208	0.3913	0.6483	0.6306	-0.7333	0.3019
90.0	-0.2472	-0.5808	-0.5412	-0.4548	-0.3466	-0.2127	-0.0517	0.1354	0.3477	0.5856	0.8550	1.1439	0.8134	-0.9134	0.3887
112.5	-0.0318	-0.3025	-0.3991	-0.3855	-0.2937	-0.1380	0.0688	0.3111	0.5694	0.8201	1.0350	1.1482	0.7757	-0.7286	0.5190
135.0	0.2431	0.2680	0.1628	0.1138	0.1354	0.2112	0.3246	0.4576	0.5884	0.6878	0.7237	0.6768	0.6074	-0.3556	0.6882
157.5	0.4483	0.7246	0.8012	0.8025	0.7696	0.7080	0.6223	0.5197	0.4094	0.3011	0.2127	0.2083	0.4602	-0.2103	0.8515
180.0	0.5218	0.8715	1.0695	1.1297	1.0851	0.9545	0.7591	0.5264	0.2901	0.0905	-0.0203	0.0475	0.4067	-0.2328	0.9228

DIAMETER EXPANSION FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
135.0	0.0	-1.423	-3.502	-5.624	-7.560	-9.054	-9.891	-9.925	-9.107	-7.492	-5.244	-2.484	0.0	-34.391

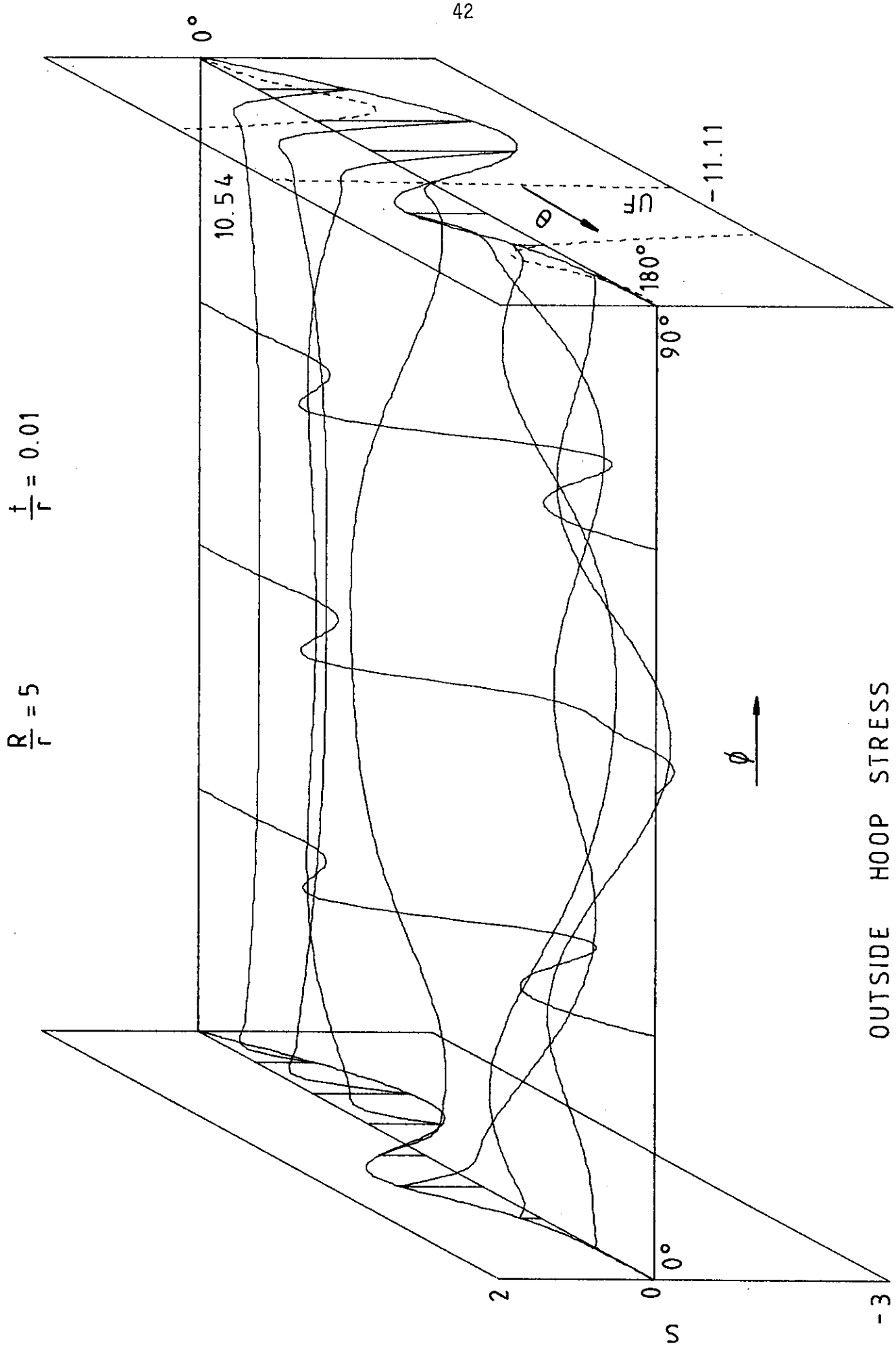
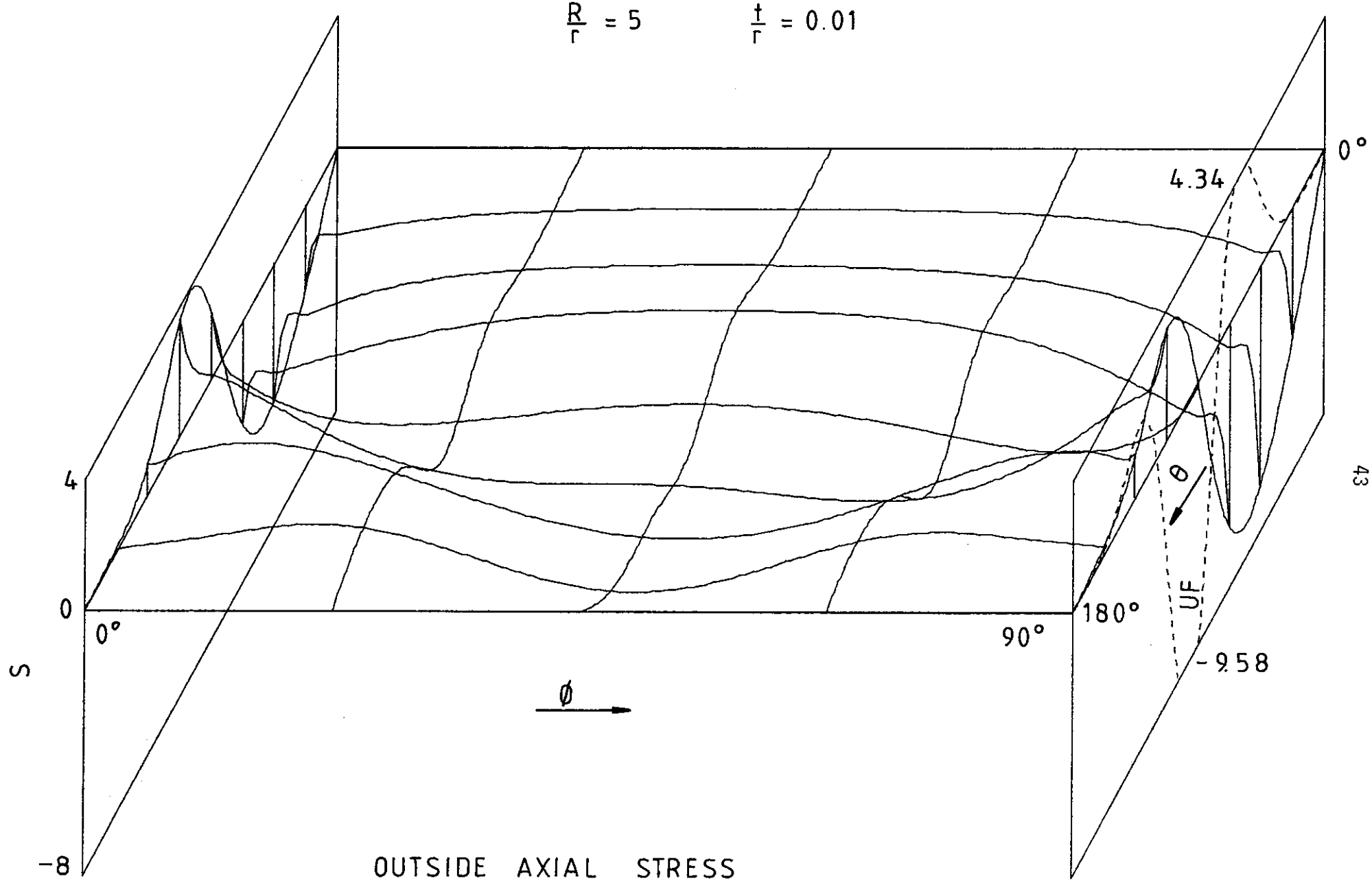


