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AUSTRALIAN ATOMIC ENERGY COMMISSION

RESEARCH ESTABLISHMENT

LUCAS HEIGHTS RESEARCH LABORATORIES

RESULTS OF PIPE BEND ANALYSIS
PART VIII: STRESSES IN ELBOWS WITH LONG TANGENTS UNDER IN-PLANE BENDING

by

J.F. WHATHAM

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ABSTRACT

Graphs of outside surface stress distributions are presented an numerical values of stresses on inside and outside surfaces tabulated for wide range of 90° pipe bends with long tangent pipes subjected to in-plan bending; calculations are based on linear thin shell theory.

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BENDING; EXPERIMENTAL DATA; PIPES; SHEAR; SPATIAL DISTRIBUTION; STRESSES

CONTENTS

1. INTRODUCTION

The objective of this report is to present the surface stress distributions for a range of 90° pipe bends terminated by long tangent pipes and subjected to an in-plane bending moment, 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 1979, 1981, 1982]. 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 pipe bend 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 joined to a tangent pipe at least one pipe circumference long. 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

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

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:

$$\begin{aligned} \sigma'_{\theta\theta} &= \sigma_{\theta\theta} - z(A+\nu B)/(1-\nu^2) \quad , \\ \sigma'_{\eta\eta} &= \sigma_{\eta\eta} - z(B+\nu A)/(1-\nu^2) \quad , \\ \sigma'_{\eta\theta} &= \sigma_{\eta\theta} - \frac{z}{2r}\left[(r/(r+z)+r/(r_\eta+z))\,\sigma_{\eta\theta} - (r_\eta-r)\bar{\sigma}_{\eta\theta}/(r_\eta+z)\right] \quad , \end{aligned} \tag{6}$$

where

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

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

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

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

3. ELBOW CONFIGURATION AND RESULTS

Stresses are duplicated each side of the bend in Figure 1 because of lateral symmetry, and hoop and axial stresses on the outside surface from $\theta = 0$ to 180° are plotted in Appendix A, together with the stresses on theoretically unterminated pipe bends, no tangent effects, in which case the stresses are 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 pipe bends with tangents under in-plane bending, or flanged pipe bends under any 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.

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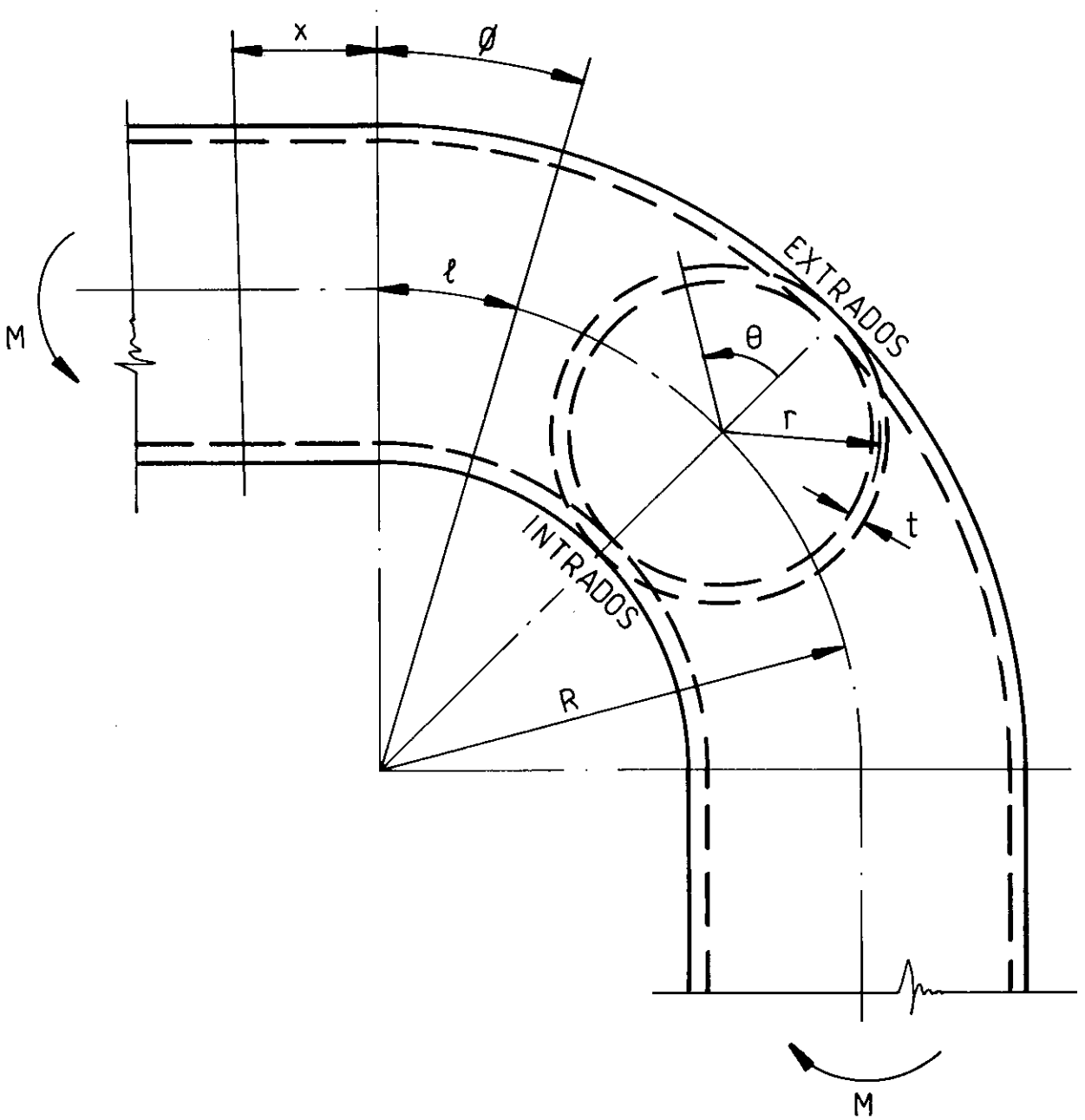


FIGURE 1. PIPE BEND CONFIGURATION

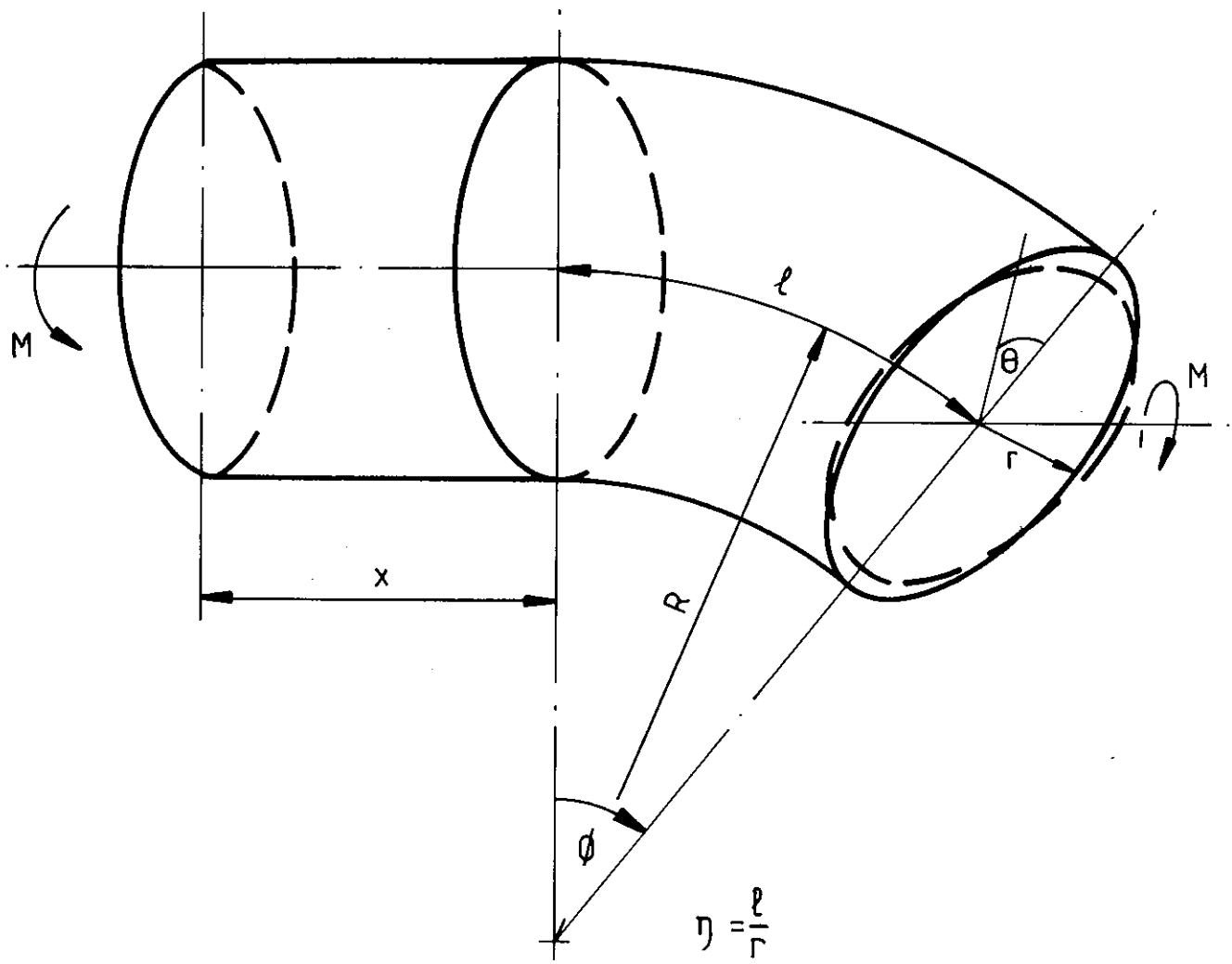


FIGURE 2. PIPE MIDDLE SURFACE

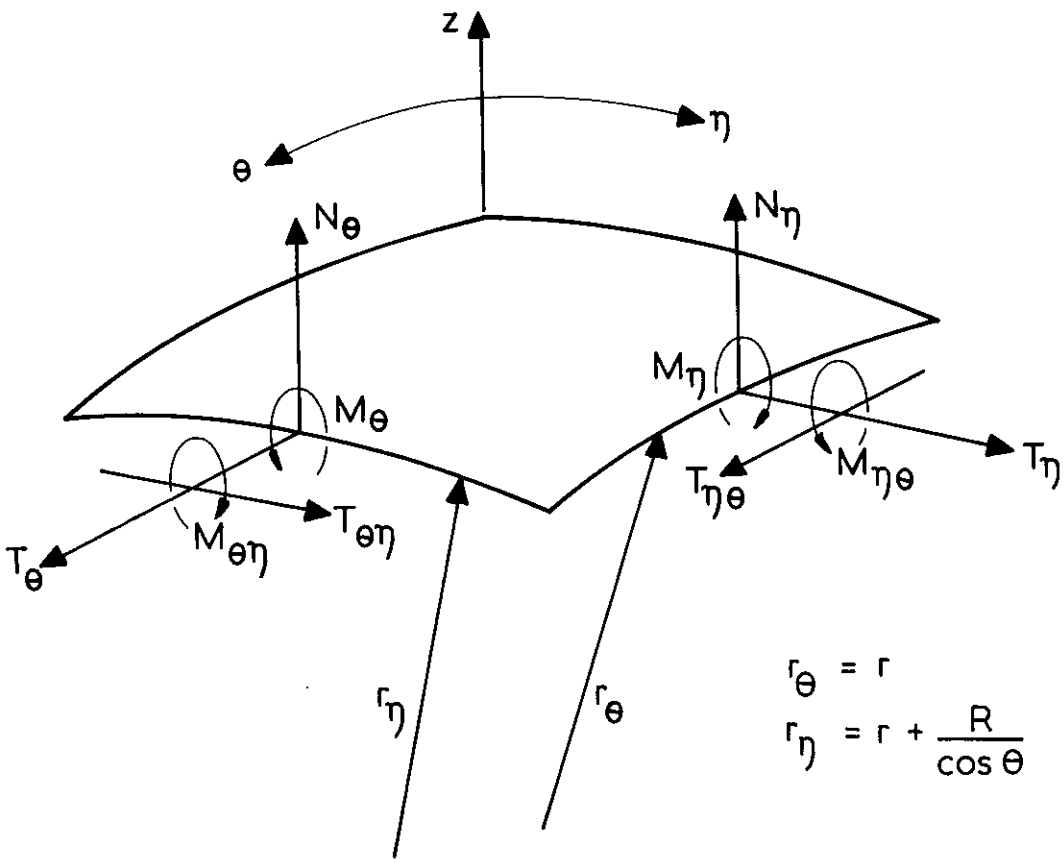


FIGURE 3. ELEMENT OF PIPE MIDDLE SURFACE

APPENDIX A

STRESSES IN PIPE ELBOWS WITH LONG TANGENTS UNDER IN-PLANE BENDING

Parameters of pipe elbows considered:

R/r = 2, 3, 5

t/r = 0.01, 0.02, 0.05, 0.1

ν = 0.3

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

NT = no tangent effects

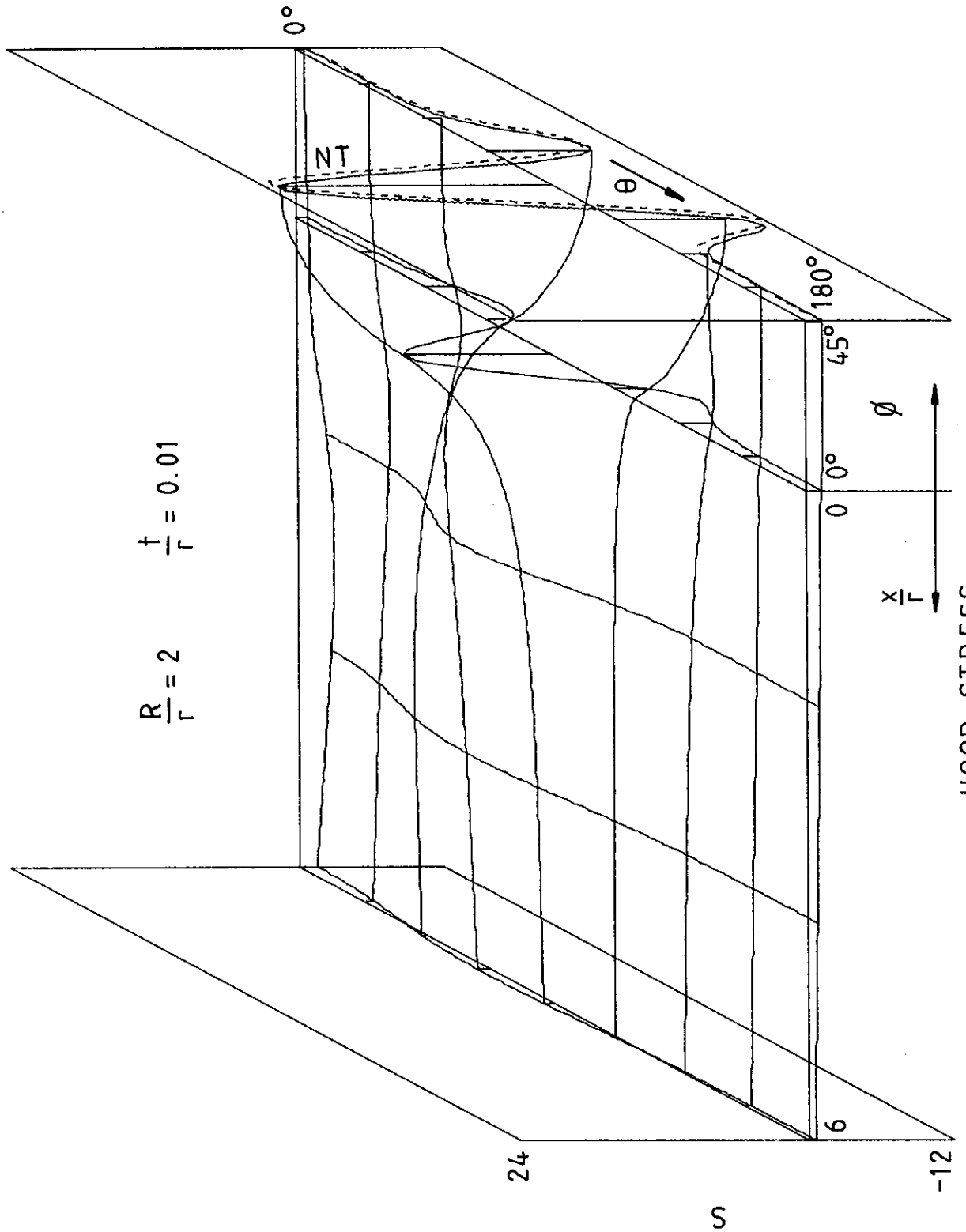
NB = no bend effects

In straight pipe with no bend effects, outside axial stress factors are given by

$$S = \frac{(1 + t/2r)\cos\theta}{1 + \gamma/12}$$

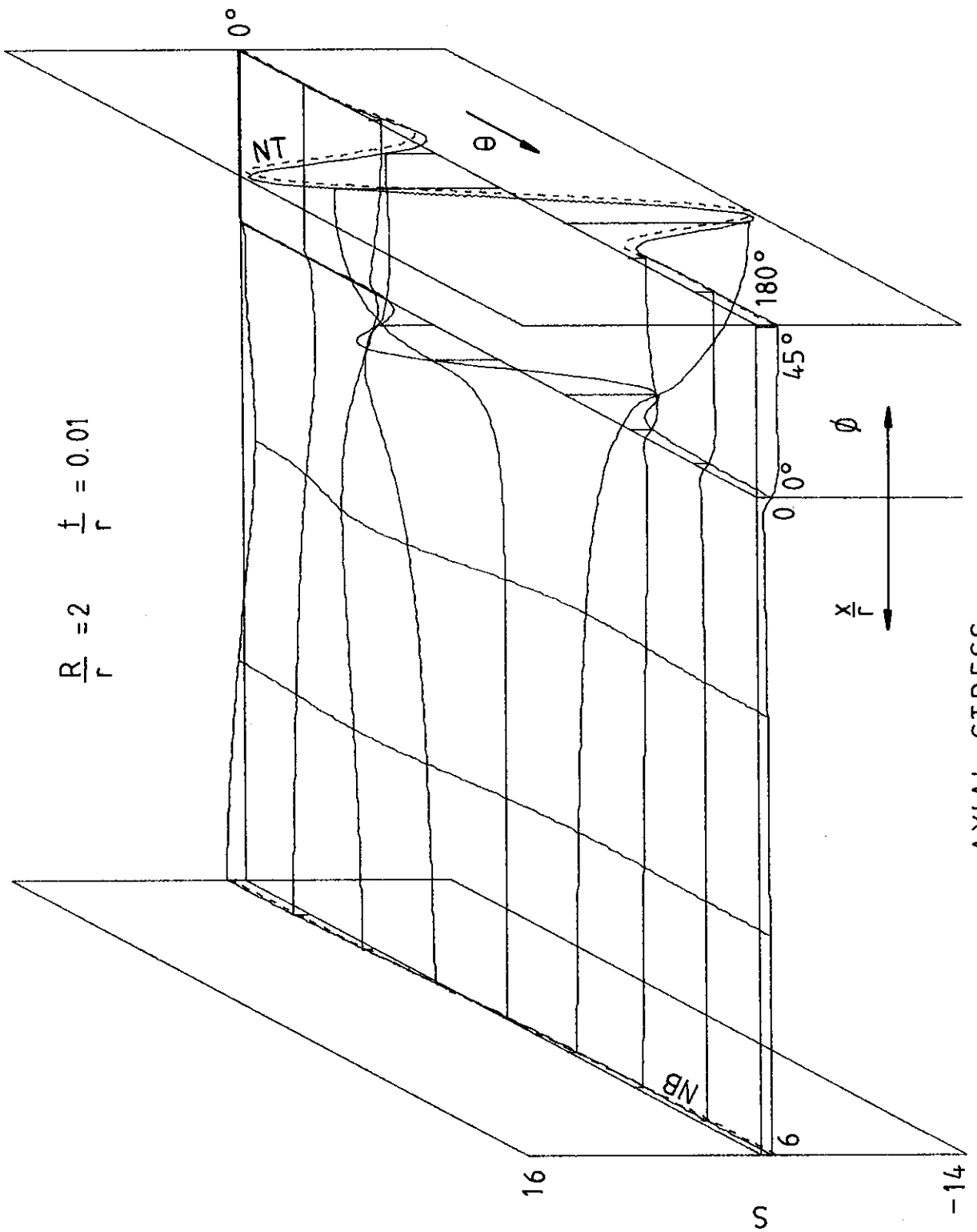
Diameter expansion factor = diameter expansion . $\pi r\ Et/M$