FIGURE A17



OUTSIDE AXIAL STRESS

FIGURE A18

TABLE A17

R/r = 5.0 t/r = 0.01

OUTSIDE HOOP STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	-0.7653	0.0874	0.0221	-0.0129	-0.0301	-0.0376	-0.0386	-0.0335	-0.0206	0.0047	0.0530	0.1424	-1.1653	-0.5082
45.0	-1.2671	0.1505	0.0227	-0.0756	-0.1352	-0.1639	-0.1743	-0.1716	-0.1477	-0.0839	0.0382	0.2200	-1.9936	-0.3540
67.5	-0.9341	0.4360	0.7075	0.8068	0.7875	0.7345	0.7037	0.7166	0.7672	0.8120	0.7636	0.5413	-1.8347	8.9538
90.0	0.6043	-0.2514	-0.0396	0.3694	0.7103	0.8921	0.9685	0.9920	0.9098	0.6312	0.1920	-0.1492	-0.0359	1.7888
112.5	1.0648	-0.2724	-1.0187	-1.4108	-1.3462	-1.0572	-0.8782	-1.0019	-1.3234	-1.5147	-1.2493	-0.4873	1.0170	-10.6752
135.0	0.2720	0.5668	0.5912	0.1300	-0.4041	-0.7597	-0.9251	-0.9260	-0.7110	-0.2263	0.3394	0.5073	0.3908	-0.4015
157.5	0.0311	0.1314	0.4657	0.6410	0.2565	-0.4635	-0.9107	-0.7013	-0.0320	0.4946	0.4791	0.1816	0.0801	0.2573
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OUTSIDE AXIAL STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	-2.5508	-0.5792	-0.2954	-0.1630	-0.1001	-0.0737	-0.0713	-0.0917	-0.1431	-0.2481	-0.4588	-0.8965	-3.8844	-0.0187
45.0	-4.2236	-0.9974	-0.4498	-0.1853	-0.0640	-0.0169	-0.0175	-0.0637	-0.1710	-0.3838	-0.8041	-1.6398	-6.6453	1.8848
67.5	-3.1136	-1.1318	-0.4766	-0.0176	0.2391	0.3455	0.3580	0.2965	0.1226	-0.2548	-0.9479	-2.0299	-6.1156	3.7060
90.0	2.0144	-0.8796	-1.3684	-1.2900	-1.0247	-0.8029	-0.7334	-0.8586	-1.1899	-1.6706	-2.0911	-2.0053	-0.1197	-7.8975
112.5	3.5494	1.1363	-0.1365	-0.9788	-1.3399	-1.3993	-1.4404	-1.6312	-1.8605	-1.8118	-1.1673	0.2227	3.3900	-4.0912
135.0	0.9066	1.5454	1.3649	0.6626	-0.1538	-0.8478	-1.2478	-1.2388	-0.8235	-0.0845	0.7975	1.3726	1.3026	1.9575
157.5	0.1036	0.4652	0.8306	0.7833	0.1664	-0.6426	-1.1244	-0.9860	-0.3221	0.4108	0.7066	0.5221	0.2671	0.2361
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OUTSIDE SHEAR STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x cos + const.	
0.0	0.4411	0.2635	0.1288	0.0649	0.0347	0.0199	0.0104	-0.0017	-0.0251	-0.0739	-0.1747	-0.3824	-0.6519	-0.5157	0.3290
22.5	0.2315	0.1610	0.0808	0.0417	0.0239	0.0166	0.0129	0.0074	-0.0060	-0.0365	-0.1004	-0.2277	-0.3365	-0.5373	0.3374
45.0	-0.3312	-0.1635	-0.0843	-0.0397	-0.0129	0.0055	0.0212	0.0376	0.0586	0.0912	0.1492	0.2590	0.5262	-0.6727	0.3634
67.5	-0.8474	-0.5730	-0.3581	-0.2124	-0.1065	-0.0297	0.0313	0.0986	0.1985	0.3548	0.5934	0.9643	1.4825	-0.7298	0.4084
90.0	-0.4032	-0.4309	-0.3628	-0.3027	-0.2147	-0.0923	0.0576	0.2300	0.4216	0.6275	0.8545	1.1437	1.3655	-0.0536	0.4729
112.5	0.4345	0.0657	-0.0391	-0.0755	-0.0824	-0.0126	0.1513	0.3502	0.5098	0.6190	0.7110	0.7429	0.4253	-0.0344	0.5541
135.0	0.4131	0.3440	0.1821	0.1569	0.2202	0.2769	0.2884	0.3043	0.3832	0.4968	0.5326	0.3901	0.2471	-0.6071	0.6405
157.5	0.2060	0.3613	0.4071	0.4092	0.4360	0.4408	0.3950	0.3344	0.3059	0.2987	0.2628	0.2609	0.4064	-0.7397	0.7100
180.0	0.1522	0.2763	0.4940	0.5922	0.5151	0.4310	0.4291	0.4221	0.3019	0.1343	0.1276	0.3063	0.4585	-0.7749	0.7371

DIAMETER EXPANSION FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
45.0	0.0	4.273	13.245	27.512	42.708	54.571	60.429	59.024	50.368	36.087	20.090	7.756	0.0	390.564

TABLE A18

R/r = 5.0 t/r = 0.01

INSIDE HOOP STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	0.0387	0.0918	0.0655	0.0570	0.0536	0.0524	0.0526	0.0539	0.0574	0.0658	0.0855	0.1361	0.0557	0.4543
45.0	0.0307	0.1084	0.1095	0.1432	0.1703	0.1849	0.1941	0.2028	0.2071	0.1985	0.1809	0.1988	0.0391	0.1686
67.5	-0.0893	-0.2944	-0.6508	-0.7993	-0.8042	-0.7607	-0.7295	-0.7319	-0.7592	-0.7597	-0.6297	-0.2681	-0.1296	-9.5582
90.0	-0.1775	0.2740	0.0258	-0.4220	-0.7816	-0.9638	-1.0381	-1.0682	-0.9935	-0.7050	-0.2292	0.1592	-0.3270	-1.9601
112.5	0.2317	0.4918	1.1463	1.4530	1.3138	0.9696	0.7562	0.8665	1.1989	1.4315	1.2391	0.5864	0.0760	11.3356
135.0	0.3273	-0.1679	-0.2929	0.0205	0.3801	0.5586	0.6121	0.6180	0.5100	0.1827	-0.1988	-0.1750	0.3162	0.7172
157.5	0.1002	0.1055	-0.1637	-0.4495	-0.2680	0.2745	0.6236	0.4133	-0.1409	-0.4586	-0.2589	0.0637	0.1246	-0.1380
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INSIDE AXIAL STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	0.1290	-0.5760	-0.2834	-0.1454	-0.0801	-0.0528	-0.0506	-0.0720	-0.1256	-0.2344	-0.4518	-0.8987	0.1857	0.2448
45.0	0.1023	-1.0024	-0.4353	-0.1395	0.0044	0.0629	0.0671	0.0224	-0.0902	-0.3223	-0.7770	-1.6426	0.1304	1.9177
67.5	-0.2975	-1.2757	-0.8605	-0.5058	-0.2590	-0.1279	-0.0989	-0.1689	-0.3686	-0.7509	-1.3598	-2.2018	-0.4318	-1.5375
90.0	-0.5918	-0.5515	-1.1327	-1.3320	-1.3188	-1.2403	-1.2322	-1.3698	-1.6274	-1.8914	-1.9944	-1.6993	-1.0899	-7.3296
112.5	0.7724	1.2544	0.5963	0.0788	-0.3317	-0.6351	-0.8317	-0.9189	-0.8792	-0.6762	-0.2544	0.4993	0.2532	3.3151
135.0	1.0908	1.1358	0.8760	0.5343	0.1401	-0.2746	-0.5481	-0.5493	-0.3160	0.0287	0.4557	0.9499	1.0540	2.3153
157.5	0.3341	0.4826	0.4868	0.2027	-0.0942	-0.2407	-0.3107	-0.3812	-0.3534	-0.0899	0.2975	0.4747	0.4155	0.1540
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INSIDE SHEAR STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x cos + const.	
0.0	0.4367	0.3009	0.1611	0.0915	0.0540	0.0306	0.0116	-0.0103	-0.0438	-0.1024	-0.2129	-0.4323	-0.6454	-0.3002	0.3242
22.5	0.2292	0.2022	0.1176	0.0716	0.0453	0.0283	0.0139	-0.0026	-0.0272	-0.0688	-0.1434	-0.2808	-0.3331	-0.3021	0.3326
45.0	-0.3279	-0.0852	-0.0100	0.0141	0.0205	0.0223	0.0235	0.0249	0.0272	0.0355	0.0663	0.1642	0.5210	-0.3419	0.3585
67.5	-0.8389	-0.5884	-0.2890	-0.1183	-0.0294	0.0154	0.0447	0.0777	0.1353	0.2545	0.4943	0.9407	1.4678	-0.7676	0.4032
90.0	-0.3992	-0.7783	-0.6339	-0.4082	-0.1980	-0.0446	0.0619	0.1791	0.3758	0.6884	1.1006	1.5235	1.3519	-1.0978	0.4676
112.5	0.4302	0.1276	-0.2780	-0.4335	-0.3760	-0.1792	0.0994	0.4191	0.7363	0.9792	1.0323	0.7793	0.4211	-0.3967	0.5488
135.0	0.4090	0.5928	0.4283	0.1249	-0.0806	-0.0403	0.2290	0.5523	0.7170	0.6208	0.3400	0.1055	0.2446	-0.2756	0.6354
157.5	0.2040	0.3148	0.5240	0.6273	0.6200	0.5463	0.4241	0.2826	0.1554	0.0688	0.0886	0.2593	0.4024	-0.4238	0.7053
180.0	0.1507	0.1963	0.3920	0.7587	1.0090	0.9179	0.5265	0.0584	-0.2161	-0.1410	0.1552	0.3695	0.4540	-0.4487	0.7325

DIAMETER EXPANSION FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
135.0	0.0	-4.273	-13.245	-27.512	-42.708	-54.571	-60.429	-59.024	-50.368	-36.087	-20.090	-7.756	0.0	-390.564

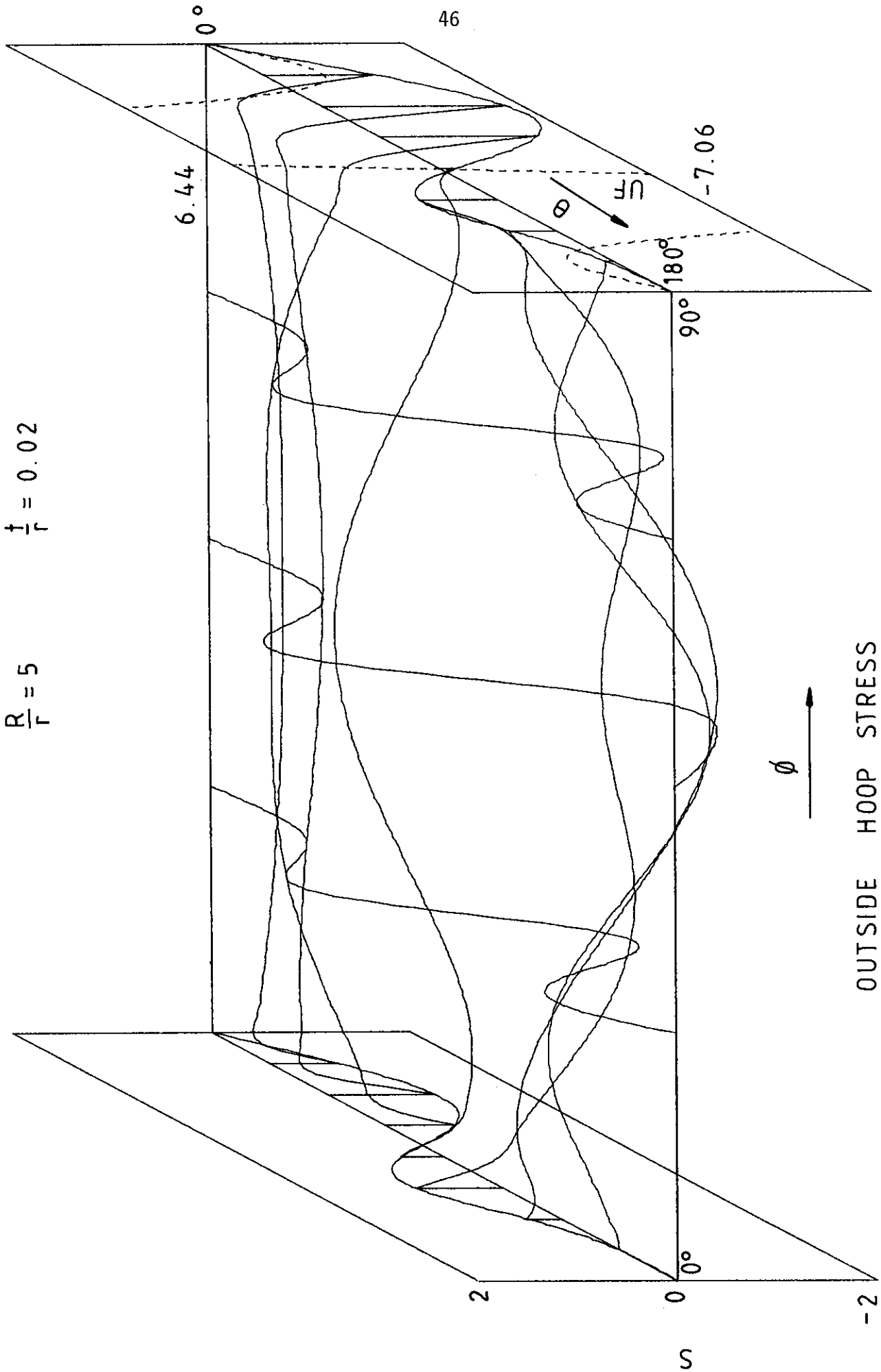

0°
6.44
-7.06
UF
θ
180°
90°
$\frac{R}{r} = 5$
$\frac{t}{r} = 0.02$
ϕ
OUTSIDE HOOP STRESS
2
0
-2
S
0°