E = Young's modulus



HOOP STRESS

FIGURE A1



AXIAL STRESS

FIGURE A2

TABLE A1

R/r = 2.0 t/r = 0.01

OUTSIDE HOOP STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	-1.5335	-2.1495	-2.7639	-3.0372	-2.4312	-1.3085	-1.0018	-0.9060	-0.8517	-0.8042	-0.7691	-0.7481	-0.7411	-0.8258
22.5	-0.8572	-1.1418	-1.4644	-1.8597	-2.3342	-2.2034	-1.2021	-1.0444	-0.9476	-0.8724	-0.8217	-0.7930	-0.7838	-0.8881
45.0	0.4335	0.6908	0.9137	0.8480	0.0127	-2.0967	-2.6364	-1.9987	-1.7385	-1.6281	-1.5926	-1.5870	-1.5875	-2.3000
67.5	1.1124	1.5181	1.9756	2.5305	3.2563	3.5873	-1.8094	-4.6349	-6.3403	-7.4962	-8.2307	-8.6349	-8.7636	-7.7007
90.0	0.8680	1.0740	1.3459	1.7969	2.6643	4.7793	12.2275	15.5292	18.1174	20.0535	21.3869	22.1637	22.4185	23.3854
112.5	0.2411	0.2336	0.2299	0.2214	0.1653	-0.1030	-2.6768	-5.0504	-6.5268	-7.7246	-8.5822	-9.0941	-9.2640	-11.1507
135.0	-0.2544	-0.3546	-0.4836	-0.6725	-0.9814	-1.5561	-2.7710	-2.9104	-2.7682	-2.6086	-2.4843	-2.4051	-2.3780	-1.7647
157.5	-0.4963	-0.6099	-0.7412	-0.8934	-1.0647	-1.2251	-1.4182	-1.5404	-1.5662	-1.5499	-1.5447	-1.5428	-1.5423	-1.3633
180.0	-0.5606	-0.6707	-0.7880	-0.9050	-1.0053	-1.0561	-1.1973	-1.3070	-1.3561	-1.3507	-1.3523	-1.3555	-1.3567	-1.1951

OUTSIDE AXIAL STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	1.2323	0.8946	0.3352	-0.3962	-0.8674	-0.4997	-0.0810	0.0973	0.0940	0.0848	0.0744	0.0667	0.0638	0.0234
22.5	1.1099	0.9889	0.8172	0.5613	0.0659	-0.5926	-0.1013	0.1298	0.1348	0.1253	0.1126	0.1029	0.0994	0.0548
45.0	0.7507	0.9449	1.2862	1.7434	2.0587	1.3466	-0.2697	-0.1317	-0.3871	-0.5882	-0.7304	-0.8144	-0.8420	-0.9486
67.5	0.2256	0.4276	0.7203	1.1565	1.9643	3.6696	3.9853	3.3294	3.0924	3.0918	3.1749	3.2552	3.2868	5.2491
90.0	-0.2906	-0.2690	-0.2728	-0.2882	-0.2691	0.0209	4.6241	7.4571	9.1976	10.2445	10.8325	11.1229	11.2093	8.0969
112.5	-0.6201	-0.6945	-0.8135	-1.0031	-1.3499	-2.1566	-6.2860	-8.8930	-10.4312	-11.5018	-12.1724	-12.5366	-12.6515	-11.7260
135.0	-0.7279	-0.7810	-0.8503	-0.9455	-1.0769	-1.2201	-1.5123	-1.8864	-1.5901	-1.4002	-1.2714	-1.1965	-1.1721	-0.9160
157.5	-0.7154	-0.7220	-0.7239	-0.7159	-0.6836	-0.5937	-0.9546	-1.4760	-1.4421	-1.4201	-1.4159	-1.4133	-1.4124	-1.2391
180.0	-0.6966	-0.6845	-0.6617	-0.6206	-0.5514	-0.4484	-0.8481	-1.3617	-1.3587	-1.3439	-1.3488	-1.3529	-1.3543	-1.1878

OUTSIDE SHEAR STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0	0.0	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	-0.1086	-0.0804	0.0059	0.1743	0.3540	0.2473	0.0203	0.0481	0.0530	0.0458	0.0325	0.0166	0.0	0.0
45.0	-0.1188	-0.1112	-0.0947	-0.0641	0.0646	0.5185	0.4453	0.3513	0.2788	0.1998	0.1266	0.0610	0.0	0.0
67.5	-0.0461	-0.0670	-0.1206	-0.2236	-0.3916	-0.5487	0.9582	0.4503	0.1532	0.0089	-0.0400	-0.0329	0.0	0.0
90.0	0.0331	0.0189	-0.0064	-0.0476	-0.1435	-0.4978	-2.7211	-1.9563	-1.3198	-0.8492	-0.4990	-0.2293	0.0	0.0
112.5	0.0735	0.0799	0.0949	0.1243	0.1866	0.3743	1.5374	1.3406	1.0349	0.7476	0.4802	0.2338	0.0	0.0
135.0	0.0720	0.0844	0.1032	0.1309	0.1749	0.2439	0.1186	0.0537	0.0003	-0.0172	-0.0180	-0.0107	0.0	0.0
157.5	0.0423	0.0492	0.0574	0.0664	0.0733	0.0657	0.0227	0.0224	0.0147	0.0099	0.0067	0.0033	0.0	0.0
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

DIAMETER EXPANSION FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
90.0	115.03	147.68	185.61	231.86	292.34	380.10	528.73	574.26	612.95	643.19	664.64	677.38	681.60	701.06

TABLE A2

R/r = 2.0 t/r = 0.01

INSIDE HOOP STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	1.5658	2.1992	2.8299	3.0960	2.4229	1.2545	0.9760	0.8576	0.8034	0.7613	0.7327	0.7166	0.7114	0.8259
22.5	0.8714	1.1609	1.4893	1.8972	2.3967	2.2170	1.1498	0.9781	0.8860	0.8228	0.7838	0.7631	0.7567	0.8880
45.0	-0.4488	-0.7169	-0.9493	-0.8774	0.0108	2.2753	2.5074	1.8348	1.6443	1.5935	1.6001	1.6191	1.6277	2.3477
67.5	-1.1340	-1.5479	-2.0153	-2.5898	-3.3623	-3.7424	1.8242	4.2997	6.2203	7.4903	8.2831	8.7139	8.8500	7.4080
90.0	-0.8759	-1.0813	-1.3541	-1.8117	-2.6997	-4.9163	-13.4962	-17.5563	-20.6485	-22.9649	-24.5564	-25.4825	-25.7860	-26.9049
112.5	-0.2373	-0.2268	-0.2192	-0.2029	-0.1271	0.2114	2.2802	3.7573	5.3604	6.6724	7.6283	8.2056	8.3982	10.8953
135.0	0.2602	0.3621	0.4937	0.6870	1.0028	1.5837	2.5793	2.7392	2.6366	2.5471	2.4602	2.4008	2.3800	1.7920
157.5	0.5000	0.6138	0.7452	0.8971	1.0663	1.2195	1.3621	1.5475	1.5036	1.5101	1.5170	1.5204	1.5215	1.3642
180.0	0.5631	0.6730	0.7895	0.9049	1.0022	1.0493	1.1667	1.3656	1.3208	1.3243	1.3319	1.3360	1.3373	1.1946

INSIDE AXIAL STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	2.1156	2.1678	2.0245	1.5337	0.7282	0.2817	0.1984	0.0372	0.0386	0.0331	0.0252	0.0188	0.0165	-0.0323
22.5	1.5997	1.6531	1.6792	1.6682	1.5100	0.8758	0.2412	0.0843	0.0844	0.0708	0.0547	0.0429	0.0387	-0.0238
45.0	0.4896	0.5139	0.6854	1.1219	1.8772	2.5478	1.0045	0.2042	-0.0824	-0.2881	-0.4225	-0.4978	-0.5221	-0.4013
67.5	-0.4276	-0.4767	-0.4681	-0.3805	-0.0738	1.1268	4.2529	4.6549	5.1492	5.5855	5.9193	6.1262	6.1961	7.0971
90.0	-0.7942	-0.8899	-1.0423	-1.3020	-1.7504	-2.5918	-3.4323	-3.5017	-3.7478	-4.0910	-4.4052	-4.6187	-4.6937	-7.0406
112.5	-0.7525	-0.8163	-0.9246	-1.0965	-1.3844	-1.9634	-3.5336	-3.4034	-3.4690	-3.3539	-3.2112	-3.1022	-3.0621	-1.1067
135.0	-0.5711	-0.5636	-0.5565	-0.5416	-0.4983	-0.3380	1.1239	2.0478	2.1469	2.2205	2.2538	2.2650	2.2674	1.8986
157.5	-0.4196	-0.3601	-0.2863	-0.1914	-0.0630	0.1159	0.8357	1.3928	1.3821	1.3744	1.3794	1.3820	1.3828	1.2426
180.0	-0.3644	-0.2885	-0.1980	-0.0898	0.0373	0.1722	0.7929	1.3216	1.3277	1.3162	1.3217	1.3255	1.3266	1.1828

INSIDE SHEAR STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0	0.0	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	0.1482	0.2115	0.2634	0.2374	0.0323	-0.2371	-0.0842	-0.0618	-0.0412	-0.0234	-0.0113	-0.0043	0.0	0.0
45.0	0.1386	0.1818	0.2312	0.3061	0.4211	0.2929	-0.4553	-0.2133	-0.0908	-0.0249	0.0025	0.0067	0.0	0.0
67.5	0.0191	0.0091	0.0103	0.0567	0.2215	0.7641	1.2740	1.0199	0.8238	0.6098	0.3989	0.1965	0.0	0.0
90.0	-0.0677	-0.0955	-0.1270	-0.1747	-0.2668	-0.4399	0.3324	-0.0581	-0.2902	-0.3417	-0.2805	-0.1548	0.0	0.0
112.5	-0.0738	-0.0903	-0.1144	-0.1566	-0.2374	-0.4373	-1.3976	-0.9709	-0.5569	-0.2966	-0.1414	-0.0541	0.0	0.0
135.0	-0.0429	-0.0468	-0.0515	-0.0544	-0.0472	0.0070	0.3253	0.2683	0.1880	0.1245	0.0736	0.0338	0.0	0.0
157.5	-0.0160	-0.0152	-0.0123	-0.0046	0.0123	0.0436	0.0585	0.0388	0.0182	0.0087	0.0030	0.0006	0.0	0.0
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

DIAMETER EXPANSION FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
180.0	-119.51	-156.04	-196.20	-235.88	-267.93	-289.12	-308.69	-311.64	-315.25	-318.74	-321.62	-323.50	-324.16	-330.35

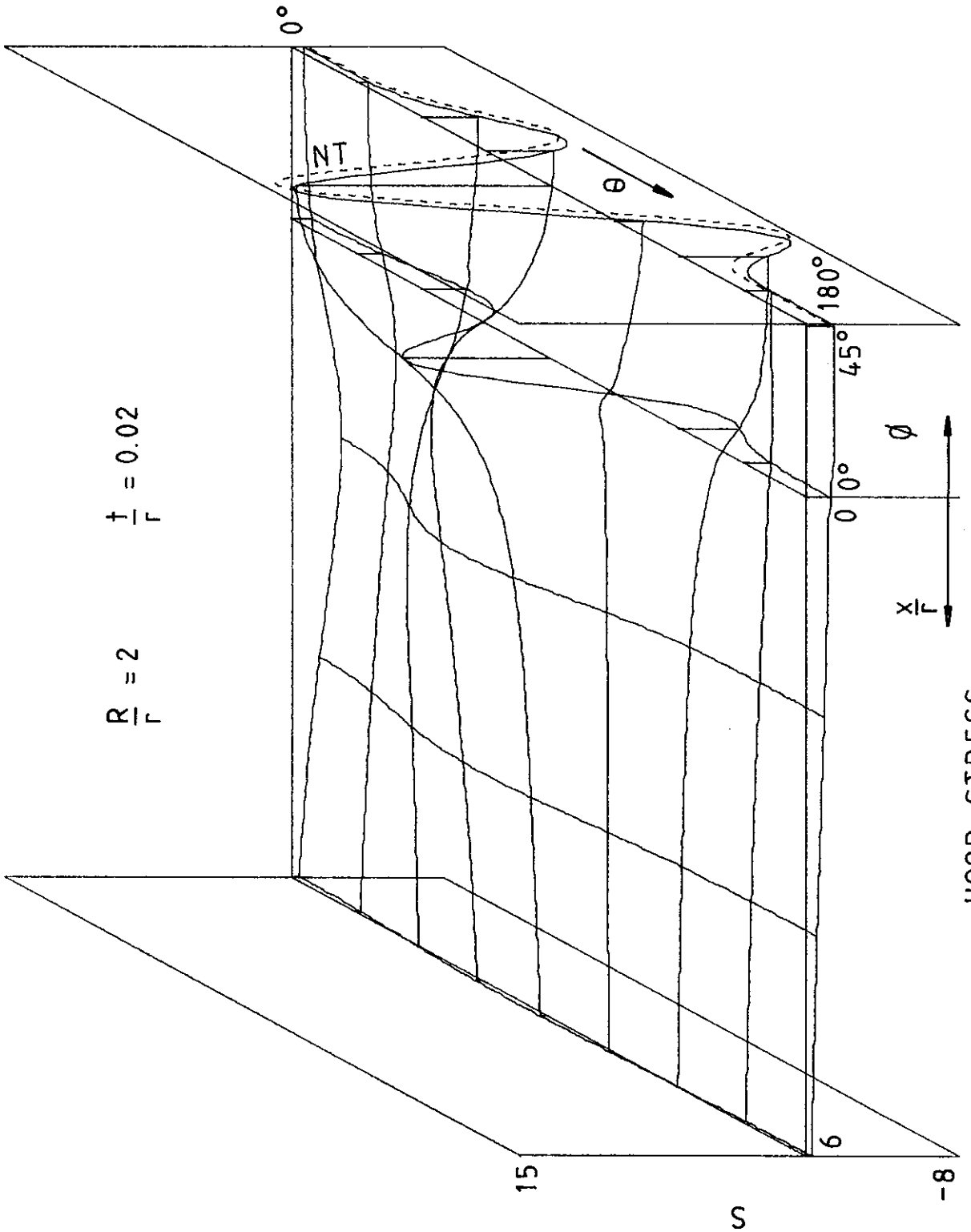


FIGURE A3

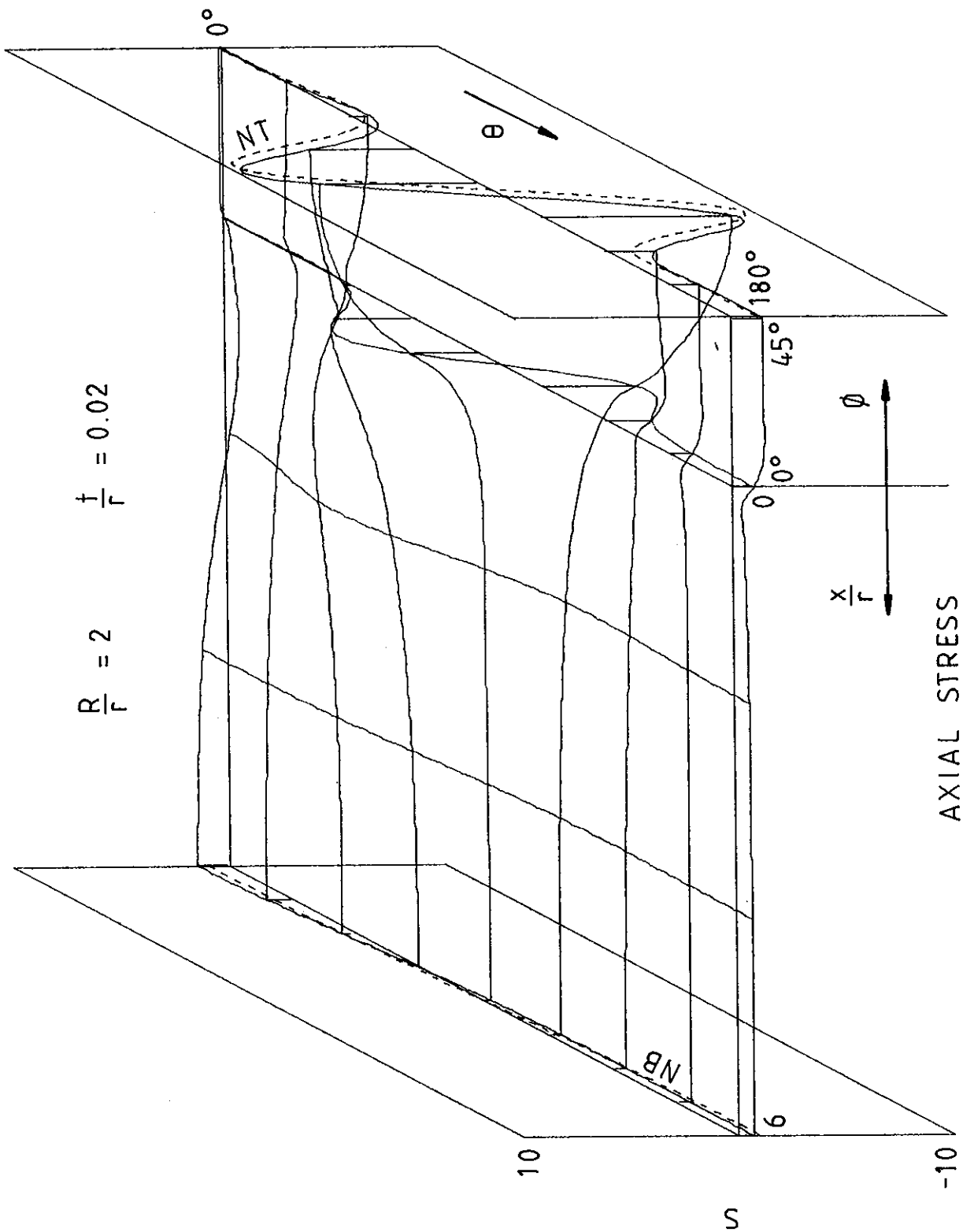


FIGURE A4

TABLE A3

R/r = 2.0 t/r = 0.02

OUTSIDE HOOP STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	-0.4728	-0.9052	-1.5167	-2.2330	-2.6398	-1.9940	-1.0618	-0.9154	-0.8242	-0.7477	-0.6943	-0.6634	-0.6534	-0.7469
22.5	-0.3060	-0.5468	-0.8639	-1.2534	-1.7149	-2.0896	-1.4043	-1.0487	-0.8661	-0.7437	-0.6689	-0.6288	-0.6163	-0.8669
45.0	0.0609	0.1883	0.4035	0.6429	0.5671	-0.6096	-2.4189	-2.5176	-2.6447	-2.7940	-2.9197	-3.0016	-3.0298	-3.8065
67.5	0.3511	0.6712	1.1085	1.6497	2.2832	2.8341	0.3034	-1.4505	-2.3886	-2.9985	-3.3698	-3.5684	-3.6306	-2.1347
90.0	0.3855	0.6246	0.9018	1.2534	1.8586	3.2962	7.6388	9.4170	10.8408	11.9054	12.6506	13.0911	13.2367	14.2537
112.5	0.1969	0.2467	0.2733	0.2964	0.3439	0.4293	0.3837	-0.3472	-0.6605	-0.9910	-1.2735	-1.4581	-1.5219	-4.2219
135.0	-0.0569	-0.1394	-0.2521	-0.4020	-0.6405	-1.1441	-3.2007	-3.9546	-4.3372	-4.5204	-4.6261	-4.6801	-4.6962	-3.6569
157.5	-0.2420	-0.3710	-0.5179	-0.6926	-0.9115	-1.1812	-1.5018	-1.5436	-1.5711	-1.5308	-1.4946	-1.4758	-1.4702	-1.2206
180.0	-0.3062	-0.4418	-0.5897	-0.7557	-0.9323	-1.0760	-1.2676	-1.3338	-1.4163	-1.4267	-1.4233	-1.4235	-1.4243	-1.1844

OUTSIDE AXIAL STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	1.4508	1.3739	1.1306	0.6017	-0.2131	-0.6648	-0.0592	0.1563	0.1548	0.1467	0.1350	0.1259	0.1226	0.0684
22.5	1.2163	1.1755	1.0713	0.8772	0.5395	-0.0992	-0.1525	0.1117	0.0656	0.0234	-0.0125	-0.0357	-0.0438	-0.1654
45.0	0.6567	0.6851	0.8074	1.1090	1.5895	1.7037	0.2296	0.0239	-0.3616	-0.6160	-0.7791	-0.8698	-0.8989	-0.6659
67.5	0.0653	0.1260	0.2935	0.6175	1.1918	2.3886	3.7090	3.7990	4.0788	4.3514	4.5751	4.7194	4.7690	6.2809
90.0	-0.3551	-0.3200	-0.2699	-0.2303	-0.1906	0.0626	3.1109	4.7564	5.8624	6.5611	6.9898	7.2189	7.2907	5.1399
112.5	-0.5782	-0.5853	-0.6337	-0.7534	-0.9948	-1.5765	-4.2705	-5.8942	-6.9436	-7.7877	-8.3747	-8.7178	-8.8306	-9.5356
135.0	-0.6718	-0.6947	-0.7480	-0.8355	-0.9744	-1.2065	-2.0960	-2.7508	-2.6548	-2.5410	-2.4577	-2.4014	-2.3813	-1.3663
157.5	-0.7034	-0.7162	-0.7311	-0.7413	-0.7366	-0.6784	-1.0064	-1.4699	-1.4864	-1.4335	-1.4109	-1.4041	-1.4024	-1.2056
180.0	-0.7103	-0.7146	-0.7096	-0.6882	-0.6354	-0.5236	-0.8998	-1.3653	-1.4387	-1.4147	-1.4070	-1.4103	-1.4123	-1.1721