FIGURE A19

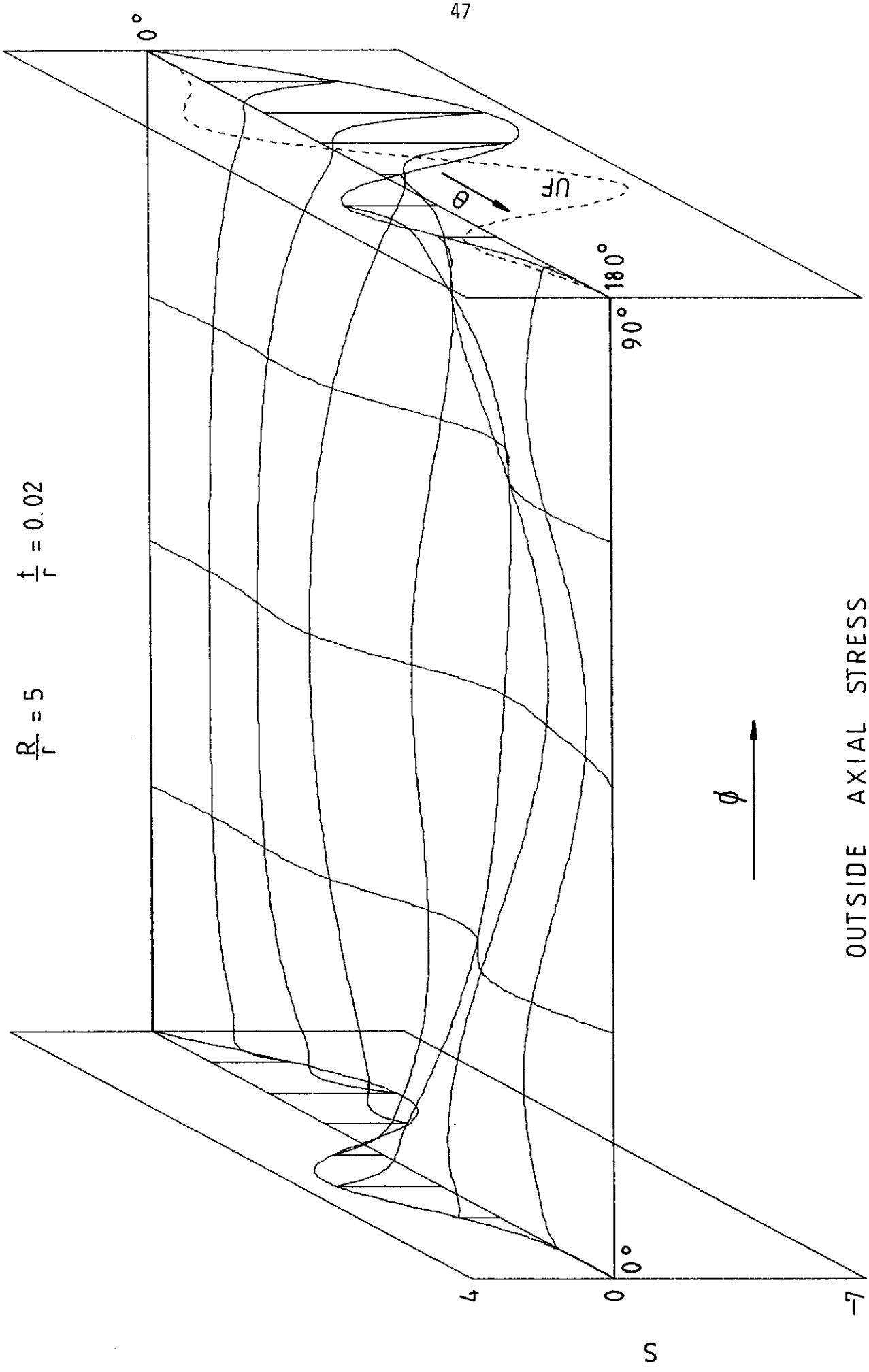


FIGURE A20

TABLE A19

R/r = 5.0 t/r = 0.02

OUTSIDE HOOP STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	-0.6876	0.0673	-0.0281	-0.0965	-0.1372	-0.1568	-0.1635	-0.1609	-0.1440	-0.1008	-0.0178	0.1117	-1.1003	-0.5986
45.0	-1.0820	0.2718	0.2625	0.2018	0.1231	0.0559	0.0209	0.0292	0.0826	0.1721	0.2749	0.3528	-1.8381	1.6416
67.5	-0.6850	0.3731	0.7352	0.9895	1.1072	1.1325	1.1348	1.1547	1.1699	1.1088	0.8999	0.5353	-1.5778	6.3268
90.0	0.4334	-0.2765	-0.1874	0.1431	0.5437	0.8817	1.0637	1.0393	0.8113	0.4355	0.0298	-0.2007	-0.1798	0.9742
112.5	0.8821	-0.3392	-0.9643	-1.3148	-1.3204	-1.1462	-1.0292	-1.1068	-1.3178	-1.4303	-1.1935	-0.5558	0.7872	-7.0265
135.0	0.3471	0.4366	0.2754	-0.2099	-0.7955	-1.3033	-1.5848	-1.5512	-1.2136	-0.6663	-0.0703	0.2995	0.4720	-2.6221
157.5	0.0104	0.3336	0.6702	0.6184	0.1047	-0.5453	-0.9270	-0.8118	-0.2678	0.3492	0.6022	0.3814	0.0768	0.4587
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OUTSIDE AXIAL STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	-2.2921	-0.4496	-0.1932	-0.0848	-0.0425	-0.0305	-0.0351	-0.0544	-0.0956	-0.1808	-0.3632	-0.7653	-3.6677	0.4314
45.0	-3.6068	-0.7508	-0.2056	0.0792	0.2110	0.2552	0.2525	0.2162	0.1243	-0.0839	-0.5156	-1.3572	-6.1270	2.2122
67.5	-2.2834	-1.0070	-0.5311	-0.1197	0.1786	0.3543	0.4114	0.3453	0.1284	-0.2870	-0.9486	-1.8707	-5.2592	1.2110
90.0	1.4447	-0.7828	-1.2394	-1.2766	-1.1081	-0.9067	-0.8264	-0.9573	-1.2824	-1.6871	-1.9865	-1.8911	-0.5993	-5.1797
112.5	2.9403	0.6782	-0.3313	-1.0236	-1.4297	-1.6590	-1.8139	-1.9404	-2.0048	-1.8783	-1.3591	-0.2640	2.6239	-4.2810
135.0	1.1570	1.4153	1.1067	0.4769	-0.2708	-0.9532	-1.3693	-1.3854	-1.0055	-0.3458	0.4398	1.1217	1.5732	0.8254
157.5	0.0345	0.6680	0.9266	0.6918	0.1131	-0.4805	-0.8301	-0.7989	-0.3784	0.2562	0.7325	0.7221	0.2561	0.7280
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OUTSIDE SHEAR STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x cos + const.	
0.0	0.3056	0.1960	0.0870	0.0382	0.0185	0.0126	0.0117	0.0085	-0.0054	-0.0427	-0.1269	-0.3060	-0.4792	-0.5170	0.3313
0.0	0.3056	0.1960	0.0870	0.0382	0.0185	0.0126	0.0117	0.0085	-0.0054	-0.0427	-0.1269	-0.3060	-0.4792	-0.5170	0.3313
22.5	0.1271	0.0919	0.0353	0.0139	0.0087	0.0106	0.0144	0.0165	0.0124	-0.0050	-0.0496	-0.1496	-0.1996	-0.5625	0.3398
45.0	-0.3181	-0.1996	-0.1315	-0.0807	-0.0396	-0.0072	0.0191	0.0462	0.0823	0.1337	0.2063	0.3136	0.5377	-0.6782	0.3659
67.5	-0.6270	-0.4447	-0.3119	-0.2240	-0.1450	-0.0643	0.0226	0.1202	0.2353	0.3773	0.5649	0.8479	1.2496	-0.6067	0.4109
90.0	-0.3022	-0.2904	-0.2284	-0.2051	-0.1687	-0.0822	0.0591	0.2276	0.3902	0.5397	0.7093	0.9647	1.1990	-0.1683	0.4755
112.5	0.2829	0.0378	0.0161	0.0323	0.0585	0.1041	0.1737	0.2644	0.3697	0.4861	0.6177	0.7362	0.5699	-0.0908	0.5567
135.0	0.3902	0.2348	0.1446	0.2061	0.3065	0.3446	0.3074	0.2636	0.2967	0.4228	0.5461	0.5077	0.2960	-0.5254	0.6430
157.5	0.2210	0.3359	0.3346	0.3346	0.3498	0.3672	0.3812	0.3898	0.3922	0.3864	0.3588	0.3159	0.3951	-0.7556	0.7123
180.0	0.1467	0.3419	0.4710	0.4227	0.3236	0.3112	0.3994	0.4956	0.4872	0.3479	0.2080	0.2577	0.4625	-0.7870	0.7394

DIAMETER EXPANSION FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
45.0	0.0	4.784	13.096	24.298	35.948	45.406	50.348	49.436	42.797	31.950	19.395	8.222	0.0	200.304

TABLE A20

R/r = 5.0 t/r = 0.02

INSIDE HOOP STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	0.0730	0.0790	0.0984	0.1305	0.1540	0.1664	0.1726	0.1761	0.1743	0.1617	0.1394	0.1324	0.1086	0.5400
45.0	0.0810	-0.0779	-0.1766	-0.1698	-0.1159	-0.0580	-0.0221	-0.0202	-0.0500	-0.0925	-0.1034	-0.0043	0.1281	-1.8764
67.5	-0.0688	-0.2709	-0.7166	-1.0254	-1.1691	-1.2011	-1.2008	-1.2136	-1.2119	-1.1095	-0.8173	-0.3156	-0.0702	-6.8150
90.0	-0.1988	0.3166	0.1992	-0.1792	-0.6207	-0.9852	-1.1805	-1.1574	-0.9162	-0.5073	-0.0493	0.2274	-0.3259	-1.1019
112.5	0.0662	0.5055	1.0981	1.3991	1.3291	1.0718	0.8996	0.9729	1.2230	1.3893	1.1992	0.6063	-0.1144	7.5183
135.0	0.3066	-0.1115	-0.0398	0.3379	0.7991	1.1906	1.3955	1.3465	1.0588	0.6120	0.1461	-0.0671	0.2400	2.9899
157.5	0.1665	-0.0658	-0.4454	-0.5301	-0.1382	0.4385	0.7764	0.6346	0.1064	-0.4098	-0.4860	-0.1306	0.1819	-0.3327
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INSIDE AXIAL STRESS FACTORS

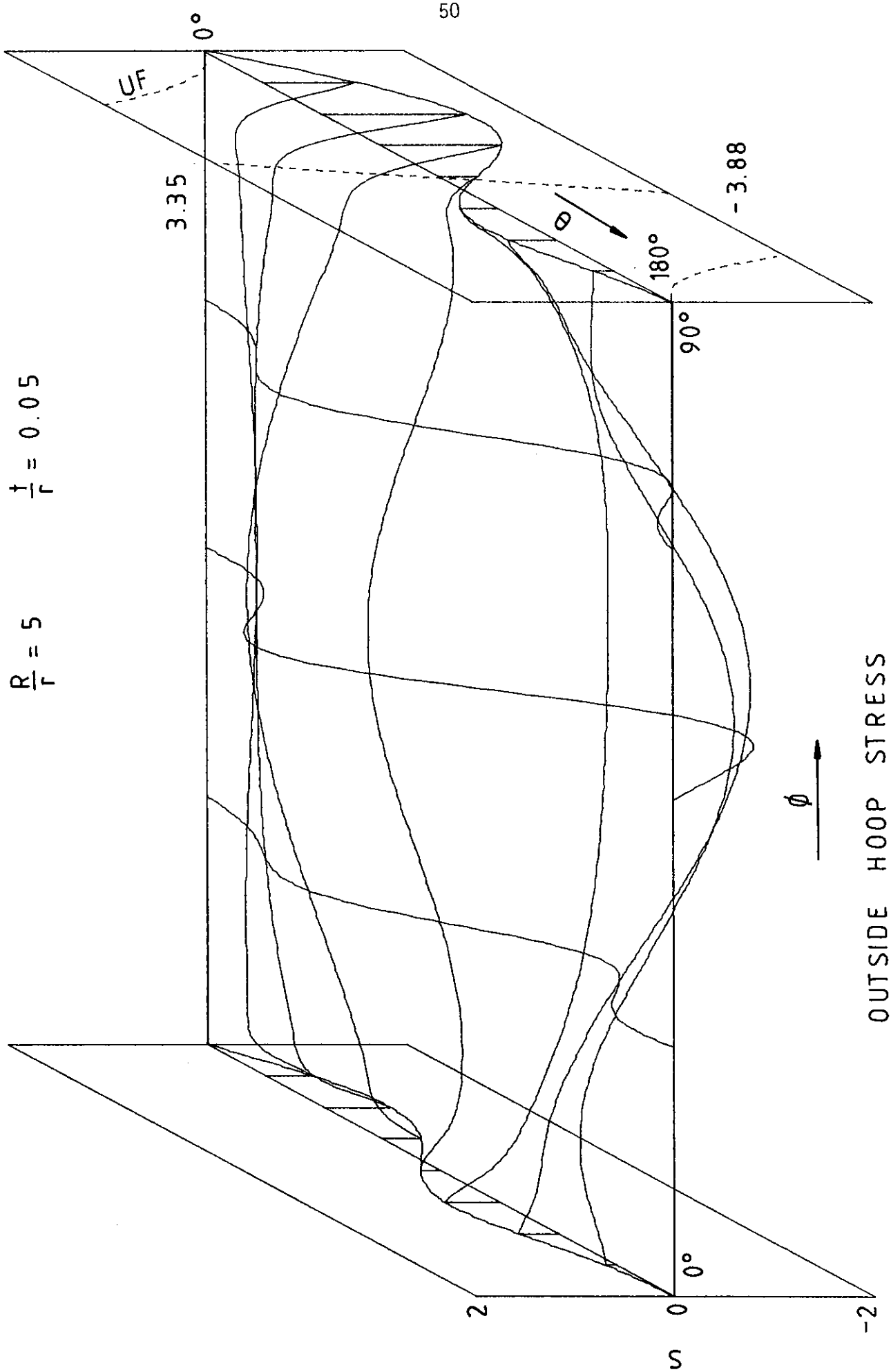
Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	0.2434	-0.4441	-0.1623	-0.0275	0.0323	0.0531	0.0519	0.0327	-0.0140	-0.1151	-0.3264	-0.7613	0.3621	0.7297
45.0	0.2701	-0.8289	-0.3497	-0.0634	0.0996	0.1783	0.1955	0.1550	0.0369	-0.2064	-0.6554	-1.4455	0.4272	1.0857
67.5	-0.2293	-1.0644	-0.8788	-0.6755	-0.4877	-0.3523	-0.3085	-0.3862	-0.5962	-0.9354	-1.3995	-1.9812	-0.2341	-2.2729
90.0	-0.6627	-0.4180	-0.8609	-1.1037	-1.2242	-1.2855	-1.3499	-1.4544	-1.5905	-1.7051	-1.7163	-1.4972	-1.0864	-4.4593
112.5	0.2207	0.8381	0.3944	0.0169	-0.3622	-0.7151	-0.9555	-1.0210	-0.9238	-0.7199	-0.4191	0.0886	-0.3812	0.9732
135.0	1.0219	0.9821	0.7706	0.5335	0.2894	0.0645	-0.0970	-0.1582	-0.1025	0.0655	0.3424	0.7288	0.8000	2.6197
157.5	0.5550	0.4639	0.3168	0.0976	0.0079	0.0345	0.0446	-0.0408	-0.1535	-0.1264	0.1232	0.4158	0.6062	0.5087
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INSIDE SHEAR STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x cos + const.	
0.0	0.2996	0.2622	0.1422	0.0821	0.0498	0.0298	0.0132	-0.0064	-0.0369	-0.0909	-0.1930	-0.3945	-0.4697	-0.2851	0.3218
22.5	0.1245	0.1807	0.1123	0.0719	0.0470	0.0303	0.0167	0.0006	-0.0244	-0.0666	-0.1389	-0.2641	-0.1956	-0.2905	0.3302
45.0	-0.3118	-0.1000	-0.0098	0.0268	0.0377	0.0362	0.0293	0.0210	0.0155	0.0216	0.0587	0.1699	0.5271	-0.4039	0.3560
67.5	-0.6146	-0.5547	-0.3042	-0.1374	-0.0337	0.0205	0.0444	0.0686	0.1297	0.2628	0.5057	0.9146	1.2249	-0.7642	0.4006
90.0	-0.2962	-0.6514	-0.5660	-0.4127	-0.2490	-0.0981	0.0451	0.2052	0.4141	0.6937	1.0374	1.3894	1.1753	-0.9396	0.4649
112.5	0.2773	0.0299	-0.2666	-0.3945	-0.3699	-0.2012	0.0825	0.4159	0.7204	0.9349	1.0089	0.8685	0.5587	-0.5218	0.5461
135.0	0.3825	0.5393	0.3265	0.0909	-0.0165	0.0454	0.2346	0.4653	0.6313	0.6348	0.4488	0.1898	0.2902	-0.2802	0.6328
157.5	0.2167	0.3644	0.5271	0.6091	0.6197	0.5582	0.4357	0.2898	0.1657	0.0928	0.0913	0.2006	0.3872	-0.3924	0.7028
180.0	0.1438	0.1890	0.4894	0.8124	0.9407	0.8239	0.5295	0.1719	-0.1084	-0.1686	0.0383	0.3425	0.4533	-0.4489	0.7302

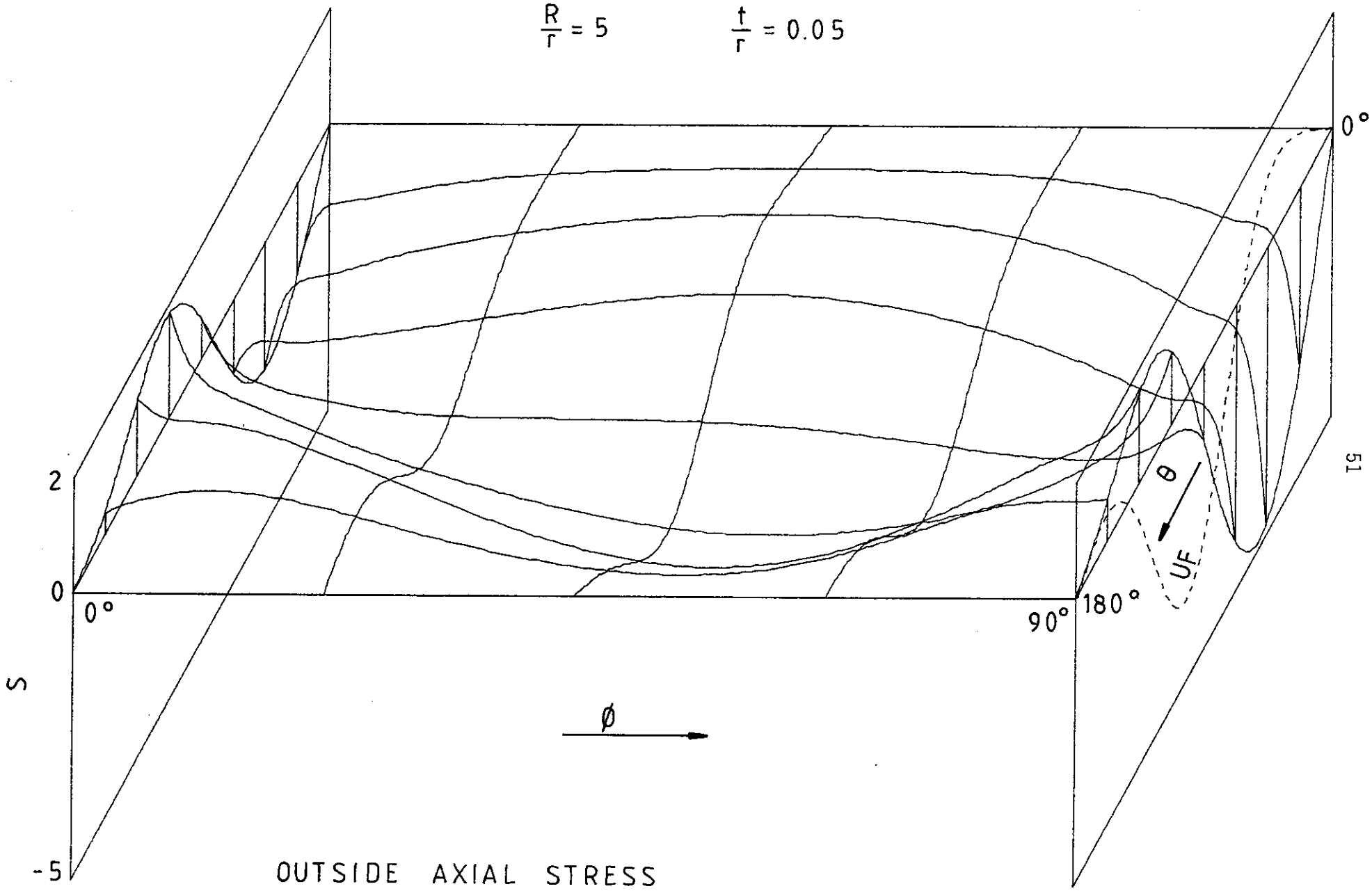
DIAMETER EXPANSION FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
135.0	0.0	-4.784	-13.096	-24.298	-35.948	-45.406	-50.348	-49.436	-42.797	-31.950	-19.395	-8.222	0.0	-200.304