OUTSIDE SHEAR STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0	0.0	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	-0.1094	-0.1289	-0.1215	-0.0358	0.1900	0.3994	0.1152	0.1111	0.1015	0.0786	0.0524	0.0259	0.0	0.0
45.0	-0.1295	-0.1477	-0.1507	-0.1268	-0.0506	0.2555	0.7402	0.4891	0.3442	0.2280	0.1375	0.0643	0.0	0.0
67.5	-0.0586	-0.0618	-0.0763	-0.1332	-0.2781	-0.4928	0.2292	0.0433	-0.0837	-0.1217	-0.1065	-0.0604	0.0	0.0
90.0	0.0334	0.0407	0.0326	-0.0047	-0.0945	-0.3864	-1.8397	-1.3875	-0.9789	-0.6602	-0.4061	-0.1929	0.0	0.0
112.5	0.0843	0.0936	0.1009	0.1159	0.1565	0.2729	0.7533	0.7459	0.6318	0.5019	0.3465	0.1763	0.0	0.0
135.0	0.0823	0.0901	0.1046	0.1334	0.1873	0.3014	0.5070	0.4077	0.2680	0.1646	0.0945	0.0429	0.0	0.0
157.5	0.0473	0.0521	0.0620	0.0777	0.0979	0.1120	0.0275	0.0205	0.0141	0.0061	0.0030	0.0015	0.0	0.0
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

DIAMETER EXPANSION FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
90.0	24.06	39.88	59.43	83.32	113.87	157.30	226.82	247.00	264.42	278.23	288.17	294.16	296.15	309.87

TABLE A4

R/r = 2.0 t/r = 0.02

INSIDE HOOP STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.4868	0.9377	1.5794	2.3326	2.7368	1.9657	1.0011	0.8426	0.7531	0.6874	0.6450	0.6218	0.6145	0.7474
22.5	0.3145	0.5637	0.8921	1.2962	1.7822	2.1781	1.3046	0.9391	0.7766	0.6773	0.6213	0.5933	0.5849	0.8725
45.0	-0.0639	-0.2001	-0.4321	-0.6924	-0.6060	0.7176	2.4039	2.3290	2.5799	2.8058	2.9821	3.0925	3.1300	3.8834
67.5	-0.3621	-0.6951	-1.1511	-1.7164	-2.3913	-3.0204	-0.3921	1.0543	2.1123	2.7702	3.1626	3.3687	3.4327	1.5103
90.0	-0.3953	-0.6390	-0.9191	-1.2740	-1.8987	-3.4386	-8.6787	-11.0310	-12.7973	-14.1311	-15.0632	-15.6129	-15.7945	-17.0399
112.5	-0.1997	-0.2464	-0.2668	-0.2811	-0.3119	-0.3376	-0.9396	-1.0937	-0.8647	-0.5462	-0.2657	-0.0768	-0.0104	3.4071
135.0	0.0599	0.1465	0.2639	0.4201	0.6710	1.2030	2.9926	3.7322	4.1102	4.4021	4.5873	4.6852	4.7156	3.7993
157.5	0.2473	0.3778	0.5258	0.7014	0.9200	1.1818	1.4075	1.5780	1.5034	1.4648	1.4519	1.4452	1.4428	1.2179
180.0	0.3117	0.4476	0.5951	0.7600	0.9325	1.0666	1.2152	1.4278	1.3968	1.3831	1.3912	1.3993	1.4020	1.1829

INSIDE AXIAL STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	1.6624	1.8421	1.9834	1.9535	1.5241	0.7123	0.2134	0.0697	0.0813	0.0731	0.0611	0.0515	0.0480	-0.0336
22.5	1.3513	1.4540	1.5443	1.5958	1.5643	1.2766	0.3701	0.0475	-0.0104	-0.0724	-0.1196	-0.1489	-0.1588	-0.2445
45.0	0.6190	0.5723	0.5522	0.6575	1.0689	1.8276	1.4742	0.7463	0.5313	0.3924	0.3113	0.2694	0.2565	0.6610
67.5	-0.1147	-0.2451	-0.3497	-0.3752	-0.2364	0.3881	2.5913	3.3352	3.8141	4.1886	4.4506	4.6055	4.6567	4.9620
90.0	-0.5541	-0.6620	-0.7740	-0.9250	-1.1957	-1.6936	-2.1360	-2.1929	-2.3108	-2.4490	-2.5807	-2.6712	-2.7031	-4.3042
112.5	-0.6782	-0.7140	-0.7700	-0.8840	-1.1155	-1.6348	-3.4596	-3.9025	-4.4027	-4.6509	-4.7878	-4.8563	-4.8768	-3.4875
135.0	-0.6321	-0.6046	-0.5876	-0.5838	-0.5844	-0.5500	0.7340	1.8999	2.2444	2.4873	2.6672	2.7714	2.8051	2.7142
157.5	-0.5584	-0.4949	-0.4247	-0.3366	-0.2127	-0.0156	0.8664	1.4026	1.4684	1.4421	1.4330	1.4323	1.4323	1.1833
180.0	-0.5281	-0.4533	-0.3646	-0.2508	-0.1012	0.0906	0.8157	1.3108	1.4064	1.3944	1.3926	1.3986	1.4015	1.1888

INSIDE SHEAR STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0	0.0	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	0.0589	0.1163	0.2015	0.2924	0.2752	-0.0407	-0.2073	-0.1125	-0.0654	-0.0333	-0.0147	-0.0052	0.0	0.0
45.0	0.0708	0.1242	0.1945	0.2799	0.3920	0.4685	-0.1924	-0.0392	0.0470	0.0731	0.0647	0.0367	0.0	0.0
67.5	0.0324	0.0374	0.0341	0.0372	0.1195	0.5040	1.3431	0.9941	0.7528	0.5367	0.3441	0.1678	0.0	0.0
90.0	-0.0193	-0.0488	-0.0915	-0.1439	-0.2144	-0.3231	0.2640	0.0546	-0.0879	-0.1389	-0.1247	-0.0714	0.0	0.0
112.5	-0.0471	-0.0753	-0.1073	-0.1493	-0.2299	-0.4499	-1.5091	-1.2246	-0.8606	-0.5755	-0.3513	-0.1659	0.0	0.0
135.0	-0.0435	-0.0553	-0.0651	-0.0762	-0.0883	-0.0778	0.2755	0.2853	0.2344	0.1873	0.1290	0.0652	0.0	0.0
157.5	-0.0234	-0.0249	-0.0247	-0.0222	-0.0097	0.0324	0.0935	0.0703	0.0350	0.0166	0.0072	0.0024	0.0	0.0
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

DIAMETER EXPANSION FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
180.0	-24.12	-40.52	-61.37	-86.35	-112.72	-134.32	-149.49	-151.63	-154.31	-156.87	-158.93	-160.28	-160.74	-165.04

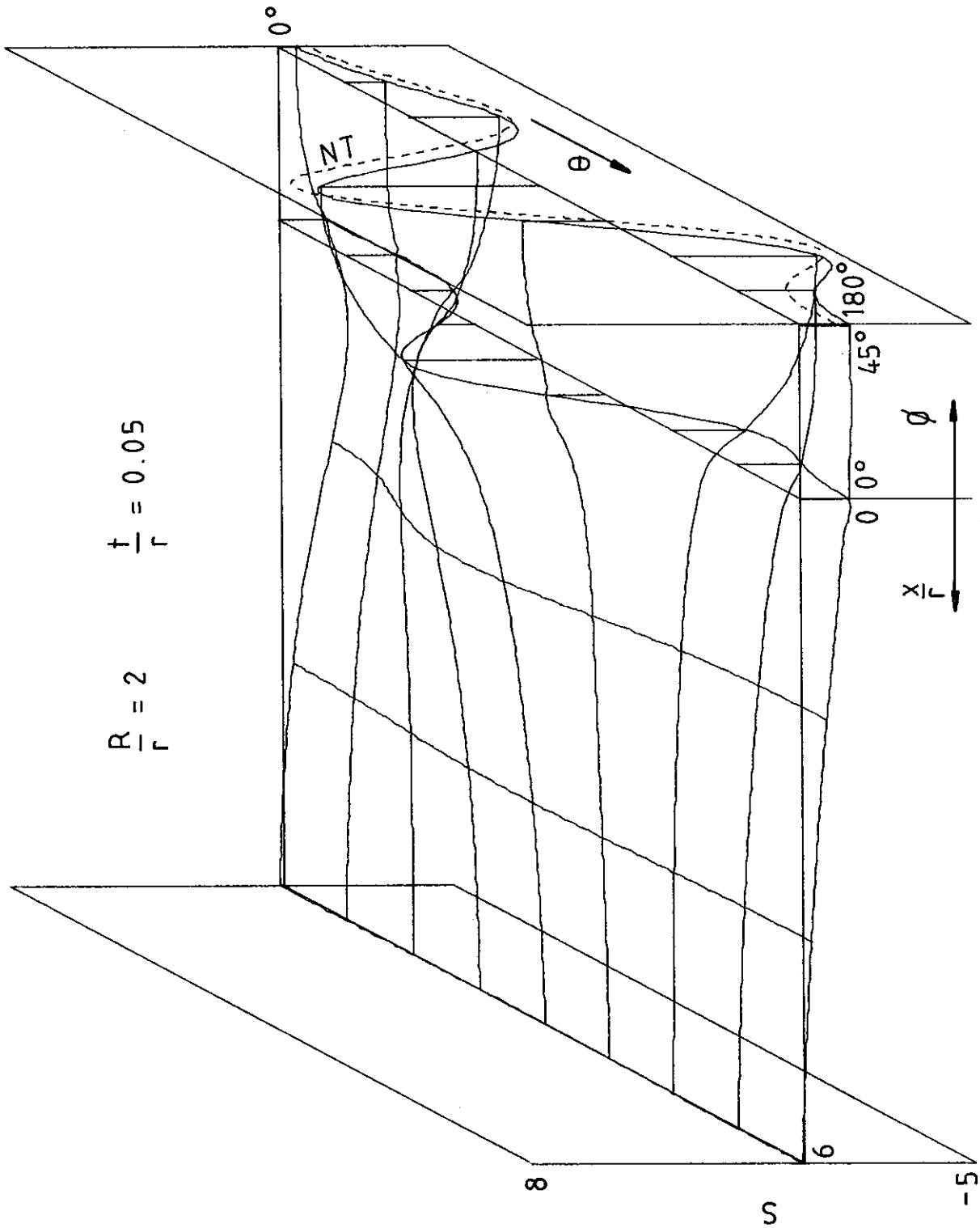


FIGURE A5

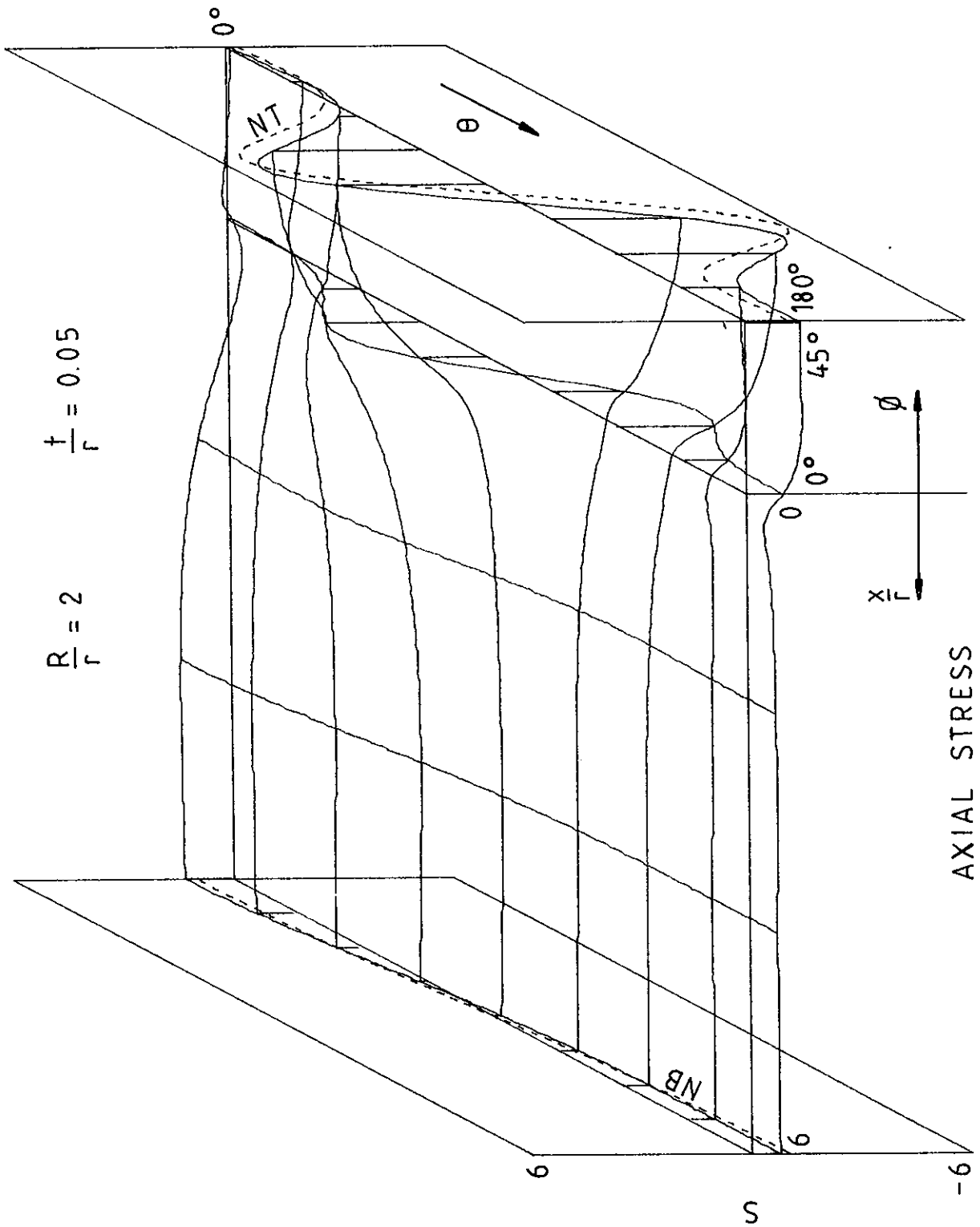


FIGURE A6

TABLE A5

R/r = 2.0 t/r = 0.05

OUTSIDE HOOP STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0694	-0.0686	-0.3453	-0.8339	-1.5308	-2.0131	-1.3889	-1.0130	-0.7911	-0.6617	-0.5811	-0.5383	-0.5250	-0.8641
22.5	0.0456	-0.0482	-0.2244	-0.5174	-0.9462	-1.4472	-1.5454	-1.4077	-1.3042	-1.2681	-1.2524	-1.2472	-1.2462	-1.7357
45.0	-0.0074	0.0007	0.0415	0.1492	0.3000	0.1183	-1.2584	-1.8613	-2.1519	-2.3813	-2.5388	-2.6304	-2.6605	-2.8812
67.5	-0.0512	0.0488	0.2538	0.6201	1.1719	1.7606	1.1357	0.5137	0.2288	0.0586	-0.0400	-0.0893	-0.1042	1.1226
90.0	-0.0589	0.0676	0.2849	0.6142	1.0984	1.9763	4.0213	4.7557	5.3695	5.8357	6.1591	6.3507	6.4144	7.2329
112.5	-0.0323	0.0468	0.1534	0.2696	0.4014	0.6867	1.7396	1.8402	2.0688	2.2442	2.3485	2.4013	2.4174	0.6523
135.0	0.0071	-0.0008	-0.0356	-0.1195	-0.2728	-0.5683	-2.1622	-2.9938	-3.5525	-3.9038	-4.1304	-4.2623	-4.3060	-4.5341
157.5	0.0378	-0.0474	-0.1828	-0.3722	-0.6271	-1.0029	-1.9334	-2.0873	-2.2429	-2.3179	-2.3419	-2.3469	-2.3474	-1.5186
180.0	0.0490	-0.0665	-0.2364	-0.4539	-0.7205	-1.0418	-1.4077	-1.4027	-1.4546	-1.4750	-1.4681	-1.4556	-1.4502	-1.0336

OUTSIDE AXIAL STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	1.2927	1.3569	1.3794	1.2677	0.8369	-0.0093	-0.1504	0.1101	0.0371	-0.0281	-0.0757	-0.1056	-0.1157	-0.2856
22.5	1.1316	1.1718	1.1856	1.1317	0.9375	0.4861	0.0063	0.0842	-0.0615	-0.1776	-0.2548	-0.3002	-0.3151	-0.3464
45.0	0.7147	0.7036	0.6993	0.7473	0.9574	1.3498	0.9594	0.7779	0.6461	0.5477	0.4928	0.4648	0.4562	1.0458
67.5	0.1999	0.1517	0.1347	0.2170	0.5288	1.2967	2.6267	2.9645	3.3719	3.6596	3.8631	3.9852	4.0259	4.8176
90.0	-0.2538	-0.3019	-0.3181	-0.2802	-0.1783	0.0705	1.8538	2.6181	3.2231	3.6213	3.8744	4.0164	4.0623	2.8162
112.5	-0.5590	-0.5797	-0.5860	-0.6006	-0.6903	-0.9970	-1.9535	-2.5165	-2.8571	-3.1439	-3.3650	-3.5020	-3.5481	-5.1786
135.0	-0.7150	-0.7050	-0.7013	-0.7294	-0.8310	-1.0924	-2.6087	-3.5225	-3.8995	-4.1132	-4.2580	-4.3452	-4.3743	-3.5269
157.5	-0.7725	-0.7437	-0.7343	-0.7481	-0.7760	-0.7890	-1.2427	-1.6493	-1.7458	-1.7094	-1.6577	-1.6258	-1.6158	-0.9343
180.0	-0.7846	-0.7501	-0.7390	-0.7432	-0.7331	-0.6517	-0.9779	-1.3413	-1.4883	-1.5032	-1.4825	-1.4665	-1.4616	-1.1432

OUTSIDE SHEAR STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0	0.0	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	-0.0533	-0.0837	-0.1205	-0.1429	-0.0757	0.2025	0.3902	0.2575	0.1815	0.1226	0.0748	0.0353	0.0	0.0
45.0	-0.0731	-0.1102	-0.1527	-0.1848	-0.1643	0.0168	0.5682	0.3760	0.2333	0.1428	0.0803	0.0358	0.0	0.0
67.5	-0.0482	-0.0663	-0.0834	-0.1037	-0.1612	-0.3211	-0.1748	-0.1648	-0.1761	-0.1531	-0.1113	-0.0584	0.0	0.0
90.0	0.0039	0.0128	0.0263	0.0313	-0.0159	-0.2380	-1.0189	-0.8033	-0.5961	-0.4185	-0.2653	-0.1287	0.0	0.0
112.5	0.0512	0.0761	0.1036	0.1272	0.1442	0.1642	0.0438	0.1103	0.1171	0.1096	0.0858	0.0471	0.0	0.0
135.0	0.0675	0.0922	0.1155	0.1405	0.1869	0.3167	0.7723	0.7156	0.5679	0.4108	0.2664	0.1313	0.0	0.0
157.5	0.0461	0.0601	0.0718	0.0861	0.1167	0.1812	0.1790	0.1492	0.1202	0.0829	0.0494	0.0228	0.0	0.0
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

DIAMETER EXPANSION FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
90.0	-1.382	1.840	7.401	15.942	28.103	45.262	70.386	77.079	82.985	87.755	91.224	93.328	94.032	101.501

TABLE A6

R/r = 2.0 t/r = 0.05

INSIDE HOOP STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	-0.0776	0.0692	0.3681	0.9046	1.6796	2.1780	1.2640	0.8210	0.6695	0.5666	0.5094	0.4814	0.4731	0.8654
22.5	-0.0507	0.0491	0.2381	0.5553	1.0237	1.5782	1.4876	1.2099	1.2007	1.2057	1.2202	1.2333	1.2383	1.7640
45.0	0.0089	0.0002	-0.0463	-0.1729	-0.3576	-0.1416	1.3067	1.6718	2.0815	2.3760	2.5729	2.6867	2.7239	2.8487
67.5	0.0574	-0.0490	-0.2707	-0.6726	-1.2868	-1.9673	-1.3417	-0.9300	-0.6418	-0.4685	-0.3770	-0.3338	-0.3213	-1.9492
90.0	0.0649	-0.0696	-0.3006	-0.6488	-1.1597	-2.1302	-4.8283	-5.9364	-6.7820	-7.4017	-7.8357	-8.0940	-8.1798	-9.2749
112.5	0.0347	-0.0492	-0.1592	-0.2722	-0.3887	-0.6434	-2.4461	-3.1595	-3.6182	-3.8946	-4.0591	-4.1472	-4.1750	-1.8869
135.0	-0.0085	0.0001	0.0393	0.1346	0.3093	0.6595	1.9207	2.5665	3.0192	3.3907	3.6683	3.8377	3.8943	4.6040
157.5	-0.0413	0.0491	0.1919	0.3895	0.6518	1.0335	1.7757	2.0947	2.1868	2.2321	2.2707	2.2987	2.3088	1.5491
180.0	-0.0530	0.0694	0.2470	0.4698	0.7364	1.0433	1.2922	1.4793	1.4820	1.4493	1.4304	1.4253	1.4250	1.0297