OUTSIDE HOOP STRESS

FIGURE A21



OUTSIDE AXIAL STRESS

FIGURE A22

TABLE A21

R/r = 5.0 t/r = 0.05

OUTSIDE HOOP STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	-0.4845	0.1840	0.1964	0.1801	0.1418	0.1004	0.0751	0.0785	0.1112	0.1623	0.2136	0.2566	-0.9257	0.7673
45.0	-0.6743	0.3264	0.4811	0.5863	0.6393	0.6598	0.6677	0.6749	0.6803	0.6673	0.6078	0.4972	-1.4419	2.4702
67.5	-0.3861	0.1962	0.4572	0.7454	1.0111	1.2192	1.3374	1.3442	1.2354	1.0221	0.7255	0.4089	-1.2273	3.2538
90.0	0.2007	-0.2034	-0.1870	0.0023	0.2815	0.5464	0.7053	0.7020	0.5323	0.2525	-0.0262	-0.1507	-0.3913	0.3839
112.5	0.5481	-0.2778	-0.6197	-0.8571	-0.9903	-1.0606	-1.0966	-1.1116	-1.1034	-1.0416	-0.8546	-0.4771	0.3673	-3.4100
135.0	0.3976	0.1420	-0.1292	-0.6069	-1.1504	-1.6228	-1.9046	-1.9193	-1.6530	-1.1636	-0.5776	-0.0877	0.4829	-3.2288
157.5	0.1131	0.3268	0.3196	0.0088	-0.4559	-0.8919	-1.1564	-1.1632	-0.8941	-0.4273	0.0395	0.2433	0.2146	-0.9726
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OUTSIDE AXIAL STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	-1.6149	-0.2259	0.0221	0.1563	0.2285	0.2632	0.2723	0.2585	0.2136	0.1144	-0.0879	-0.4951	-3.0856	0.9466
45.0	-2.2477	-0.4876	-0.1017	0.1598	0.3431	0.4617	0.5111	0.4804	0.3548	0.1090	-0.3115	-1.0211	-4.8062	1.2797
67.5	-1.2870	-0.7316	-0.5304	-0.3095	-0.0965	0.0686	0.1414	0.0866	-0.1128	-0.4566	-0.9384	-1.5528	-4.0909	-0.3083
90.0	0.6691	-0.5865	-0.8743	-0.9881	-1.0187	-1.0314	-1.0668	-1.1505	-1.2943	-1.4827	-1.6476	-1.6421	-1.3044	-3.0005
112.5	1.8269	0.1873	-0.3951	-0.8812	-1.3007	-1.6499	-1.8924	-1.9967	-1.9556	-1.7727	-1.4140	-0.7817	1.2242	-3.1815
135.0	1.3254	0.8926	0.5011	-0.0485	-0.6198	-1.1112	-1.4396	-1.5427	-1.3826	-0.9590	-0.3239	0.3741	1.6097	-0.7968
157.5	0.3770	0.7530	0.6606	0.3278	-0.0526	-0.3723	-0.5840	-0.6526	-0.5338	-0.2016	0.2738	0.6359	0.7154	0.4826
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OUTSIDE SHEAR STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x cos + const.	
0.0	0.0696	0.0321	-0.0214	-0.0283	-0.0177	-0.0017	0.0143	0.0277	0.0359	0.0317	-0.0029	-0.1162	-0.1596	-0.5742	0.3382
22.5	-0.0286	-0.0367	-0.0649	-0.0606	-0.0418	-0.0163	0.0117	0.0392	0.0634	0.0787	0.0731	0.0148	0.0347	-0.5977	0.3467
45.0	-0.2342	-0.1789	-0.1570	-0.1350	-0.1017	-0.0538	0.0070	0.0747	0.1423	0.2058	0.2666	0.3344	0.4972	-0.6124	0.3730
67.5	-0.3324	-0.2406	-0.1889	-0.1654	-0.1300	-0.0681	0.0202	0.1251	0.2343	0.3417	0.4591	0.6371	0.9089	-0.5027	0.4183
90.0	-0.1745	-0.1386	-0.0794	-0.0493	-0.0176	0.0271	0.0879	0.1658	0.2609	0.3744	0.5187	0.7406	0.9661	-0.2865	0.4831
112.5	0.1134	0.0192	0.0814	0.1564	0.2071	0.2213	0.2098	0.2007	0.2288	0.3214	0.4842	0.6896	0.7063	-0.2249	0.5643
135.0	0.2685	0.1446	0.1738	0.2582	0.3210	0.3370	0.3168	0.2897	0.2933	0.3603	0.4871	0.5908	0.4608	-0.4519	0.6502
157.5	0.2477	0.2759	0.2423	0.2254	0.2391	0.2863	0.3582	0.4363	0.4976	0.5227	0.5018	0.4390	0.3984	-0.7227	0.7190
180.0	0.2107	0.3480	0.2861	0.1923	0.1633	0.2277	0.3622	0.5148	0.6193	0.6163	0.4946	0.3474	0.4079	-0.8214	0.7458

DIAMETER EXPANSION FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
45.0	0.0	3.432	8.790	15.462	22.175	27.632	30.714	30.710	27.479	21.522	13.948	6.381	0.0	73.726

TABLE A22

R/r = 5.0 t/r = 0.05

INSIDE HOOP STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	0.0935	-0.0944	-0.1709	-0.1776	-0.1475	-0.1070	-0.0792	-0.0777	-0.1011	-0.1319	-0.1389	-0.0620	0.1689	-0.8508
45.0	0.0902	-0.2123	-0.4639	-0.6122	-0.6856	-0.7132	-0.7201	-0.7195	-0.7070	-0.6566	-0.5216	-0.2249	0.1974	-2.7092
67.5	-0.0402	-0.1189	-0.4551	-0.7980	-1.1058	-1.3427	-1.4735	-1.4733	-1.3358	-1.0690	-0.6873	-0.2090	0.0115	-3.5787
90.0	-0.1630	0.2600	0.2327	-0.0029	-0.3431	-0.6649	-0.8581	-0.8548	-0.6502	-0.3107	0.0334	0.2227	-0.2458	-0.4637
112.5	-0.0794	0.3815	0.7359	0.9417	1.0208	1.0354	1.0308	1.0309	1.0371	1.0104	0.8571	0.4916	-0.2648	3.7104
135.0	0.1323	0.0327	0.2488	0.6793	1.1947	1.6483	1.9080	1.8923	1.5955	1.0957	0.5420	0.1388	-0.0238	3.5730
157.5	0.1762	-0.1690	-0.2532	0.0013	0.4579	0.9035	1.1657	1.1445	0.8297	0.3333	-0.0942	-0.1654	0.1154	1.1241
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INSIDE AXIAL STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	0.3118	-0.2979	-0.0986	0.0266	0.1117	0.1657	0.1873	0.1713	0.1099	-0.0106	-0.2213	-0.5916	0.5629	0.4133
45.0	0.3008	-0.5780	-0.3533	-0.1958	-0.0760	0.0057	0.0362	0.0008	-0.1134	-0.3205	-0.6509	-1.1797	0.6581	-0.2143
67.5	-0.1340	-0.6435	-0.6423	-0.6342	-0.6271	-0.6303	-0.6553	-0.7142	-0.8191	-0.9810	-1.2111	-1.5255	0.0383	-1.8465
90.0	-0.5432	-0.2388	-0.4943	-0.7056	-0.9107	-1.0957	-1.2359	-1.3161	-1.3406	-1.3293	-1.2970	-1.2040	-0.8193	-2.2635
112.5	-0.2646	0.3869	0.1115	-0.1296	-0.3746	-0.5995	-0.7706	-0.8619	-0.8641	-0.7839	-0.6293	-0.3382	-0.8826	-0.2131
135.0	0.4411	0.5998	0.4239	0.3179	0.2610	0.2211	0.1644	0.0779	-0.0180	-0.0700	-0.0097	0.2447	-0.0792	1.5298
157.5	0.5875	0.3471	0.2358	0.2151	0.2817	0.3678	0.4017	0.3456	0.2162	0.0883	0.0688	0.2304	0.3848	1.1406
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INSIDE SHEAR STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x cos + const.	
0.0	0.0662	0.1954	0.1247	0.0872	0.0635	0.0439	0.0233	-0.0022	-0.0374	-0.0914	-0.1821	-0.3451	-0.1518	-0.2657	0.3144
22.5	-0.0272	0.1086	0.0836	0.0704	0.0597	0.0460	0.0269	0.0025	-0.0272	-0.0651	-0.1197	-0.2067	0.0330	-0.3135	0.3227
45.0	-0.2228	-0.1389	-0.0582	-0.0091	0.0193	0.0309	0.0307	0.0266	0.0286	0.0485	0.1006	0.2114	0.4730	-0.4707	0.3482
67.5	-0.3162	-0.4234	-0.2846	-0.1857	-0.1093	-0.0432	0.0220	0.0938	0.1826	0.3068	0.4965	0.7961	0.8645	-0.6915	0.3926
90.0	-0.1659	-0.4507	-0.4196	-0.3609	-0.2730	-0.1474	0.0163	0.2088	0.4188	0.6428	0.8882	1.1589	0.9190	-0.7745	0.4567
112.5	0.1079	-0.0802	-0.2403	-0.2926	-0.2470	-0.1170	0.0792	0.3182	0.5694	0.7925	0.9378	0.9495	0.6718	-0.5948	0.5378
135.0	0.2554	0.3278	0.1745	0.0992	0.1031	0.1596	0.2484	0.3598	0.4794	0.5711	0.5726	0.4363	0.4383	-0.3795	0.6248
157.5	0.2356	0.4115	0.5075	0.5561	0.5575	0.5167	0.4425	0.3478	0.2495	0.1688	0.1297	0.1554	0.3790	-0.3489	0.6953
180.0	0.2004	0.3621	0.6150	0.7515	0.7603	0.6754	0.5273	0.3365	0.1319	-0.0281	-0.0530	0.1192	0.3880	-0.3810	0.7229