INSIDE AXIAL STRESS FACTORS

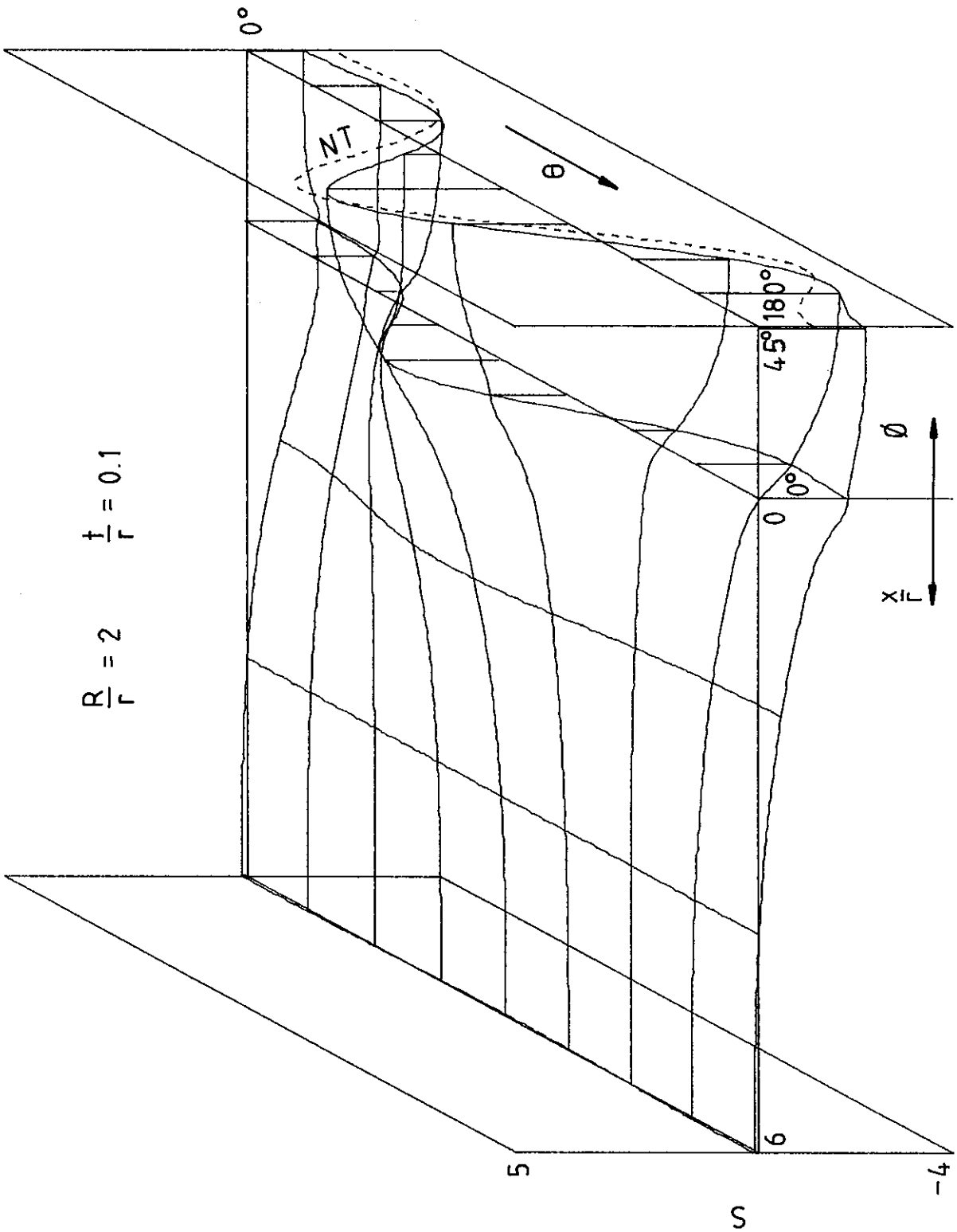
Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	1.1535	1.2790	1.4454	1.6263	1.7046	1.4091	0.4583	0.0501	-0.0296	-0.1037	-0.1614	-0.1961	-0.2077	-0.3164
22.5	1.0257	1.1093	1.2166	1.3348	1.4219	1.3717	0.7424	0.3032	0.1846	0.1036	0.0453	0.0117	0.0007	0.0641
45.0	0.6865	0.6756	0.6535	0.6319	0.6835	0.9903	1.3456	1.2309	1.1960	1.2098	1.2227	1.2323	1.2357	1.6092
67.5	0.2458	0.1541	0.0309	-0.1044	-0.1744	0.0311	1.0554	1.5702	1.7996	1.9887	2.1163	2.1891	2.2128	2.1155
90.0	-0.1748	-0.2846	-0.4191	-0.5697	-0.7364	-0.9465	-1.1469	-1.1634	-1.2315	-1.2760	-1.3105	-1.3349	-1.3437	-2.2038
112.5	-0.4930	-0.5571	-0.6259	-0.7030	-0.8311	-1.1539	-2.3056	-2.6448	-3.0248	-3.2735	-3.4238	-3.5064	-3.5331	-3.1149
135.0	-0.6865	-0.6763	-0.6567	-0.6344	-0.6331	-0.6965	-0.3109	0.3803	0.5878	0.6891	0.7701	0.8265	0.8466	1.5266
157.5	-0.7785	-0.7063	-0.6216	-0.5274	-0.4163	-0.2462	0.8755	1.5046	1.7969	1.9096	1.9617	1.9912	2.0016	1.6202
180.0	-0.8039	-0.7084	-0.6008	-0.4820	-0.3325	-0.0973	0.8762	1.3065	1.5093	1.5636	1.5664	1.5624	1.5611	1.1249

INSIDE SHEAR STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0	0.0	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	-0.0075	0.0151	0.0648	0.1603	0.2927	0.2855	-0.1117	-0.0459	0.0071	0.0236	0.0233	0.0137	0.0	0.0
45.0	-0.0085	0.0211	0.0788	0.1786	0.3270	0.4892	0.3105	0.2554	0.2404	0.1950	0.1355	0.0693	0.0	0.0
67.5	-0.0030	0.0145	0.0383	0.0637	0.1023	0.2937	0.9552	0.7183	0.5338	0.3797	0.2432	0.1187	0.0	0.0
90.0	0.0033	-0.0005	-0.0182	-0.0628	-0.1384	-0.2063	0.2017	0.1125	0.0451	0.0090	-0.0061	-0.0067	0.0	0.0
112.5	0.0055	-0.0149	-0.0523	-0.1120	-0.2035	-0.3999	-1.0279	-0.9013	-0.6972	-0.4992	-0.3212	-0.1574	0.0	0.0
135.0	0.0038	-0.0204	-0.0530	-0.0898	-0.1312	-0.1987	-0.2805	-0.2123	-0.1651	-0.1088	-0.0615	-0.0270	0.0	0.0
157.5	0.0014	-0.0142	-0.0310	-0.0436	-0.0482	-0.0253	0.1908	0.1878	0.1407	0.0967	0.0616	0.0304	0.0	0.0
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

DIAMETER EXPANSION FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
180.0	1.384	-1.840	-7.435	-16.108	-28.249	-42.714	-55.663	-57.545	-59.582	-61.454	-62.906	-63.817	-64.127	-66.861



HOOP STRESS

FIGURE A7

TABLE A7

R/r = 2.0 t/r = 0.1

OUTSIDE HOOP STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0859	0.0675	-0.0221	-0.2517	-0.7038	-1.3128	-1.4813	-1.3866	-1.2514	-1.2046	-1.1899	-1.1849	-1.1838	-1.7442
22.5	0.0604	0.0472	-0.0141	-0.1658	-0.4603	-0.9101	-1.3146	-1.4146	-1.3920	-1.4097	-1.4350	-1.4522	-1.4582	-1.9071
45.0	-0.0008	-0.0011	0.0032	0.0261	0.0829	0.0717	-0.5610	-0.9583	-1.1252	-1.2411	-1.3225	-1.3695	-1.3848	-1.3245
67.5	-0.0610	-0.0481	0.0164	0.1850	0.5256	1.0140	1.0189	0.8211	0.7515	0.7309	0.7241	0.7228	0.7229	1.5405
90.0	-0.0847	-0.0659	0.0174	0.2142	0.5876	1.2485	2.4071	2.7613	3.0655	3.3112	3.4862	3.5900	3.6244	4.2128
112.5	-0.0588	-0.0452	0.0084	0.1194	0.3030	0.6541	1.5772	1.7405	1.9457	2.1256	2.2565	2.3340	2.3594	1.5342
135.0	0.0008	0.0011	-0.0029	-0.0241	-0.0862	-0.2046	-0.9197	-1.3597	-1.6568	-1.8423	-1.9544	-2.0154	-2.0349	-2.8364
157.5	0.0595	0.0460	-0.0108	-0.1386	-0.3682	-0.7515	-1.9795	-2.2853	-2.5622	-2.7603	-2.8842	-2.9502	-2.9708	-2.3514
180.0	0.0836	0.0644	-0.0134	-0.1807	-0.4648	-0.9055	-1.8410	-1.9204	-2.0370	-2.1296	-2.1856	-2.2128	-2.2205	-1.1576

OUTSIDE AXIAL STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	1.1459	1.2108	1.2824	1.3175	1.1890	0.6452	0.0271	0.0309	-0.0726	-0.2000	-0.2855	-0.3332	-0.3487	-0.4041
22.5	1.0375	1.0824	1.1311	1.1573	1.0947	0.8014	0.3042	0.2519	0.1631	0.0546	-0.0181	-0.0581	-0.0710	0.0575
45.0	0.7413	0.7392	0.7350	0.7375	0.7947	1.0021	1.0914	1.0699	1.1124	1.1172	1.1200	1.1236	1.1251	1.6332
67.5	0.3329	0.2864	0.2345	0.2094	0.3092	0.7592	1.8368	2.1386	2.4608	2.6843	2.8314	2.9166	2.9447	3.3249
90.0	-0.0960	-0.1580	-0.2236	-0.2628	-0.2202	0.0089	1.2324	1.6551	2.0203	2.2817	2.4512	2.5466	2.5775	1.7780
112.5	-0.4687	-0.5098	-0.5508	-0.5797	-0.6064	-0.7187	-0.9313	-1.1132	-1.1983	-1.2560	-1.3014	-1.3314	-1.3420	-2.8026
135.0	-0.7413	-0.7393	-0.7351	-0.7356	-0.7746	-0.9621	-2.2193	-2.8805	-3.2476	-3.4732	-3.6177	-3.7010	-3.7285	-3.7764
157.5	-0.9016	-0.8589	-0.8148	-0.7870	-0.7971	-0.8518	-1.6361	-2.1112	-2.3517	-2.4544	-2.4930	-2.5060	-2.5090	-1.5238
180.0	-0.9538	-0.8948	-0.8350	-0.7957	-0.7881	-0.7626	-1.1706	-1.4978	-1.6718	-1.7304	-1.7331	-1.7216	-1.7159	-0.8583

OUTSIDE SHEAR STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0	0.0	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	-0.0157	-0.0363	-0.0691	-0.1113	-0.1284	0.0017	0.3123	0.2135	0.1282	0.0773	0.0439	0.0198	0.0	0.0
45.0	-0.0222	-0.0505	-0.0941	-0.1495	-0.1881	-0.1064	0.2983	0.2059	0.1081	0.0537	0.0248	0.0093	0.0	0.0
67.5	-0.0156	-0.0345	-0.0612	-0.0939	-0.1362	-0.2183	-0.1723	-0.1447	-0.1398	-0.1196	-0.0855	-0.0444	0.0	0.0
90.0	0.0000	0.0014	0.0060	0.0136	0.0031	-0.1293	-0.5675	-0.4542	-0.3473	-0.2527	-0.1645	-0.0810	0.0	0.0
112.5	0.0157	0.0355	0.0657	0.1042	0.1385	0.1292	-0.1115	-0.0502	-0.0221	-0.0072	-0.0001	0.0015	0.0	0.0
135.0	0.0221	0.0485	0.0856	0.1302	0.1837	0.2865	0.5720	0.5551	0.4660	0.3525	0.2344	0.1168	0.0	0.0
157.5	0.0156	0.0337	0.0581	0.0862	0.1229	0.2092	0.4150	0.3846	0.3280	0.2513	0.1675	0.0832	0.0	0.0
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

DIAMETER EXPANSION FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
90.0	-1.090	-0.825	0.293	2.904	7.780	15.742	27.164	30.015	32.559	34.655	36.201	37.143	37.460	41.610

TABLE A8

R/r = 2.0 t/r = 0.1

INSIDE HOOP STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	-0.1002	-0.0818	0.0172	0.2796	0.8125	1.5401	1.4428	1.1243	1.0919	1.1059	1.1223	1.1356	1.1408	1.7450
22.5	-0.0703	-0.0570	0.0107	0.1825	0.5236	1.0561	1.3102	1.1910	1.2633	1.3443	1.4025	1.4385	1.4509	1.9088
45.0	0.0011	0.0017	-0.0031	-0.0322	-0.1119	-0.1190	0.5505	0.7665	0.9886	1.1568	1.2658	1.3275	1.3475	1.1579
67.5	0.0712	0.0584	-0.0129	-0.2060	-0.6096	-1.2149	-1.2830	-1.2298	-1.2073	-1.1983	-1.2024	-1.2093	-1.2122	-2.3647
90.0	0.0986	0.0793	-0.0126	-0.2330	-0.6539	-1.4174	-3.0825	-3.6871	-4.1698	-4.5247	-4.7711	-4.9171	-4.9656	-5.8181
112.5	0.0683	0.0538	-0.0053	-0.1258	-0.3160	-0.6597	-2.2972	-2.8532	-3.2764	-3.5772	-3.7773	-3.8922	-3.9297	-2.8123
135.0	-0.0011	-0.0017	0.0027	0.0291	0.1106	0.2992	0.5639	0.7818	0.9370	1.0648	1.1641	1.2272	1.2489	2.6379
157.5	-0.0691	-0.0552	0.0075	0.1493	0.4019	0.8307	1.7941	2.1900	2.4247	2.5837	2.6957	2.7648	2.7883	2.4216
180.0	-0.0971	-0.0769	0.0089	0.1929	0.4976	0.9589	1.6521	1.9278	2.0484	2.1028	2.1331	2.1512	2.1576	1.1554

INSIDE AXIAL STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.9708	1.0229	1.1136	1.2484	1.3968	1.4218	0.8253	0.4070	0.2174	0.1324	0.0731	0.0369	0.0250	0.0954
22.5	0.8922	0.9287	0.9913	1.0835	1.1909	1.2499	0.9126	0.6322	0.4865	0.4313	0.3947	0.3721	0.3646	0.5047
45.0	0.6713	0.6704	0.6671	0.6602	0.6637	0.7518	0.9532	1.0239	1.0150	1.0431	1.0667	1.0797	1.0838	1.2400
67.5	0.3480	0.3109	0.2458	0.1481	0.0410	0.0468	0.4387	0.7202	0.8215	0.9009	0.9586	0.9915	1.0021	0.8195
90.0	-0.0216	-0.0726	-0.1585	-0.2838	-0.4393	-0.5831	-0.7290	-0.7226	-0.7601	-0.7915	-0.8099	-0.8201	-0.8235	-1.3134
112.5	-0.3786	-0.4136	-0.4701	-0.5493	-0.6575	-0.8456	-1.4482	-1.6060	-1.7943	-1.9406	-2.0362	-2.0891	-2.1059	-2.0488
135.0	-0.6713	-0.6704	-0.6672	-0.6599	-0.6570	-0.7107	-0.6564	-0.3448	-0.2677	-0.2624	-0.2688	-0.2727	-0.2736	0.2982
157.5	-0.8616	-0.8260	-0.7670	-0.6824	-0.5747	-0.4412	0.5471	1.1069	1.4308	1.6004	1.6865	1.7280	1.7406	1.6537
180.0	-0.9275	-0.8777	-0.7963	-0.6814	-0.5323	-0.3181	0.9262	1.4191	1.7456	1.9274	2.0179	2.0583	2.0697	1.4772

INSIDE SHEAR STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0	0.0	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	-0.0173	-0.0133	0.0067	0.0617	0.1769	0.3053	0.1604	0.1232	0.1143	0.0942	0.0653	0.0332	0.0	0.0
45.0	-0.0240	-0.0182	0.0084	0.0766	0.2145	0.4222	0.4756	0.3635	0.2920	0.2231	0.1493	0.0746	0.0	0.0
67.5	-0.0165	-0.0121	0.0045	0.0391	0.0986	0.2397	0.6559	0.5129	0.3858	0.2809	0.1835	0.0904	0.0	0.0
90.0	0.0006	0.0009	-0.0015	-0.0162	-0.0599	-0.1144	0.1653	0.1194	0.0800	0.0542	0.0343	0.0166	0.0	0.0
112.5	0.0169	0.0128	-0.0057	-0.0515	-0.1438	-0.3247	-0.6159	-0.5516	-0.4423	-0.3247	-0.2109	-0.1035	0.0	0.0
135.0	0.0232	0.0169	-0.0063	-0.0536	-0.1298	-0.2610	-0.5191	-0.4530	-0.3762	-0.2839	-0.1871	-0.0923	0.0	0.0
157.5	0.0162	0.0115	-0.0039	-0.0318	-0.0677	-0.1024	0.0161	0.0384	0.0248	0.0107	0.0034	0.0008	0.0	0.0
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

DIAMETER EXPANSION FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
180.0	1.090	0.825	-0.294	-2.910	-7.773	-15.315	-24.859	-26.798	-28.501	-29.968	-31.076	-31.760	-31.990	-33.606