DIAMETER EXPANSION FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
135.0	0.0	-3.432	-8.790	-15.462	-22.175	-27.632	-30.714	-30.710	-27.479	-21.522	-13.948	-6.381	0.0	-73.726

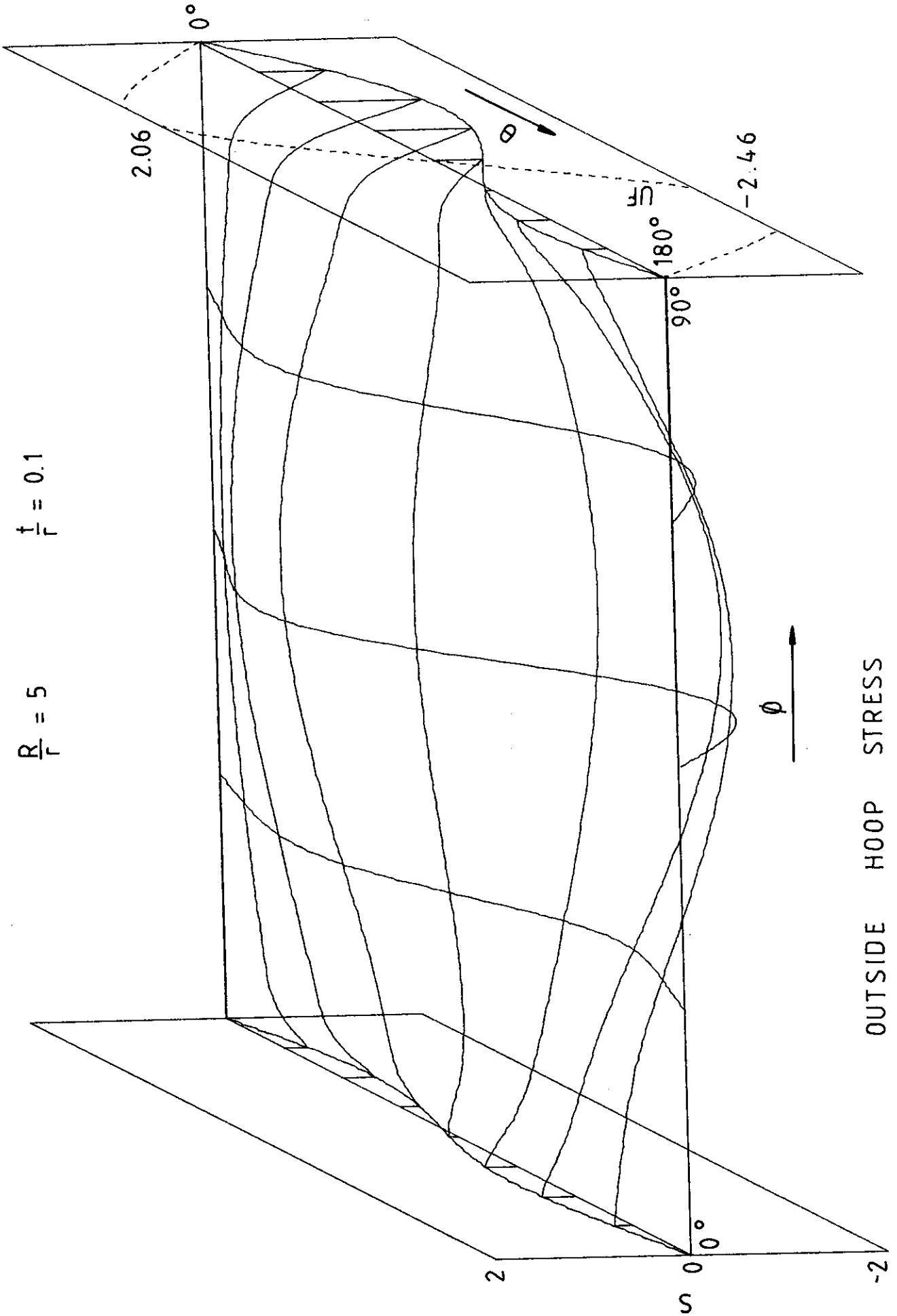
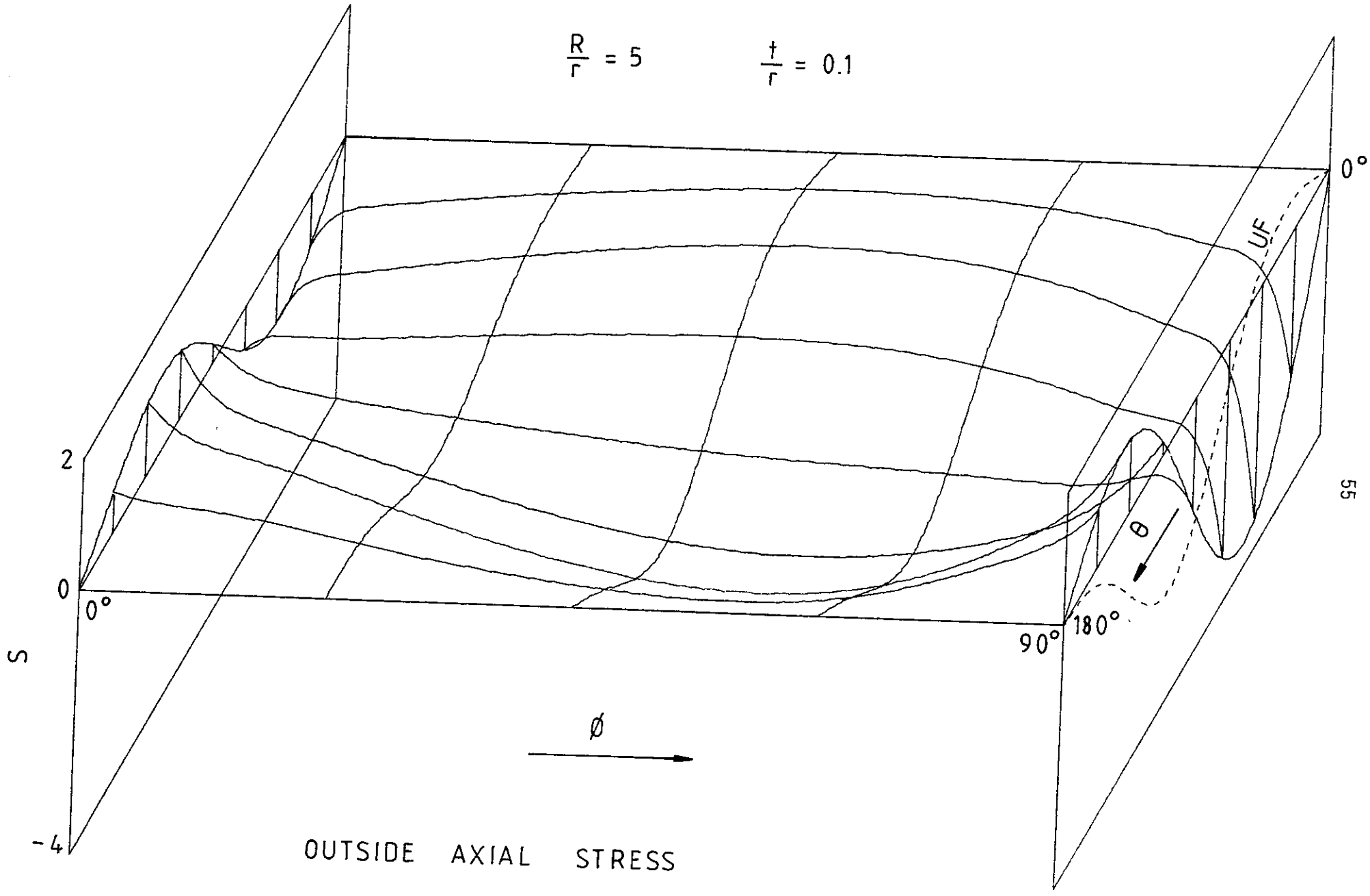

0°
2.06
θ
-2.46
UF
180°
90°
$\frac{R}{r} = 5$
$\frac{t}{r} = 0.1$
φ
OUTSIDE HOOP STRESS
0°
2
0
-2
S

FIGURE A23



OUTSIDE AXIAL STRESS

FIGURE A24

TABLE A23

R/r = 5.0 t/r = 0.1

OUTSIDE HOOP STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	-0.2465	0.1695	0.2610	0.3417	0.4068	0.4554	0.4847	0.4926	0.4794	0.4454	0.3869	0.3183	-0.6789	1.0911
45.0	-0.3373	0.2341	0.4134	0.5939	0.7560	0.8851	0.9658	0.9865	0.9426	0.8358	0.6695	0.4838	-1.0672	1.9482
67.5	-0.1998	0.1256	0.3029	0.5250	0.7464	0.9323	1.0519	1.0818	1.0100	0.8394	0.5919	0.3497	-0.9883	1.8137
90.0	0.0867	-0.0740	-0.0667	0.0184	0.1274	0.2273	0.2941	0.3100	0.2637	0.1577	0.0223	-0.0358	-0.5056	0.1969
112.5	0.3164	-0.1431	-0.3641	-0.5548	-0.7244	-0.8601	-0.9470	-0.9725	-0.9306	-0.8200	-0.6374	-0.3314	0.0558	-1.8190
135.0	0.3339	-0.0152	-0.3041	-0.6694	-1.0468	-1.3678	-1.5797	-1.6413	-1.5251	-1.2281	-0.7933	-0.2831	0.3385	-2.4299
157.5	0.1851	0.0825	-0.0873	-0.3625	-0.6656	-0.9285	-1.1045	-1.1571	-1.0590	-0.8061	-0.4490	-0.0869	0.2622	-1.4583
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OUTSIDE AXIAL STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	-0.8215	-0.1306	0.0063	0.1174	0.2077	0.2763	0.3142	0.3117	0.2600	0.1491	-0.0441	-0.3266	-2.2631	0.5184
45.0	-1.1244	-0.3008	-0.1221	0.0361	0.1698	0.2718	0.3263	0.3157	0.2230	0.0299	-0.2965	-0.7383	-3.5573	0.4059
67.5	-0.6660	-0.4451	-0.3888	-0.3190	-0.2579	-0.2163	-0.2057	-0.2406	-0.3404	-0.5278	-0.8294	-1.1738	-3.2944	-0.6359
90.0	0.2891	-0.3779	-0.5615	-0.7121	-0.8514	-0.9788	-1.0851	-1.1661	-1.2296	-1.2916	-1.3643	-1.3424	-1.6855	-1.9525
112.5	1.0547	-0.0091	-0.3713	-0.7311	-1.0686	-1.3632	-1.5880	-1.7186	-1.7380	-1.6358	-1.4036	-0.9718	0.1860	-2.2417
135.0	1.1129	0.3934	0.0456	-0.3526	-0.7234	-1.0396	-1.2826	-1.4272	-1.4359	-1.2619	-0.8733	-0.2840	1.1283	-1.2688
157.5	0.6170	0.4096	0.2185	-0.0307	-0.2567	-0.4437	-0.5911	-0.6875	-0.7010	-0.5814	-0.2940	0.1081	0.8738	-0.2776
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OUTSIDE SHEAR STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x cos + const.	
0.0	-0.0845	-0.1067	-0.1278	-0.1189	-0.0916	-0.0506	-0.0005	0.0527	0.1016	0.1371	0.1457	0.0960	0.1099	-0.6011	0.3490
22.5	-0.1136	-0.1223	-0.1369	-0.1270	-0.0986	-0.0551	-0.0006	0.0592	0.1165	0.1627	0.1861	0.1660	0.2134	-0.5965	0.3577
45.0	-0.1687	-0.1439	-0.1426	-0.1293	-0.0996	-0.0532	0.0074	0.0774	0.1508	0.2202	0.2795	0.3308	0.4620	-0.5648	0.3843
67.5	-0.1775	-0.1217	-0.0990	-0.0771	-0.0474	-0.0071	0.0440	0.1062	0.1795	0.2633	0.3600	0.4880	0.7040	-0.4795	0.4299
90.0	-0.0922	-0.0414	0.0099	0.0516	0.0821	0.1046	0.1241	0.1493	0.1919	0.2648	0.3838	0.5647	0.7963	-0.3707	0.4950
112.5	0.0554	0.0559	0.1287	0.1913	0.2264	0.2360	0.2292	0.2198	0.2273	0.2768	0.3950	0.5819	0.7150	-0.3451	0.5761
135.0	0.1801	0.1367	0.1838	0.2335	0.2704	0.2943	0.3103	0.3247	0.3471	0.3928	0.4768	0.5888	0.5656	-0.4747	0.6614
157.5	0.2357	0.2061	0.1785	0.1721	0.2000	0.2587	0.3404	0.4337	0.5232	0.5893	0.6103	0.5840	0.4606	-0.6719	0.7293
180.0	0.2461	0.2396	0.1681	0.1261	0.1467	0.2242	0.3430	0.4821	0.6118	0.6914	0.6766	0.5749	0.4283	-0.7644	0.7557

DIAMETER EXPANSION FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
45.0	0.0	1.822	4.646	7.976	11.269	14.001	15.726	16.102	14.941	12.267	8.399	3.993	0.0	27.900

TABLE A24

R/r = 5.0 t/r = 0.1

INSIDE HOOP STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	0.0556	-0.1389	-0.2672	-0.3655	-0.4405	-0.4943	-0.5246	-0.5289	-0.5061	-0.4539	-0.3599	-0.2046	0.1559	-1.1949
45.0	0.0524	-0.1876	-0.4259	-0.6429	-0.8319	-0.9797	-1.0690	-1.0855	-1.0219	-0.8764	-0.6421	-0.3184	0.1952	-2.1576
67.5	-0.0219	-0.0701	-0.3038	-0.5734	-0.8402	-1.0626	-1.2035	-1.2336	-1.1363	-0.9125	-0.5815	-0.2065	0.0696	-2.0382
90.0	-0.1061	0.1488	0.1053	-0.0161	-0.1695	-0.3089	-0.4027	-0.4271	-0.3651	-0.2176	-0.0221	0.1204	-0.1436	-0.2492
112.5	-0.1090	0.2404	0.4316	0.6162	0.7723	0.8939	0.9654	0.9745	0.9189	0.8020	0.6179	0.3588	-0.2735	2.0151
135.0	-0.0255	0.1116	0.3496	0.7299	1.1307	1.4717	1.6878	1.7303	1.5710	1.2153	0.7250	0.2708	-0.2251	2.7069
157.5	0.0328	-0.0222	0.0946	0.3826	0.7150	1.0048	1.1918	1.2312	1.0927	0.7797	0.3689	0.0657	-0.0943	1.6206
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INSIDE AXIAL STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.5	0.1853	-0.2150	-0.1398	-0.1005	-0.0702	-0.0490	-0.0411	-0.0521	-0.0894	-0.1627	-0.2864	-0.5542	0.5195	-0.1872
45.0	0.1746	-0.3670	-0.3075	-0.2929	-0.2890	-0.2933	-0.3076	-0.3377	-0.3940	-0.4928	-0.6568	-1.0281	0.6508	-0.7094
67.5	-0.0731	-0.3603	-0.4158	-0.4956	-0.5818	-0.6646	-0.7364	-0.7953	-0.8476	-0.9094	-1.0024	-1.2536	0.2321	-1.3424
90.0	-0.3537	-0.1472	-0.3179	-0.4787	-0.6391	-0.7866	-0.9078	-0.9934	-1.0406	-1.0553	-1.0445	-1.0722	-0.4787	-1.3385
112.5	-0.3634	0.1431	-0.0401	-0.1745	-0.2965	-0.4095	-0.5127	-0.6026	-0.6711	-0.7056	-0.6817	-0.5820	-0.9116	-0.4057
135.0	-0.0851	0.2814	0.1688	0.1378	0.1351	0.1303	0.1007	0.0347	-0.0628	-0.1659	-0.2175	-0.1388	-0.7505	0.6001
157.5	0.1094	0.1966	0.1530	0.1801	0.2349	0.2836	0.3002	0.2692	0.1907	0.0856	0.0060	0.0273	-0.3144	0.7052
180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

INSIDE SHEAR STRESS FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x cos + const.	
0.0	-0.0765	0.0799	0.0595	0.0585	0.0575	0.0501	0.0340	0.0090	-0.0245	-0.0688	-0.1328	-0.2635	0.0994	-0.3125	0.3015
22.5	-0.1028	0.0192	0.0197	0.0281	0.0344	0.0353	0.0294	0.0167	-0.0025	-0.0288	-0.0649	-0.1384	0.1931	-0.3553	0.3097
45.0	-0.1526	-0.1358	-0.0920	-0.0627	-0.0373	-0.0116	0.0151	0.0420	0.0688	0.0981	0.1400	0.2097	0.4180	-0.4704	0.3349
67.5	-0.1606	-0.2921	-0.2314	-0.1887	-0.1408	-0.0793	-0.0022	0.0884	0.1902	0.3054	0.4486	0.6613	0.6370	-0.6037	0.3787
90.0	-0.0835	-0.3080	-0.2929	-0.2605	-0.2007	-0.1110	0.0083	0.1553	0.3270	0.5195	0.7309	0.9764	0.7205	-0.6609	0.4423
112.5	0.0501	-0.1102	-0.1654	-0.1582	-0.1062	-0.0214	0.0925	0.2366	0.4110	0.6062	0.7941	0.9321	0.6469	-0.5848	0.5234
135.0	0.1630	0.1889	0.1365	0.1363	0.1645	0.2067	0.2589	0.3237	0.4041	0.4938	0.5655	0.5707	0.5118	-0.4424	0.6108
157.5	0.2132	0.3993	0.4416	0.4629	0.4663	0.4567	0.4349	0.3990	0.3482	0.2862	0.2258	0.1915	0.4167	-0.3498	0.6820
180.0	0.2226	0.4621	0.5663	0.6038	0.5966	0.5642	0.5107	0.4305	0.3184	0.1839	0.0671	0.0430	0.3875	-0.3274	0.7099

DIAMETER EXPANSION FACTORS

Theta	Phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	Unflanged x sin
135.0	0.0	-1.822	-4.646	-7.976	-11.269	-14.001	-15.726	-16.102	-14.941	-12.267	-8.399	-3.993	0.0	-27.900