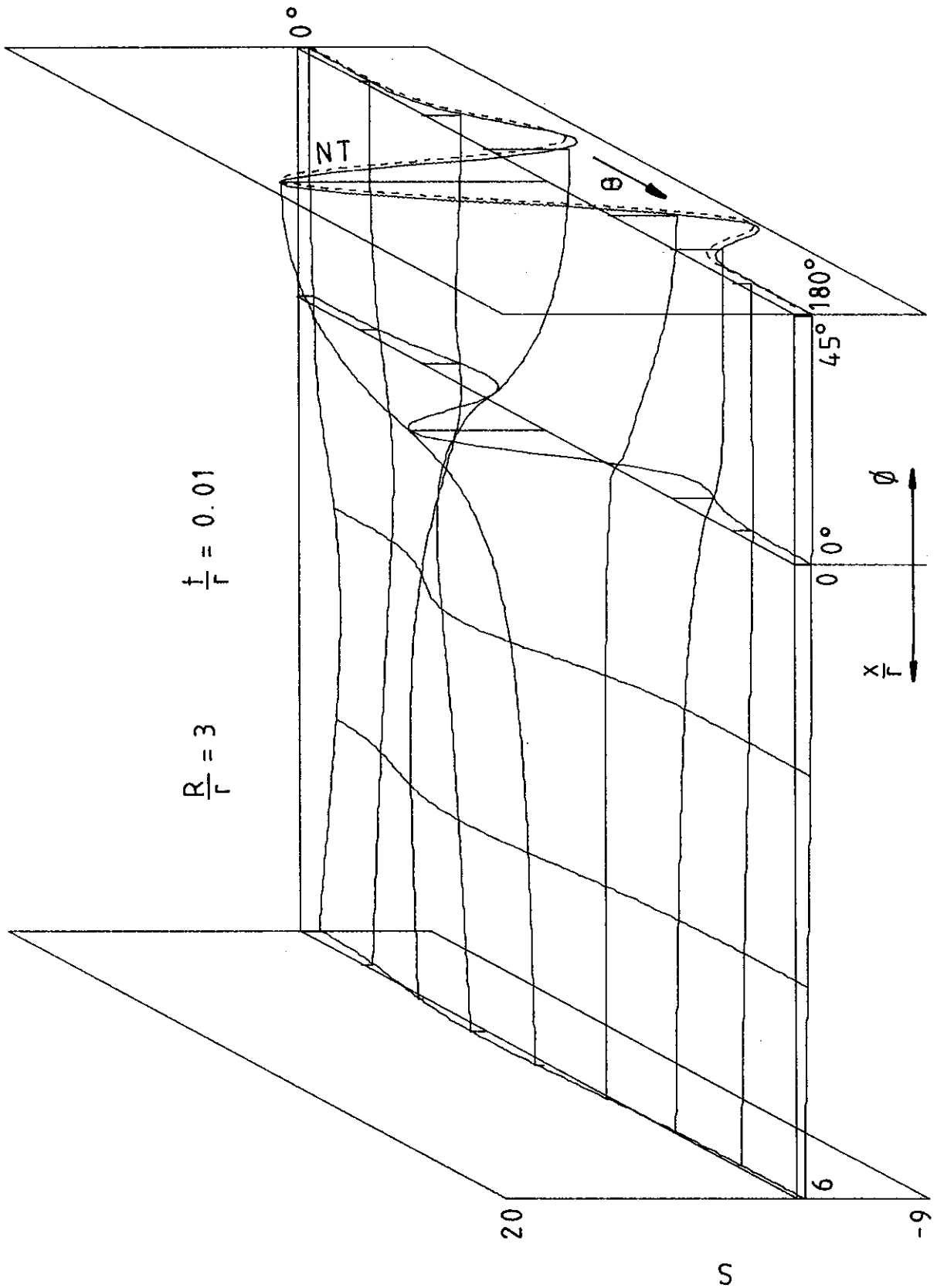
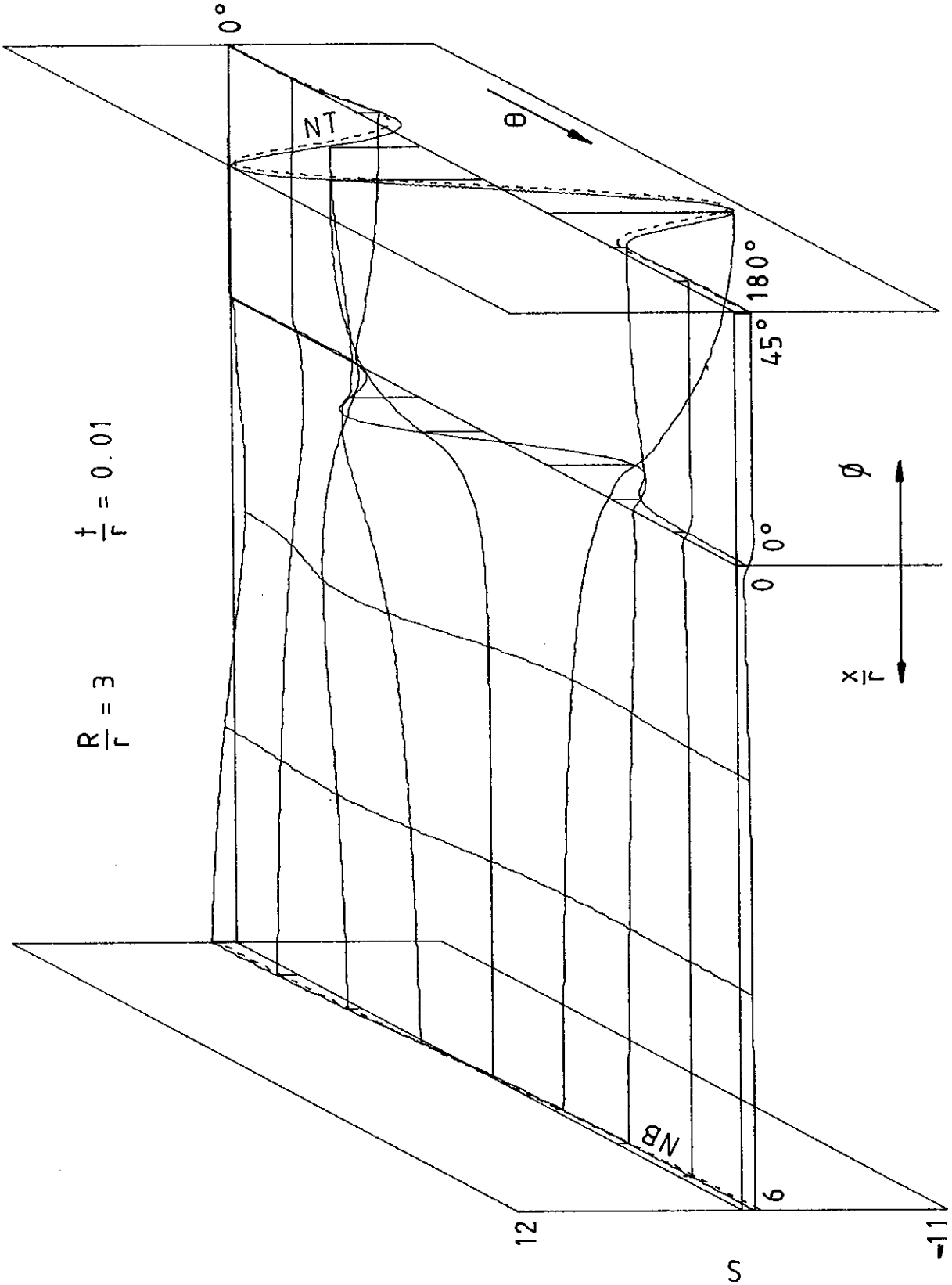


FIGURE A9



AXIAL STRESS

FIGURE A10

TABLE A9

R/r = 3.0 t/r = 0.01

OUTSIDE HOOP STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	-1.4224	-1.9924	-2.5715	-2.8816	-2.4652	-1.4616	-1.0517	-0.9484	-0.8751	-0.8176	-0.7795	-0.7587	-0.7522	-0.8527
22.5	-0.8051	-1.0754	-1.3812	-1.7436	-2.1658	-2.1770	-1.3022	-1.0319	-0.8668	-0.7607	-0.6992	-0.6682	-0.6590	-0.8132
45.0	0.3864	0.6169	0.8225	0.7897	0.1181	-1.6047	-2.6573	-2.3596	-2.3682	-2.4835	-2.6110	-2.7024	-2.7350	-3.3085
67.5	1.0367	1.4193	1.8501	2.3551	2.9743	3.2682	-0.2652	-2.8573	-4.3075	-5.1585	-5.6234	-5.8466	-5.9119	-4.4420
90.0	0.8316	1.0360	1.2998	1.7230	2.5131	4.3005	9.3809	12.3377	14.6121	16.2599	17.3519	17.9673	18.1652	18.1680
112.5	0.2460	0.2452	0.2492	0.2567	0.2449	0.1451	-0.6065	-1.7780	-2.7206	-3.5596	-4.1922	-4.5781	-4.7071	-6.2355
135.0	-0.2349	-0.3301	-0.4513	-0.6266	-0.9126	-1.4571	-2.9286	-3.4879	-3.6229	-3.6335	-3.5945	-3.5546	-3.5387	-2.8711
157.5	-0.4776	-0.5892	-0.7181	-0.8687	-1.0421	-1.2176	-1.3355	-1.3712	-1.3218	-1.2981	-1.2882	-1.2853	-1.2849	-1.1496
180.0	-0.5437	-0.6530	-0.7703	-0.8894	-0.9948	-1.0528	-1.1169	-1.1911	-1.1803	-1.1815	-1.1856	-1.1893	-1.1908	-1.0451

OUTSIDE AXIAL STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	1.2387	0.9363	0.4368	-0.2266	-0.7243	-0.5271	-0.1109	0.0346	0.0301	0.0157	-0.0002	-0.0119	-0.0161	-0.0455
22.5	1.1101	0.9976	0.8358	0.5986	0.1742	-0.4276	-0.1622	0.0546	0.0535	0.0305	0.0052	-0.0129	-0.0193	-0.0773
45.0	0.7425	0.9126	1.2118	1.6172	1.9185	1.4471	-0.0441	-0.2951	-0.7017	-0.9865	-1.1692	-1.2699	-1.3019	-1.1844
67.5	0.2209	0.4074	0.6813	1.0856	1.7929	3.1674	3.9089	3.6702	3.8512	4.1556	4.4426	4.6380	4.7065	5.8509
90.0	-0.2840	-0.2571	-0.2493	-0.2471	-0.1971	0.1406	3.2443	5.5785	6.8955	7.5940	7.9267	8.0624	8.0972	6.0826
112.5	-0.6096	-0.6757	-0.7836	-0.9555	-1.2644	-1.9572	-4.6753	-6.7386	-8.1493	-9.0940	-9.6785	-9.9902	-10.0874	-9.7407
135.0	-0.7246	-0.7754	-0.8427	-0.9364	-1.0708	-1.2463	-1.5676	-1.7125	-1.4627	-1.2491	-1.0925	-0.9990	-0.9682	-0.6012
157.5	-0.7214	-0.7294	-0.7335	-0.7292	-0.7037	-0.6238	-0.7158	-0.9388	-0.9022	-0.8891	-0.8848	-0.8841	-0.8842	-0.7955
180.0	-0.7065	-0.6965	-0.6766	-0.6395	-0.5746	-0.4735	-0.6112	-0.8463	-0.8237	-0.8172	-0.8144	-0.8134	-0.8132	-0.7180

OUTSIDE SHEAR STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0	0.0	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	-0.1028	-0.0791	-0.0056	0.1389	0.3049	0.2642	0.0364	0.0617	0.0609	0.0480	0.0316	0.0155	0.0	0.0
45.0	-0.1141	-0.1075	-0.0912	-0.0603	0.0462	0.3969	0.5251	0.3685	0.2535	0.1602	0.0912	0.0407	0.0	0.0
67.5	-0.0456	-0.0636	-0.1097	-0.1983	-0.3375	-0.4584	0.4182	0.0623	-0.1124	-0.1610	-0.1381	-0.0772	0.0	0.0
90.0	0.0312	0.0184	-0.0058	-0.0464	-0.1368	-0.4357	-1.8124	-1.2112	-0.7565	-0.4444	-0.2382	-0.1018	0.0	0.0
112.5	0.0711	0.0765	0.0891	0.1138	0.1641	0.3004	0.8917	0.8069	0.6473	0.4699	0.3001	0.1449	0.0	0.0
135.0	0.0700	0.0815	0.0992	0.1257	0.1689	0.2450	0.2953	0.1685	0.0772	0.0304	0.0096	0.0022	0.0	0.0
157.5	0.0412	0.0479	0.0561	0.0654	0.0738	0.0697	0.0188	0.0162	0.0167	0.0169	0.0140	0.0079	0.0	0.0
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

DIAMETER EXPANSION FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
90.0	109.23	140.68	177.11	221.16	277.84	357.39	480.42	534.49	579.57	613.90	637.57	651.29	655.78	656.59

TABLE A10

R/r = 3.0 t/r = 0.01

INSIDE HOOP STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	1.4518	2.0374	2.6315	2.9385	2.4706	1.4143	1.0252	0.9012	0.8339	0.7863	0.7580	0.7440	0.7400	0.8530
22.5	0.8183	1.0933	1.4047	1.7775	2.2194	2.2042	1.2449	0.9657	0.8146	0.7256	0.6785	0.6570	0.6509	0.8137
45.0	-0.3999	-0.6399	-0.8540	-0.8170	-0.1033	1.7381	2.5888	2.2354	2.3241	2.4972	2.6621	2.7742	2.8134	3.3623
67.5	-1.0567	-1.4471	-1.8871	-2.4088	-3.0644	-3.3929	0.2044	2.6045	4.1573	5.0455	5.5171	5.7370	5.8000	4.0990
90.0	-0.8395	-1.0438	-1.3087	-1.7384	-2.5487	-4.4220	-10.1165	-13.5552	-16.1689	-18.0563	-19.3044	-20.0067	-20.2325	-20.2240
112.5	-0.2429	-0.2393	-0.2398	-0.2407	-0.2127	-0.0604	0.3637	0.9404	1.9015	2.7872	3.4692	3.8904	4.0319	5.8506
135.0	0.2404	0.3372	0.4609	0.6406	0.9340	1.4896	2.8010	3.3370	3.5663	3.6324	3.6257	3.6019	3.5909	2.9345
157.5	0.4813	0.5931	0.7223	0.8727	1.0444	1.2133	1.2866	1.3130	1.2911	1.2817	1.2807	1.2829	1.2840	1.1489
180.0	0.5463	0.6554	0.7721	0.8896	0.9921	1.0460	1.0852	1.1498	1.1584	1.1716	1.1847	1.1940	1.1974	1.0445

INSIDE AXIAL STRESS FACTORS

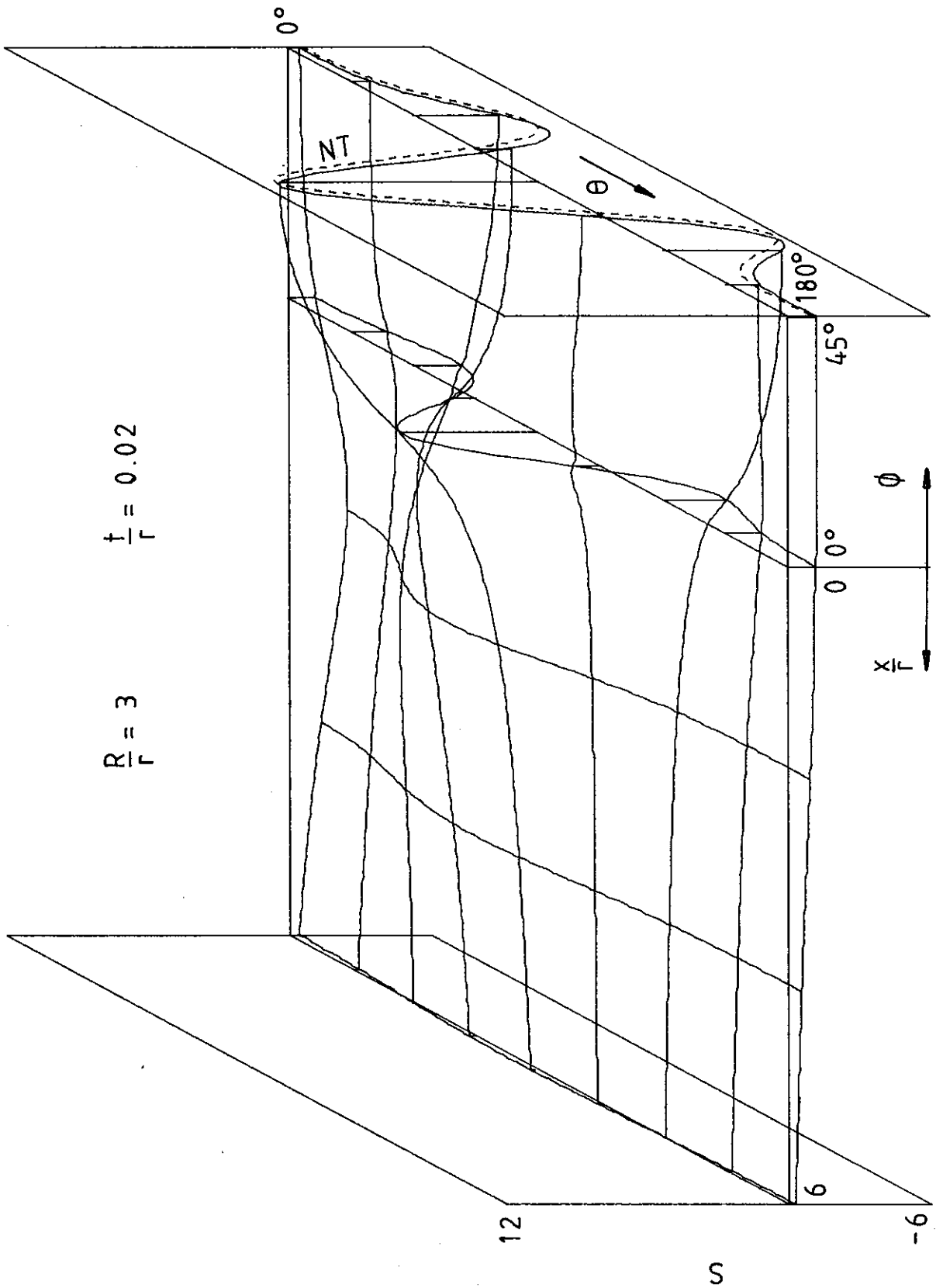
Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	2.0563	2.1134	2.0020	1.5908	0.8804	0.3736	0.2644	0.1414	0.1313	0.1118	0.0922	0.0785	0.0736	0.0532
22.5	1.5691	1.6221	1.6483	1.6364	1.5048	0.9991	0.3375	0.1678	0.1200	0.0675	0.0248	-0.0022	-0.0114	-0.0414
45.0	0.5093	0.5278	0.6728	1.0461	1.6973	2.3299	1.3555	0.5327	0.2022	0.0094	-0.0953	-0.1454	-0.1600	0.1606
67.5	-0.3872	-0.4375	-0.4319	-0.3466	-0.0666	0.9076	3.4509	4.3638	5.1170	5.7007	6.1058	6.3413	6.4182	6.5881
90.0	-0.7661	-0.8567	-0.9947	-1.2241	-1.6066	-2.2557	-2.7309	-2.7619	-3.0601	-3.4463	-3.7877	-4.0140	-4.0926	-5.4593
112.5	-0.7453	-0.8052	-0.9073	-1.0712	-1.3477	-1.9081	-3.6548	-4.4168	-4.8167	-4.9567	-4.9720	-4.9499	-4.9377	-3.6899
135.0	-0.5794	-0.5724	-0.5676	-0.5585	-0.5295	-0.4124	0.6587	1.5777	1.9313	2.1468	2.2659	2.3232	2.3399	2.1455
157.5	-0.4366	-0.3795	-0.3091	-0.2186	-0.0958	0.0804	0.5673	0.8582	0.8538	0.8548	0.8562	0.8578	0.8586	0.7554
180.0	-0.3840	-0.3106	-0.2230	-0.1176	0.0078	0.1446	0.5121	0.7904	0.7990	0.8162	0.8308	0.8408	0.8443	0.7349

INSIDE SHEAR STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0	0.0	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	0.1358	0.1934	0.2426	0.2291	0.0682	-0.1795	-0.1094	-0.0658	-0.0339	-0.0127	-0.0022	0.0008	0.0	0.0
45.0	0.1298	0.1709	0.2174	0.2823	0.3758	0.3077	-0.3057	-0.0870	0.0178	0.0560	0.0549	0.0321	0.0	0.0
67.5	0.0212	0.0135	0.0153	0.0559	0.1966	0.6134	1.1613	0.8754	0.6453	0.4412	0.2705	0.1276	0.0	0.0
90.0	-0.0616	-0.0877	-0.1168	-0.1576	-0.2293	-0.3352	0.1748	-0.1483	-0.2965	-0.3035	-0.2331	-0.1242	0.0	0.0
112.5	-0.0706	-0.0870	-0.1102	-0.1500	-0.2265	-0.4157	-1.2492	-0.8241	-0.4735	-0.2498	-0.1181	-0.0450	0.0	0.0
135.0	-0.0426	-0.0468	-0.0521	-0.0566	-0.0542	-0.0169	0.2759	0.2477	0.1882	0.1280	0.0768	0.0354	0.0	0.0
157.5	-0.0164	-0.0159	-0.0136	-0.0068	0.0088	0.0410	0.0621	0.0364	0.0179	0.0074	0.0024	0.0005	0.0	0.0
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

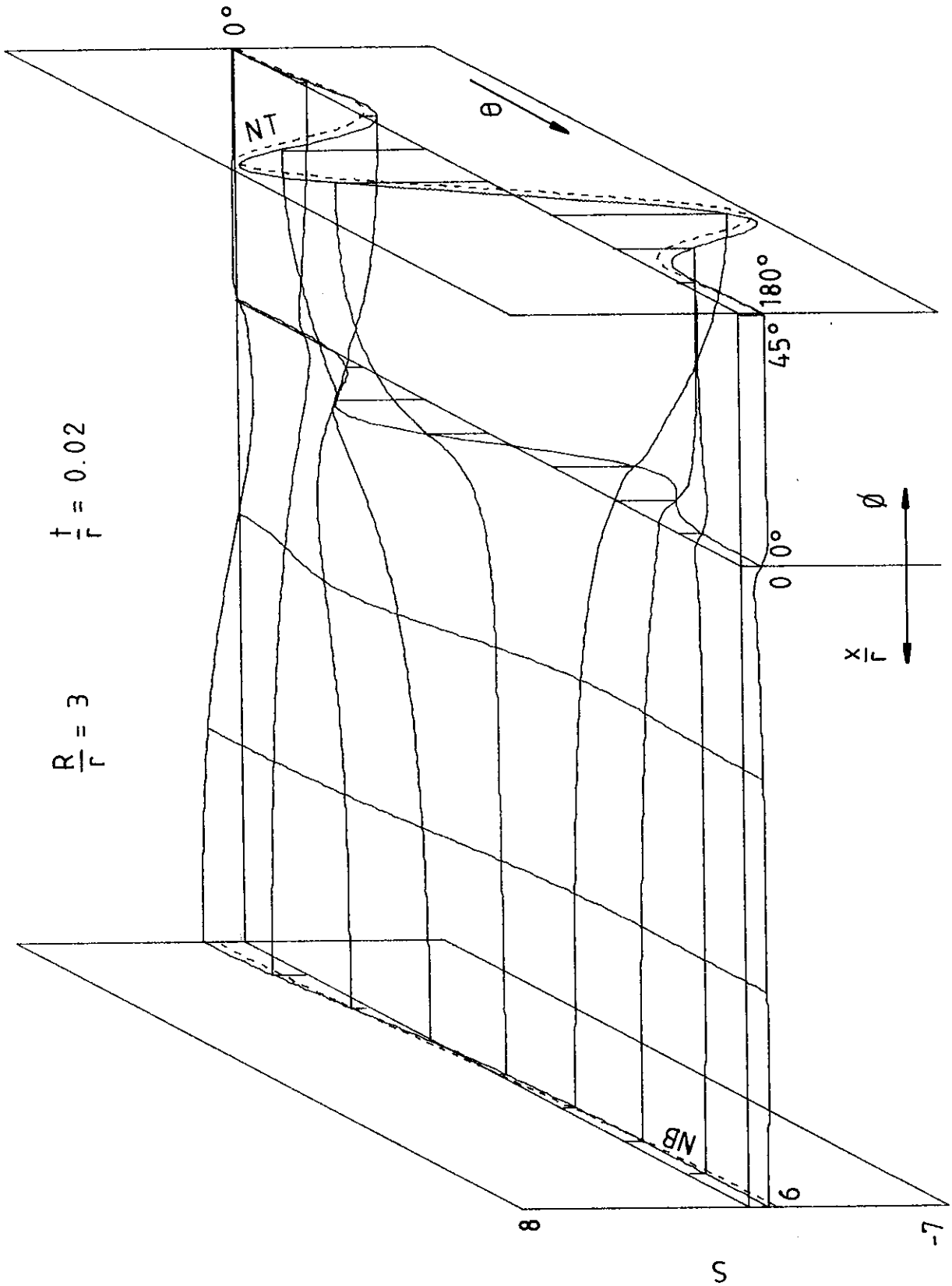
DIAMETER EXPANSION FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
180.0	-113.03	-147.81	-186.26	-224.92	-257.68	-280.68	-300.55	-306.62	-313.40	-319.80	-324.93	-328.23	-329.36	-330.41



HOOP STRESS

FIGURE A11



AXIAL STRESS

FIGURE A12

TABLE A11

R/r = 3.0 t/r = 0.02

OUTSIDE HOOP STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	-0.4241	-0.8141	-1.3631	-2.0159	-2.4583	-2.0716	-1.1647	-0.9091	-0.7427	-0.6275	-0.5564	-0.5188	-0.5072	-0.6520
22.5	-0.2764	-0.4977	-0.7898	-1.1493	-1.5660	-1.9300	-1.5400	-1.1777	-1.0029	-0.9123	-0.8706	-0 8543	-0.8502	-1.1850
45.0	0.0506	0.1586	0.3409	0.5494	0.5241	-0.3395	-2.0319	-2.5113	-2.9021	-3.2246	-3.4588	-3.5994	-3.6462	-3.9562
67.5	0.3141	0.6041	1.0018	1.4950	2.0550	2.5210	1.0579	-0.2924	-0.9553	-1.3084	-1.4813	-1.5553	-1.5752	-0.1954
90.0	0.3517	0.5789	0.8467	1.1834	1.7304	2.9138	5.8860	7.5326	8.8147	9.7693	10.4239	10.8041	10.9286	11.1326
112.5	0.1853	0.2410	0.2783	0.3144	0.3861	0.5595	1.1833	1.2013	1.2024	1.0767	0.9305	0.8222	0.7829	-0.9748
135.0	-0.0478	-0.1211	-0.2236	-0.3599	-0.5702	-1.0000	-2.6587	-3.7157	-4.2806	-4.6573	-4.8874	-5.0093	-5.0473	-4.5286
157.5	-0.2230	-0.3474	-0.4902	-0.6602	-0.8748	-1.1544	-1.5291	-1.5869	-1.5209	-1.4602	-1.4149	-1.3871	-1.3778	-1.0379
180.0	-0.2849	-0.4185	-0.5648	-0.7300	-0.9107	-1.0691	-1.1701	-1.2270	-1.2074	-1.1985	-1.1989	-1.2016	-1.2029	-1.0278

OUTSIDE AXIAL STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	1.4250	1.3598	1.1517	0.7009	-0.0110	-0.5372	-0.1213	0.0910	0.0975	0.0815	0.0608	0.0454	0.0398	-0.0331
22.5	1.2018	1.1667	1.0743	0.8995	0.6011	0.0727	-0.1567	-0.0353	-0.1406	-0.2332	-0.3028	-0.3452	-0.3595	-0.4321
45.0	0.6638	0.6869	0.7874	1.0354	1.4385	1.6146	0.5923	0.1905	-0.1767	-0.3970	-0.5236	-0.5880	-0.6076	-0.1997
67.5	0.0839	0.1353	0.2819	0.5705	1.0756	2.0338	3.2162	3.5559	4.0046	4.4000	4.6993	4.8840	4.9463	5.6537
90.0	-0.3403	-0.3089	-0.2586	-0.2071	-0.1421	0.1268	2.1279	3.5114	4.3468	4.8439	5.1207	5.2565	5.2968	3.8467
112.5	-0.5736	-0.5778	-0.6161	-0.7163	-0.9198	-1.3785	-2.8729	-3.9286	-4.7708	-5.4137	-5.8592	-6.1197	-6.2052	-6.6954
135.0	-0.6757	-0.6948	-0.7426	-0.8247	-0.9592	-1.2034	-2.0894	-2.7187	-2.8297	-2.8730	-2.8715	-2.8586	-2.8523	-2.0859
157.5	-0.7122	-0.7242	-0.7401	-0.7538	-0.7569	-0.7178	-0.7817	-0.9597	-0.8328	-0.7582	-0.7087	-0.6812	-0.6724	-0.5364
180.0	-0.7206	-0.7260	-0.7244	-0.7082	-0.6634	-0.5592	-0.6571	-0.9047	-0.8670	-0.8611	-0.8602	-0.8610	-0.8615	-0.7422

OUTSIDE SHEAR STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0	0.0	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	-0.1003	-0.1183	-0.1142	-0.0469	0.1354	0.3412	0.1860	0.1512	0.1182	0.0824	0.0508	0.0240	0.0	0.0
45.0	-0.1204	-0.1379	-0.1420	-0.1212	-0.0537	0.1747	0.6195	0.3795	0.2315	0.1323	0.0691	0.0289	0.0	0.0
67.5	-0.0567	-0.0604	-0.0728	-0.1182	-0.2321	-0.3956	-0.0442	-0.1618	-0.2138	-0.1998	-0.1490	-0.0787	0.0	0.0
90.0	0.0292	0.0361	0.0297	-0.0033	-0.0851	-0.3223	-1.2252	-0.8654	-0.5760	-0.3669	-0.2142	-0.0981	0.0	0.0
112.5	0.0791	0.0885	0.0954	0.1066	0.1352	0.2040	0.3481	0.3869	0.3690	0.3041	0.2128	0.1088	0.0	0.0
135.0	0.0792	0.0869	0.1000	0.1259	0.1753	0.2832	0.5898	0.4582	0.3109	0.2024	0.1204	0.0559	0.0	0.0
157.5	0.0462	0.0506	0.0598	0.0749	0.0961	0.1176	0.0506	0.0291	0.0144	0.0091	0.0063	0.0035	0.0	0.0
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

DIAMETER EXPANSION FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
90.0	21.94	36.78	55.20	77.72	106.14	145.10	202.62	227.17	248.05	264.38	275.97	282.85	285.13	287.68

TABLE A12

R/r = 3.0 t/r = 0.02

INSIDE HOOP STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.4365	0.8427	1.4178	2.1030	2.5511	2.0744	1.0966	0.8370	0.6818	0.5834	0.5272	0.4995	0.4913	0.6525
22.5	0.2840	0.5129	0.8154	1.1881	1.6246	2.0088	1.4661	1.0815	0.9362	0.8744	0.8543	0.8511	0.8514	1.1964
45.0	-0.0531	-0.1684	-0.3647	-0.5908	-0.5603	0.4060	2.0337	2.3895	2.8742	3.2579	3.5297	3.6905	3.7437	3.9969
67.5	-0.3237	-0.6253	-1.0398	-1.5549	-2.1481	-2.6673	-1.1908	-0.0073	0.6905	1.0439	1.2058	1.2691	1.2848	-0.3298
90.0	-0.3606	-0.5925	-0.8639	-1.2049	-1.7697	-3.0350	-6.4922	-8.5028	-10.0262	-11.1591	-11.9335	-12.3825	-12.5294	-12.7638
112.5	-0.1882	-0.2416	-0.2737	-0.3024	-0.3613	-0.4976	-1.5056	-2.0822	-2.1453	-2.0529	-1.9165	-1.8087	-1.7687	0.3152
135.0	0.0503	0.1274	0.2344	0.3767	0.5988	1.0587	2.5496	3.4587	4.1224	4.5733	4.8546	5.0065	5.0542	4.6201
157.5	0.2279	0.3540	0.4981	0.6692	0.8844	1.1590	1.4443	1.5099	1.4722	1.4413	1.4138	1.3960	1.3900	1.0419
180.0	0.2902	0.4244	0.5706	0.7349	0.9121	1.0607	1.1179	1.1813	1.1712	1.1842	1.1982	1.2093	1.2135	1.0267

INSIDE AXIAL STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	1.6117	1.7776	1.9129	1.9093	1.5789	0.8799	0.3026	0.1556	0.1201	0.0753	0.0367	0.0115	0.0028	-0.0547
22.5	1.3210	1.4176	1.5040	1.5558	1.5330	1.3130	0.5532	0.1759	0.0358	-0.0711	-0.1444	-0.1867	-0.2005	-0.1669
45.0	0.6305	0.5900	0.5707	0.6516	0.9784	1.6071	1.6149	1.1483	1.0323	0.9905	0.9838	0.9881	0.9908	1.4053
67.5	-0.0768	-0.1981	-0.2983	-0.3283	-0.2095	0.2938	1.9483	2.8032	3.3624	3.7600	4.0230	4.1718	4.2199	4.0745
90.0	-0.5204	-0.6246	-0.7317	-0.8670	-1.0907	-1.4651	-1.7146	-1.7555	-1.8861	-2.0626	-2.2219	-2.3293	-2.3669	-3.3500
112.5	-0.6662	-0.7030	-0.7565	-0.8607	-1.0714	-1.5329	-3.0164	-3.8314	-4.3619	-4.6876	-4.8781	-4.9757	-5.0055	-4.2242
135.0	-0.6405	-0.6152	-0.5989	-0.5970	-0.6066	-0.6115	-0.0408	0.7338	1.0507	1.3110	1.4902	1.5946	1.6288	1.8401
157.5	-0.5779	-0.5164	-0.4492	-0.3668	-0.2522	-0.0693	0.6020	1.0328	1.0863	1.1315	1.1562	1.1684	1.1721	0.9351
180.0	-0.5507	-0.4779	-0.3930	-0.2847	-0.1410	0.0498	0.5120	0.8131	0.8087	0.8237	0.8367	0.8457	0.8490	0.7001

INSIDE SHEAR STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0	0.0	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	0.0525	0.1032	0.1778	0.2598	0.2641	0.0342	-0.1938	-0.0886	-0.0332	-0.0044	0.0060	0.0055	0.0	0.0
45.0	0.0639	0.1125	0.1768	0.2548	0.3497	0.4206	0.0247	0.1206	0.1573	0.1450	0.1070	0.0561	0.0	0.0
67.5	0.0304	0.0370	0.0374	0.0428	0.1098	0.3966	1.0421	0.7433	0.5275	0.3551	0.2170	0.1025	0.0	0.0
90.0	-0.0162	-0.0418	-0.0796	-0.1259	-0.1817	-0.2431	0.1236	-0.0502	-0.1464	-0.1617	-0.1292	-0.0704	0.0	0.0
112.5	-0.0427	-0.0694	-0.1004	-0.1404	-0.2131	-0.3996	-1.1081	-0.8451	-0.5792	-0.3780	-0.2244	-0.1038	0.0	0.0
135.0	-0.0410	-0.0534	-0.0643	-0.0766	-0.0927	-0.1038	0.0200	0.0747	0.1018	0.0957	0.0714	0.0376	0.0	0.0
157.5	-0.0227	-0.0250	-0.0257	-0.0244	-0.0148	0.0229	0.1311	0.1028	0.0688	0.0427	0.0237	0.0104	0.0	0.0
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

DIAMETER EXPANSION FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
180.0	-21.98	-37.26	-56.70	-80.11	-105.38	-127.55	-143.78	-148.25	-153.20	-157.77	-161.39	-163.69	-164.48	-165.31

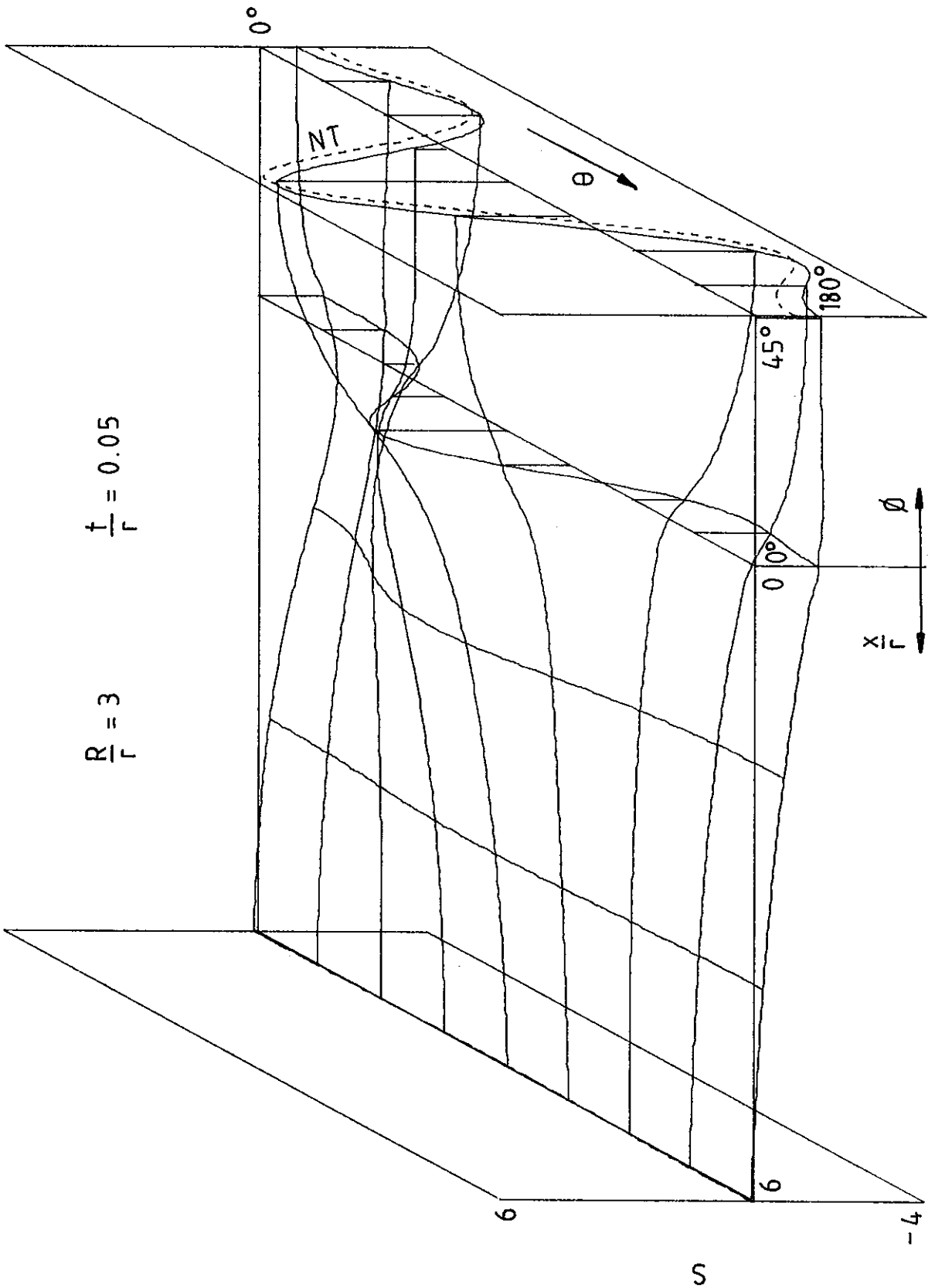
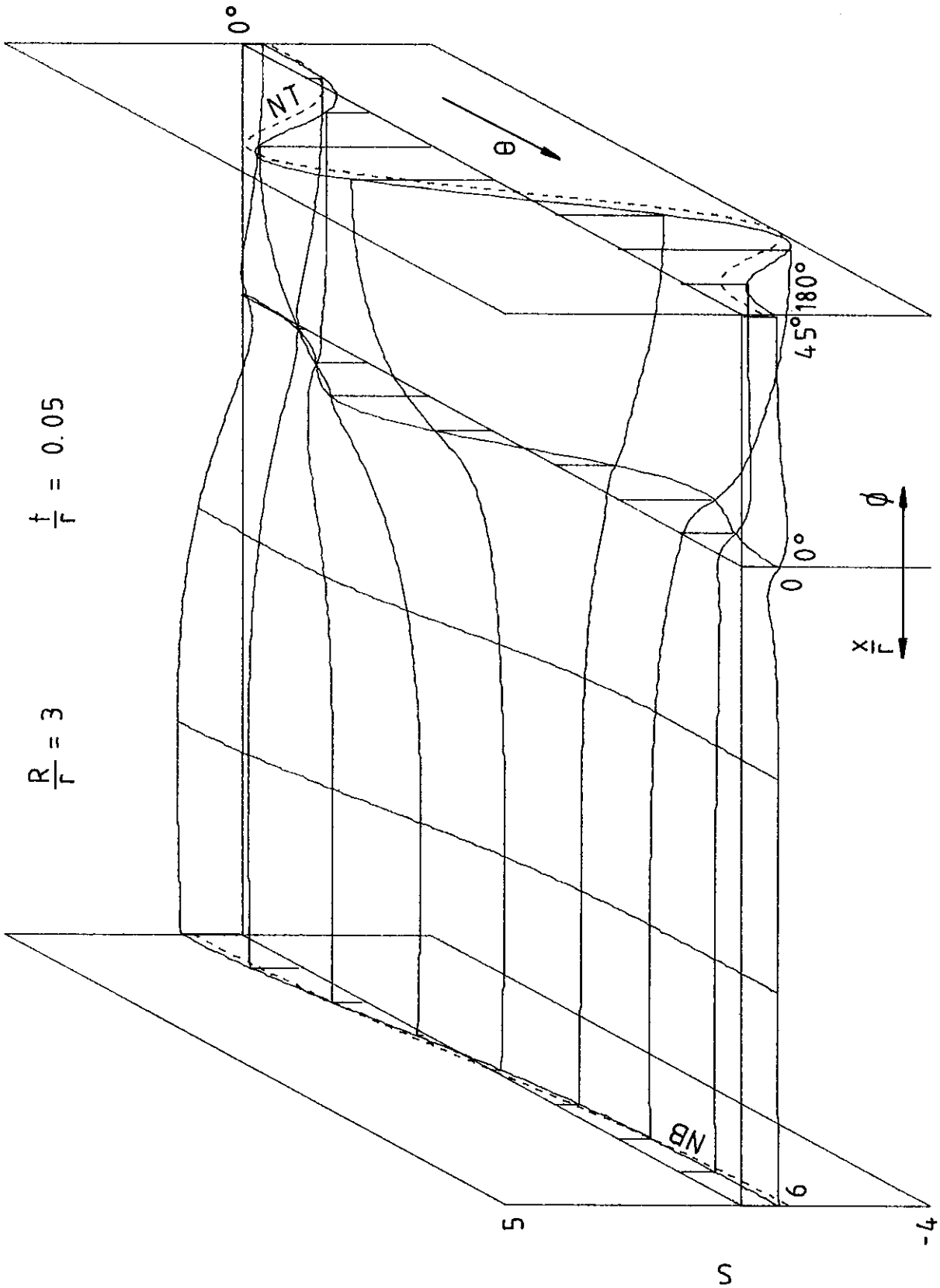


FIGURE A13



AXIAL STRESS

FIGURE A14

TABLE A13

R/r = 3.0 t/r = 0.05

OUTSIDE HOOP STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0681	-0.0514	-0.2894	-0.7060	-1.3098	-1.8223	-1.5273	-1.1774	-1.0056	-0.9226	-0.8867	-0.8737	-0.8707	-1.3110
22.5	0.0455	-0.0363	-0.1900	-0.4456	-0.8203	-1.2675	-1.5005	-1.4662	-1.4693	-1.5054	-1.5448	-1.5735	-1.5838	-1.9614
45.0	-0.0058	0.0001	0.0307	0.1119	0.2314	0.1448	-0.8241	-1.4313	-1.7649	-2.0005	-2.1544	-2.2416	-2.2699	-2.1330
67.5	-0.0499	0.0364	0.2121	0.5242	0.9945	1.5073	1.2863	0.8991	0.7699	0.7276	0.7267	0.7366	0.7416	1.6497
90.0	-0.0598	0.0513	0.2449	0.5424	0.9780	1.6987	3.1316	3.8602	4.4497	4.8926	5.2046	5.3902	5.4517	5.7116
112.5	-0.0349	0.0361	0.1368	0.2558	0.3998	0.6863	1.6165	1.9693	2.3057	2.5117	2.6334	2.6977	2.7178	1.6253
135.0	0.0056	-0.0001	-0.0270	-0.0937	-0.2157	-0.4256	-1.2337	-1.8979	-2.2650	-2.5350	-2.7293	-2.8451	-2.8835	-3.2713
157.5	0.0393	-0.0362	-0.1588	-0.3344	-0.5740	-0.9275	-1.7846	-2.1666	-2.3797	-2.5011	-2.5816	-2.6273	-2.6420	-2.0819
180.0	0.0519	-0.0511	-0.2077	-0.4152	-0.6775	-1.0159	-1.4695	-1.5441	-1.5594	-1.5344	-1.5149	-1.5033	-1.4993	-0.9225

OUTSIDE AXIAL STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	1.2651	1.3232	1.3467	1.2622	0.9264	0.2308	-0.1122	-0.0169	-0.1704	-0.2883	-0.3733	-0.4239	-0.4406	-0.5289
22.5	1.1132	1.1502	1.1650	1.1228	0.9634	0.5980	0.1530	0.0976	-0.0924	-0.2239	-0.3115	-0.3615	-0.3777	-0.2930
45.0	0.7171	0.7084	0.7046	0.7389	0.8906	1.1946	1.0808	0.9562	0.8877	0.8641	0.8609	0.8636	0.8653	1.3287
67.5	0.2200	0.1767	0.1590	0.2224	0.4719	1.0715	2.0856	2.5188	2.9245	3.2262	3.4373	3.5617	3.6028	3.8530
90.0	-0.2295	-0.2752	-0.2932	-0.2608	-0.1590	0.0830	1.2257	1.9084	2.3704	2.6633	2.8458	2.9447	2.9760	2.0959
112.5	-0.5447	-0.5665	-0.5745	-0.5833	-0.6414	-0.8400	-1.2616	-1.5486	-1.7809	-1.9986	-2.1616	-2.2618	-2.2956	-3.1741
135.0	-0.7172	-0.7093	-0.7058	-0.7277	-0.8129	-1.0400	-2.0266	-2.7498	-3.0796	-3.3326	-3.5037	-3.6002	-3.6313	-3.2536
157.5	-0.7885	-0.7604	-0.7496	-0.7619	-0.7939	-0.8310	-1.1507	-1.4897	-1.4708	-1.4458	-1.4302	-1.4186	-1.4142	-0.8873
180.0	-0.8057	-0.7710	-0.7579	-0.7630	-0.7637	-0.7089	-0.7481	-0.9453	-0.8555	-0.7749	-0.7266	-0.6984	-0.6889	-0.4274

OUTSIDE SHEAR STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0	0.0	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	-0.0471	-0.0735	-0.1054	-0.1270	-0.0840	0.1193	0.3447	0.2141	0.1341	0.0795	0.0435	0.0190	0.0	0.0
45.0	-0.0648	-0.0978	-0.1356	-0.1656	-0.1536	-0.0210	0.3689	0.2066	0.0989	0.0397	0.0112	0.0013	0.0	0.0
67.5	-0.0432	-0.0603	-0.0770	-0.0955	-0.1370	-0.2437	-0.2216	-0.2127	-0.2023	-0.1678	-0.1190	-0.0615	0.0	0.0
90.0	0.0030	0.0098	0.0205	0.0250	-0.0110	-0.1756	-0.6738	-0.5061	-0.3568	-0.2421	-0.1505	-0.0721	0.0	0.0
112.5	0.0455	0.0678	0.0927	0.1144	0.1265	0.1221	-0.0161	0.0462	0.0817	0.0892	0.0717	0.0393	0.0	0.0
135.0	0.0606	0.0839	0.1067	0.1303	0.1692	0.2686	0.5705	0.5124	0.3998	0.2978	0.1981	0.0988	0.0	0.0
157.5	0.0416	0.0554	0.0676	0.0814	0.1094	0.1753	0.2867	0.2472	0.1841	0.1306	0.0845	0.0416	0.0	0.0
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

DIAMETER EXPANSION FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
90.0	-1.416	1.415	6.355	14.007	24.941	40.065	60.946	69.458	76.883	82.811	87.103	89.696	90.563	92.780

TABLE A14

R/r = 3.0 t/r = 0.05

INSIDE HOOP STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	-0.0757	0.0514	0.3078	0.7635	1.4315	1.9772	1.4476	1.0305	0.9096	0.8613	0.8512	0.8537	0.8559	1.3121
22.5	-0.0503	0.0366	0.2014	0.4776	0.8857	1.3766	1.4659	1.3293	1.4001	1.4775	1.5459	1.5913	1.6071	1.9794
45.0	0.0070	0.0006	-0.0342	-0.1293	-0.2743	-0.1749	0.8235	1.2945	1.7063	1.9827	2.1615	2.2620	2.2944	2.0624
67.5	0.0555	-0.0362	-0.2258	-0.5674	-1.0886	-1.6703	-1.4806	-1.2245	-1.1058	-1.0859	-1.1046	-1.1276	-1.1371	-2.2472
90.0	0.0657	-0.0523	-0.2582	-0.5738	-1.0353	-1.8257	-3.6110	-4.5956	-5.3325	-5.8891	-6.2802	-6.5118	-6.5885	-6.9128
112.5	0.0376	-0.0377	-0.1424	-0.2608	-0.3959	-0.6697	-1.9986	-2.7594	-3.2015	-3.4761	-3.6442	-3.7341	-3.7623	-2.4216
135.0	-0.0067	-0.0005	0.0298	0.1058	0.2459	0.4986	1.1024	1.5193	1.8888	2.2006	2.4232	2.5560	2.6001	3.2124
157.5	-0.0429	0.0373	0.1668	0.3506	0.5988	0.9632	1.6838	2.0560	2.2646	2.4390	2.5583	2.6262	2.6483	2.1187
180.0	-0.0563	0.0530	0.2173	0.4311	0.6958	1.0255	1.3563	1.4880	1.4831	1.4987	1.5120	1.5190	1.5212	0.9202

INSIDE AXIAL STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	1.1321	1.2432	1.3901	1.5526	1.6427	1.4527	0.6693	0.2119	0.0571	-0.0658	-0.1484	-0.1957	-0.2110	-0.1552
22.5	1.0109	1.0855	1.1815	1.2885	1.3723	1.3500	0.8989	0.5172	0.3988	0.3148	0.2620	0.2332	0.2240	0.3870
45.0	0.6873	0.6789	0.6619	0.6445	0.6779	0.8944	1.2490	1.2852	1.3592	1.4268	1.4779	1.5095	1.5202	1.7294
67.5	0.2612	0.1803	0.0720	-0.0488	-0.1205	0.0176	0.7524	1.2221	1.4787	1.6567	1.7696	1.8322	1.8522	1.5963
90.0	-0.1544	-0.2536	-0.3761	-0.5141	-0.6611	-0.8207	-0.9247	-0.9517	-1.0020	-1.0578	-1.1115	-1.1486	-1.1617	-1.7255
112.5	-0.4796	-0.5392	-0.6052	-0.6792	-0.7921	-1.0487	-1.8481	-2.2867	-2.6258	-2.8457	-2.9941	-3.0803	-3.1086	-2.9195
135.0	-0.6873	-0.6793	-0.6639	-0.6459	-0.6465	-0.7143	-0.7687	-0.5153	-0.5223	-0.4867	-0.4485	-0.4233	-0.4145	0.0782
157.5	-0.7925	-0.7266	-0.6482	-0.5605	-0.4597	-0.3174	0.3454	0.9014	1.0703	1.1982	1.2966	1.3552	1.3745	1.2644
180.0	-0.8233	-0.7352	-0.6340	-0.5217	-0.3833	-0.1683	0.5705	1.0203	1.1373	1.2108	1.2704	1.3061	1.3177	0.9518

INSIDE SHEAR STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0	0.0	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	-0.0074	0.0120	0.0537	0.1324	0.2446	0.2768	0.0145	0.0555	0.0786	0.0728	0.0536	0.0280	0.0	0.0
45.0	-0.0088	0.0169	0.0666	0.1521	0.2787	0.4181	0.3734	0.3109	0.2666	0.2048	0.1376	0.0689	0.0	0.0
67.5	-0.0038	0.0118	0.0342	0.0607	0.0989	0.2352	0.6819	0.4954	0.3537	0.2420	0.1508	0.0723	0.0	0.0
90.0	0.0026	-0.0002	-0.0137	-0.0482	-0.1066	-0.1521	0.0816	0.0144	-0.0294	-0.0445	-0.0392	-0.0222	0.0	0.0
112.5	0.0058	-0.0120	-0.0447	-0.0976	-0.1782	-0.3294	-0.7041	-0.5884	-0.4374	-0.3106	-0.1991	-0.0971	0.0	0.0
135.0	0.0050	-0.0167	-0.0473	-0.0840	-0.1280	-0.2030	-0.3757	-0.2918	-0.1921	-0.1174	-0.0664	-0.0297	0.0	0.0
157.5	0.0025	-0.0117	-0.0284	-0.0432	-0.0531	-0.0487	0.0817	0.0895	0.0780	0.0651	0.0461	0.0238	0.0	0.0
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

DIAMETER EXPANSION FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
180.0	1.417	-1.415	-6.375	-14.108	-25.024	-38.478	-51.867	-55.885	-59.784	-63.114	-65.629	-67.184	-67.710	-68.001

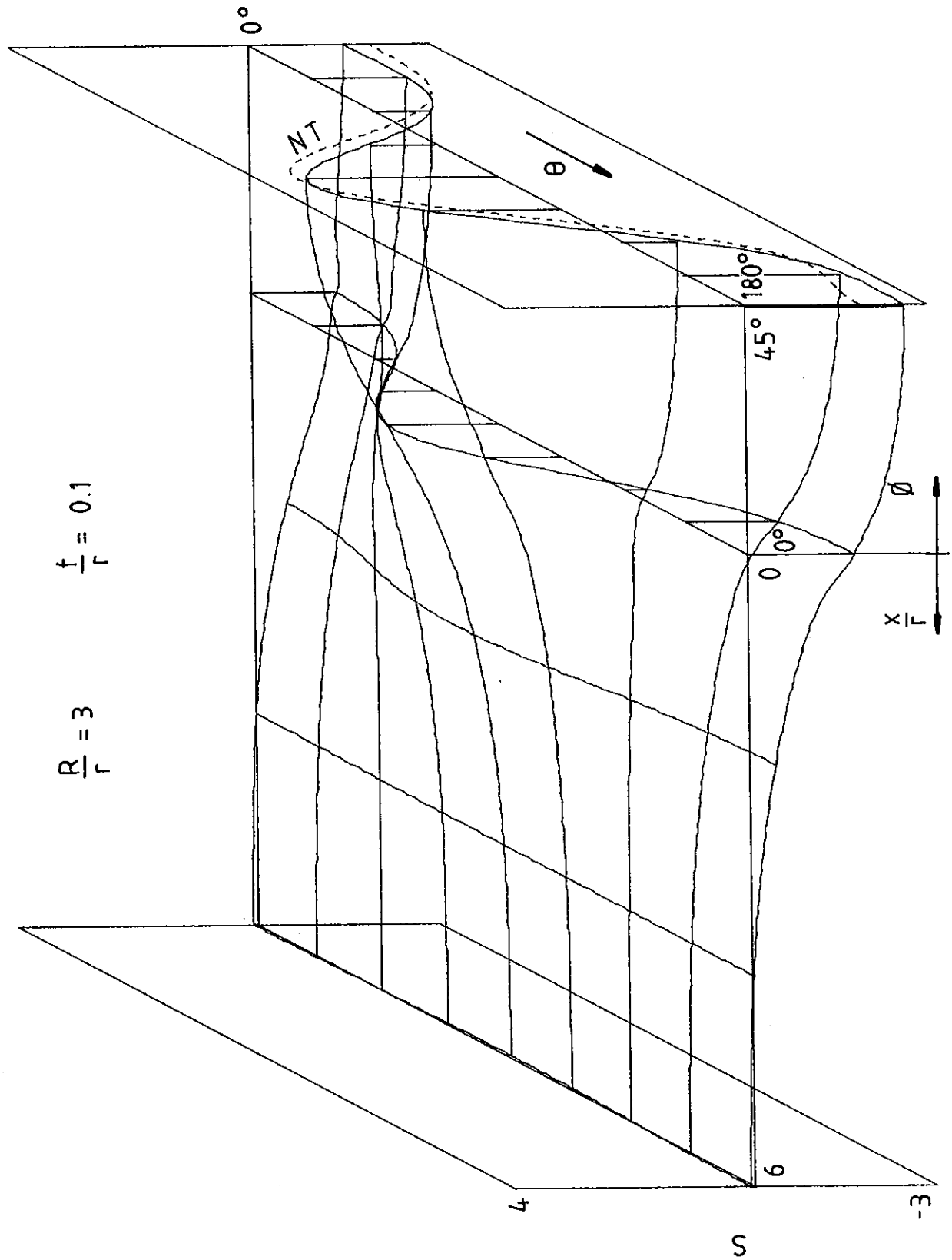
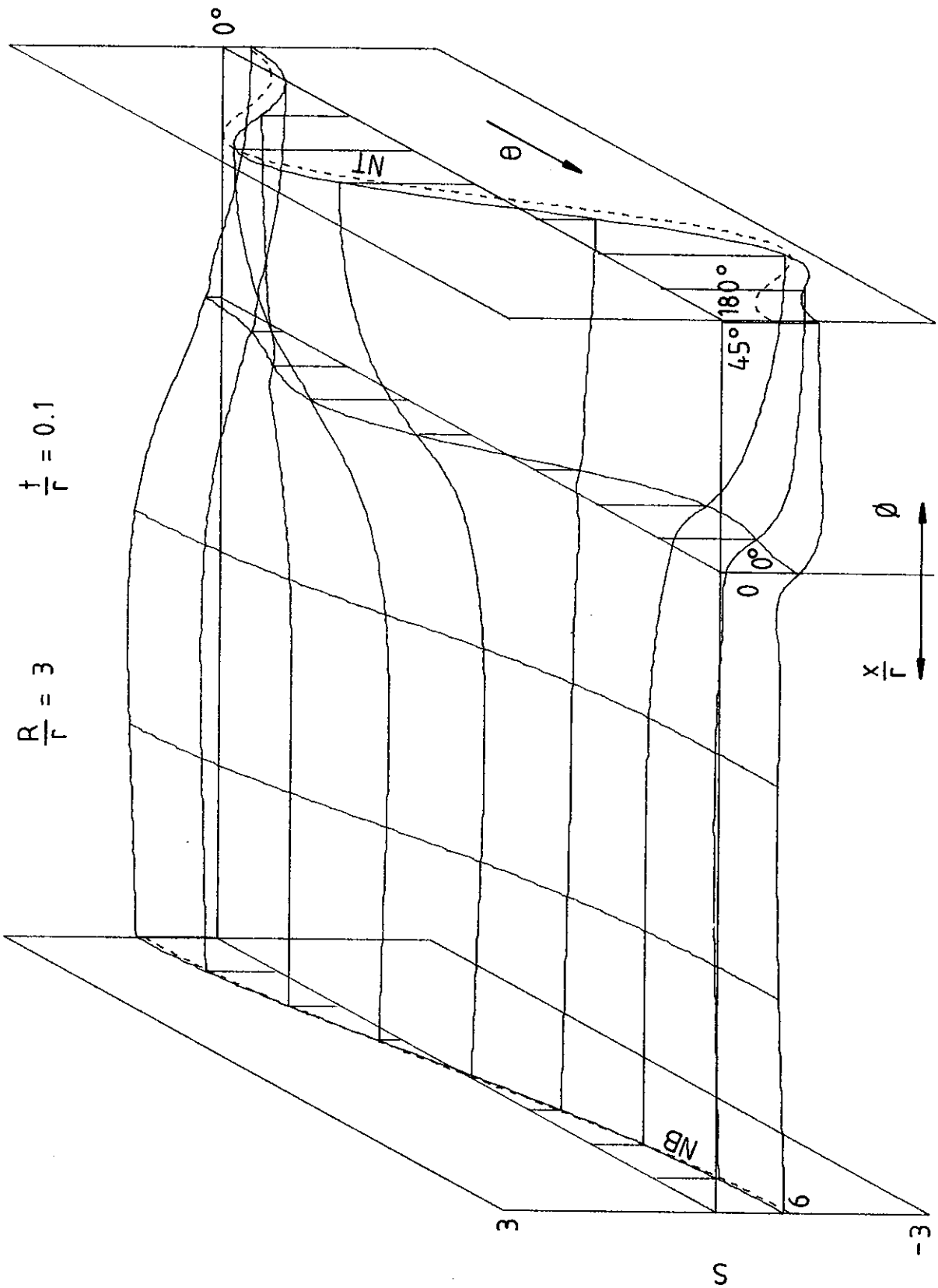


FIGURE A15



AXIAL STRESS

FIGURE A16

TABLE A15

R/r = 3.0 t/r = 0.1

OUTSIDE HOOP STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0738	0.0602	-0.0110	-0.1943	-0.5566	-1.0769	-1.4087	-1.4345	-1.4318	-1.4808	-1.5294	-1.5630	-1.5750	-1.9848
22.5	0.0519	0.0423	-0.0068	-0.1296	-0.3690	-0.7417	-1.1588	-1.3204	-1.3859	-1.4679	-1.5333	-1.5748	-1.5890	-1.8438
45.0	-0.0005	-0.0007	0.0021	0.0168	0.0543	0.0588	-0.3294	-0.6425	-0.7764	-0.8720	-0.9337	-0.9683	-0.9795	-0.8183
67.5	-0.0523	-0.0428	0.0083	0.1421	0.4115	0.8104	0.9703	0.9116	0.9468	0.9965	1.0422	1.0736	1.0846	1.5784
90.0	-0.0730	-0.0592	0.0080	0.1703	0.4804	1.0112	1.8742	2.2623	2.5944	2.8506	3.0318	3.1405	3.1767	3.3624
112.5	-0.0509	-0.0409	0.0031	0.0994	0.2664	0.5730	1.2916	1.5598	1.8305	2.0319	2.1659	2.2428	2.2680	1.7555
135.0	0.0005	0.0007	-0.0019	-0.0159	-0.0563	-0.1235	-0.3748	-0.6463	-0.7666	-0.8368	-0.8881	-0.9206	-0.9317	-1.4023
157.5	0.0513	0.0415	-0.0046	-0.1119	-0.3089	-0.6390	-1.5079	-1.9218	-2.1992	-2.3713	-2.4851	-2.5528	-2.5755	-2.2597
180.0	0.0722	0.0582	-0.0054	-0.1481	-0.4002	-0.8109	-1.7459	-2.0702	-2.3100	-2.4527	-2.5429	-2.5962	-2.6140	-1.8824

OUTSIDE AXIAL STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	1.1294	1.1841	1.2450	1.2789	1.1933	0.8012	0.2293	0.0992	-0.0880	-0.2346	-0.3276	-0.3799	-0.3968	-0.3029
22.5	1.0259	1.0639	1.1057	1.1305	1.0872	0.8705	0.4683	0.3543	0.2209	0.1157	0.0512	0.0156	0.0043	0.1867
45.0	0.7415	0.7401	0.7374	0.7388	0.7744	0.9087	1.0375	1.0773	1.1305	1.1618	1.1883	1.2054	1.2112	1.4945
67.5	0.3446	0.3055	0.2616	0.2376	0.3050	0.6221	1.3871	1.7374	2.0349	2.2354	2.3698	2.4473	2.4726	2.5023
90.0	-0.0798	-0.1326	-0.1896	-0.2258	-0.1928	-0.0021	0.7813	1.1853	1.4857	1.6779	1.7980	1.8643	1.8855	1.3099
112.5	-0.4575	-0.4930	-0.5298	-0.5562	-0.5710	-0.6141	-0.6361	-0.6941	-0.7175	-0.7581	-0.7983	-0.8256	-0.8351	-1.5775
135.0	-0.7415	-0.7402	-0.7374	-0.7379	-0.7649	-0.8944	-1.5396	-2.0066	-2.2338	-2.3997	-2.5210	-2.5938	-2.6178	-2.6914
157.5	-0.9130	-0.8764	-0.8376	-0.8119	-0.8210	-0.8860	-1.3648	-1.7783	-1.8952	-1.9486	-1.9882	-2.0130	-2.0212	-1.4797
180.0	-0.9698	-0.9189	-0.8658	-0.8293	-0.8263	-0.8405	-1.0883	-1.3873	-1.4096	-1.3795	-1.3600	-1.3506	-1.3476	-0.6837

OUTSIDE SHEAR STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0	0.0	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	-0.0127	-0.0297	-0.0566	-0.0914	-0.1111	-0.0341	0.1966	0.1121	0.0490	0.0183	0.0045	0.0001	0.0	0.0
45.0	-0.0180	-0.0415	-0.0777	-0.1241	-0.1598	-0.1134	0.1435	0.0641	-0.0016	-0.0262	-0.0281	-0.0171	0.0	0.0
67.5	-0.0127	-0.0285	-0.0515	-0.0800	-0.1140	-0.1660	-0.1715	-0.1582	-0.1504	-0.1253	-0.0893	-0.0464	0.0	0.0
90.0	0.0000	0.0009	0.0039	0.0089	0.0021	-0.0817	-0.3595	-0.2792	-0.2066	-0.1459	-0.0937	-0.0460	0.0	0.0
112.5	0.0127	0.0292	0.0545	0.0868	0.1156	0.1068	-0.0501	-0.0043	0.0209	0.0323	0.0297	0.0172	0.0	0.0
135.0	0.0179	0.0402	0.0722	0.1115	0.1568	0.2276	0.3919	0.3773	0.3118	0.2417	0.1665	0.0851	0.0	0.0
157.5	0.0127	0.0281	0.0494	0.0750	0.1072	0.1749	0.3722	0.3478	0.2822	0.2128	0.1437	0.0727	0.0	0.0
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

DIAMETER EXPANSION FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
90.0	-0.940	-0.744	0.158	2.310	6.369	12.988	22.379	26.120	29.444	32.127	34.076	35.256	35.651	36.846

TABLE A16

R/r = 3.0 t/r = 0.1

INSIDE HOOP STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	-0.0859	-0.0726	0.0059	0.2145	0.6380	1.2562	1.4021	1.2499	1.3376	1.4318	1.5097	1.5604	1.5778	1.9872
22.5	-0.0604	-0.0508	0.0033	0.1420	0.4179	0.8558	1.1557	1.1555	1.3052	1.4307	1.5236	1.5810	1.6003	1.8291
45.0	0.0007	0.0011	-0.0020	-0.0207	-0.0728	-0.0933	0.2796	0.4723	0.6571	0.7790	0.8555	0.8984	0.9122	0.6534
67.5	0.0609	0.0517	-0.0047	-0.1573	-0.4739	-0.9591	-1.1921	-1.2398	-1.3030	-1.3760	-1.4411	-1.4843	-1.4993	-2.1465
90.0	0.0849	0.0710	-0.0031	-0.1848	-0.5350	-1.1455	-2.2866	-2.8609	-3.3030	-3.6356	-3.8722	-4.0139	-4.0611	-4.3099
112.5	0.0591	0.0487	0.0002	-0.1051	-0.2827	-0.5984	-1.6792	-2.2257	-2.6088	-2.8727	-3.0503	-3.1539	-3.1880	-2.5210
135.0	-0.0007	-0.0011	0.0018	0.0192	0.0728	0.1823	0.1791	0.2348	0.2965	0.3707	0.4316	0.4692	0.4817	1.1824
157.5	-0.0596	-0.0496	0.0012	0.1204	0.3386	0.7088	1.3961	1.7610	2.0026	2.2079	2.3627	2.4564	2.4875	2.2678
180.0	-0.0838	-0.0694	0.0006	0.1581	0.4319	0.8711	1.6236	1.9790	2.1824	2.3559	2.4906	2.5735	2.6012	1.8776

INSIDE AXIAL STRESS FACTORS

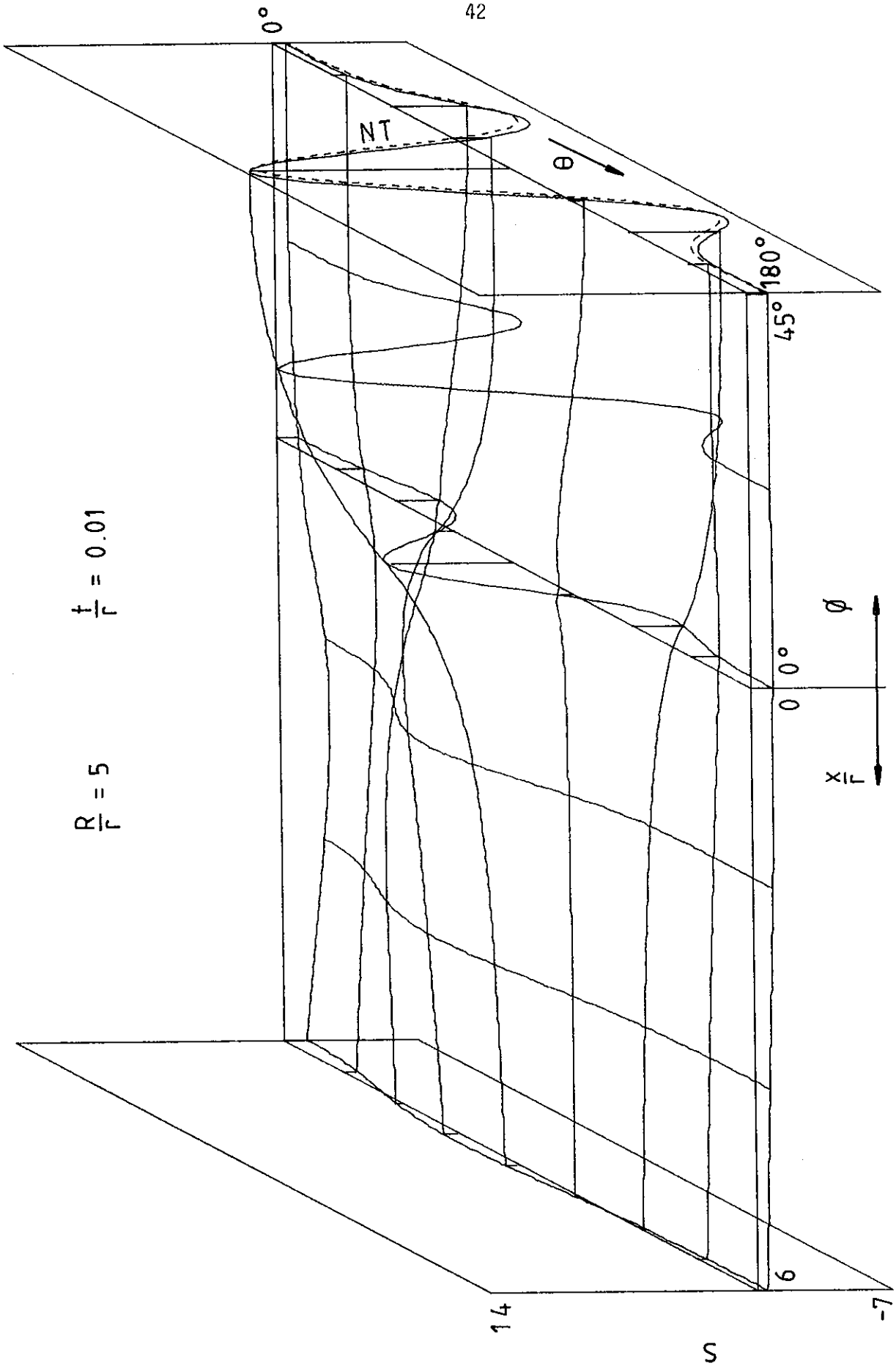
Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.9658	1.0089	1.0840	1.1962	1.3249	1.3752	0.9822	0.6137	0.4648	0.3840	0.3319	0.3039	0.2952	0.4816
22.5	0.8887	0.9189	0.9710	1.0483	1.1405	1.2017	0.9940	0.7672	0.6759	0.6347	0.6087	0.5954	0.5914	0.7644
45.0	0.6712	0.6707	0.6685	0.6640	0.6657	0.7205	0.8733	0.9560	0.9957	1.0390	1.0670	1.0832	1.0886	1.1429
67.5	0.3515	0.3209	0.2672	0.1863	0.0942	0.0744	0.3280	0.5498	0.6483	0.7180	0.7586	0.7794	0.7858	0.5752
90.0	-0.0167	-0.0589	-0.1310	-0.2369	-0.3690	-0.4917	-0.5789	-0.5925	-0.6291	-0.6593	-0.6869	-0.7067	-0.7139	-1.0452
112.5	-0.3751	-0.4043	-0.4524	-0.5212	-0.6137	-0.7573	-1.1477	-1.3436	-1.5245	-1.6452	-1.7250	-1.7725	-1.7885	-1.8210
135.0	-0.6712	-0.6707	-0.6686	-0.6638	-0.6625	-0.7004	-0.8017	-0.7132	-0.7786	-0.8193	-0.8348	-0.8404	-0.8419	-0.5912
157.5	-0.8651	-0.8355	-0.7858	-0.7135	-0.6212	-0.5113	-0.0258	0.4106	0.5615	0.6533	0.7291	0.7796	0.7970	0.8534
180.0	-0.9325	-0.8909	-0.8219	-0.7228	-0.5937	-0.4172	0.3270	0.8553	1.0833	1.2187	1.3225	1.3899	1.4131	1.2586

INSIDE SHEAR STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0	0.0	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	-0.0148	-0.0118	0.0039	0.0467	0.1356	0.2492	0.2135	0.1687	0.1413	0.1067	0.0706	0.0350	0.0	0.0
45.0	-0.0207	-0.0163	0.0049	0.0593	0.1686	0.3360	0.4421	0.3398	0.2658	0.1942	0.1261	0.0620	0.0	0.0
67.5	-0.0143	-0.0110	0.0026	0.0323	0.0848	0.1922	0.4684	0.3559	0.2620	0.1841	0.1164	0.0563	0.0	0.0
90.0	0.0004	0.0006	-0.0010	-0.0106	-0.0390	-0.0740	0.0683	0.0392	0.0205	0.0093	0.0029	0.0004	0.0	0.0
112.5	0.0146	0.0114	-0.0033	-0.0403	-0.1144	-0.2484	-0.4388	-0.3760	-0.2827	-0.1995	-0.1276	-0.0624	0.0	0.0
135.0	0.0201	0.0154	-0.0036	-0.0444	-0.1135	-0.2317	-0.4566	-0.3879	-0.2898	-0.1983	-0.1227	-0.0586	0.0	0.0
157.5	0.0141	0.0106	-0.0022	-0.0273	-0.0641	-0.1143	-0.1424	-0.1135	-0.0851	-0.0546	-0.0310	-0.0139	0.0	0.0
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

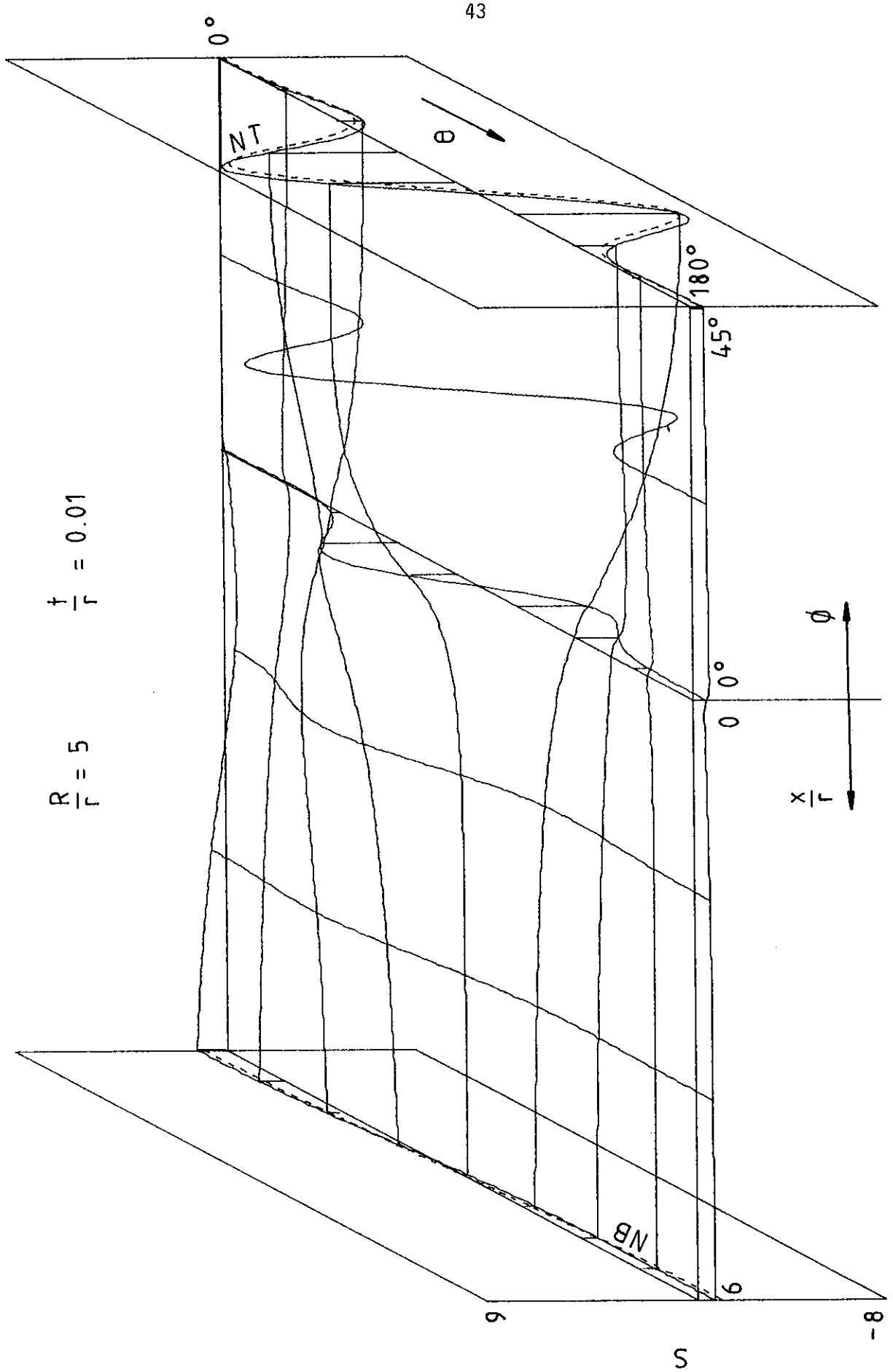
DIAMETER EXPANSION FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
180.0	0.940	0.744	-0.159	-2.313	-6.365	-12.780	-21.406	-24.574	-27.333	-29.590	-31.244	-32.251	-32.589	-32.792



HOOP STRESS

FIGURE A17



AXIAL STRESS

FIGURE A18

TABLE A17

R/r = 5.0 t/r = 0.01

OUTSIDE HOOP STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	-1.2618	-1.7578	-2.2720	-2.6055	-2.4191	-1.6572	-1.1157	-0.9359	-0.8082	-0.7295	-0.6896	-0.6731	-0.6688	-0.7686
22.5	-0.7298	-0.9755	-1.2525	-1.5667	-1.9132	-2.0403	-1.4638	-1.0556	-0.8620	-0.7840	-0.7641	-0.7655	-0.7680	-0.9662
45.0	0.3173	0.5050	0.6774	0.6769	0.2117	-1.0144	-2.2839	-2.6473	-3.1019	-3.5007	-3.7889	-3.9583	-4.0138	-4.1015
67.5	0.9255	1.2681	1.6520	2.0807	2.5556	2.7846	0.9589	-0.9888	-1.8373	-2.1544	-2.2209	-2.2038	-2.1893	-1.1074
90.0	0.7801	0.9807	1.2320	1.6128	2.2829	3.6325	6.6152	9.1102	10.9708	12.2446	13.0387	13.4636	13.5963	13.0851
112.5	0.2573	0.2691	0.2879	0.3219	0.3740	0.4713	0.8291	0.7856	0.4177	-0.0558	-0.4580	-0.7144	-0.8014	-1.7045
135.0	-0.2044	-0.2902	-0.3973	-0.5482	-0.7906	-1.2530	-2.5901	-3.7110	-4.2780	-4.5693	-4.7048	-4.7604	-4.7749	-4.2777
157.5	-0.4530	-0.5617	-0.6874	-0.8360	-1.0130	-1.2150	-1.3967	-1.3572	-1.2553	-1.1751	-1.1220	-1.0926	-1.0833	-0.9446
180.0	-0.5241	-0.6332	-0.7522	-0.8771	-0.9954	-1.0741	-1.1027	-1.1126	-1.0898	-1.0771	-1.0686	-1.0629	-1.0608	-0.9729

OUTSIDE AXIAL STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	1.2318	0.9788	0.5660	0.0091	-0.4835	-0.5050	-0.1417	0.0057	0.0099	-0.0100	-0.0341	-0.0515	-0.0577	-0.0788
22.5	1.1012	1.0009	0.8547	0.6450	0.3085	-0.1799	-0.1974	-0.0844	-0.1621	-0.2464	-0.3128	-0.3537	-0.3673	-0.3898
45.0	0.7346	0.8704	1.1080	1.4333	1.6990	1.4754	0.4034	-0.1972	-0.6503	-0.9018	-1.0288	-1.0847	-1.1000	-0.8044
67.5	0.2257	0.3893	0.6329	0.9872	1.5572	2.5389	3.3488	3.6281	4.1691	4.6794	5.0651	5.2980	5.3753	5.6610
90.0	-0.2644	-0.2296	-0.2037	-0.1744	-0.0856	0.2698	2.1208	3.9246	4.8152	5.1953	5.3187	5.3394	5.3381	4.2467
112.5	-0.5905	-0.6431	-0.7319	-0.8735	-1.1189	-1.6250	-3.0164	-4.4483	-5.5268	-6.2661	-6.7270	-6.9736	-7.0506	-6.8774
135.0	-0.7220	-0.7689	-0.8329	-0.9234	-1.0591	-1.2712	-1.7943	-2.1517	-2.1256	-2.0300	-1.9352	-1.8720	-1.8503	-1.4846
157.5	-0.7363	-0.7471	-0.7557	-0.7589	-0.7468	-0.6903	-0.6412	-0.6169	-0.5001	-0.4261	-0.3821	-0.3587	-0.3514	-0.3459
180.0	-0.7282	-0.7227	-0.7087	-0.6799	-0.6250	-0.5306	-0.5417	-0.6257	-0.5954	-0.5711	-0.5511	-0.5372	-0.5322	-0.5141

OUTSIDE SHEAR STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0	0.0	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	-0.0920	-0.0739	-0.0176	0.0936	0.2327	0.2573	0.0885	0.0889	0.0684	0.0441	0.0245	0.0106	0.0	0.0
45.0	-0.1047	-0.0993	-0.0838	-0.0533	0.0277	0.2584	0.4823	0.2781	0.1444	0.0631	0.0214	0.0047	0.0	0.0
67.5	-0.0445	-0.0586	-0.0939	-0.1614	-0.2623	-0.3419	0.0426	-0.1608	-0.2188	-0.1967	-0.1403	-0.0717	0.0	0.0
90.0	0.0271	0.0161	-0.0061	-0.0447	-0.1245	-0.3452	-1.0559	-0.6354	-0.3492	-0.1749	-0.0781	-0.0282	0.0	0.0
112.5	0.0662	0.0702	0.0790	0.0962	0.1285	0.1990	0.3637	0.3993	0.3474	0.2598	0.1673	0.0809	0.0	0.0
135.0	0.0664	0.0765	0.0923	0.1165	0.1567	0.2347	0.4154	0.2574	0.1430	0.0762	0.0385	0.0162	0.0	0.0
157.5	0.0395	0.0459	0.0540	0.0640	0.0749	0.0787	0.0279	0.0079	0.0033	0.0037	0.0038	0.0024	0.0	0.0
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

DIAMETER EXPANSION FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
90.0	101.05	130.47	164.41	204.83	255.49	323.02	416.73	481.77	534.38	572.64	597.78	611.81	616.29	598.85

TABLE A18

R/r = 5.0 t/r = 0.01

INSIDE HOOP STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	1.2870	1.7959	2.3229	2.6573	2.4388	1.6271	1.0844	0.8929	0.7763	0.7108	0.6819	0.6723	0.6704	0.7688
22.5	0.7416	0.9916	1.2736	1.5956	1.9553	2.0749	1.4145	0.9981	0.8259	0.7675	0.7620	0.7717	0.7770	0.9700
45.0	-0.3282	-0.5234	-0.7028	-0.7002	-0.2063	1.0968	2.2596	2.5756	3.0973	3.5360	3.8459	4.0256	4.0841	4.1374
67.5	-0.9431	-1.2928	-1.6849	-2.1262	-2.6247	-2.8735	-1.0448	0.8099	1.6783	1.9813	2.0258	1.9916	1.9709	0.8029
90.0	-0.7881	-0.9893	-1.2421	-1.6290	-2.3173	-3.7290	-6.9835	-9.7560	-11.8083	-13.2090	-14.0801	-14.5454	-14.6904	-14.1285
112.5	-0.2552	-0.2647	-0.2806	-0.3099	-0.3512	-0.4198	-0.9703	-1.2675	-0.9224	-0.4390	-0.0186	0.2521	0.3443	1.3597
135.0	0.2093	0.2968	0.4062	0.5612	0.8112	1.2892	2.5294	3.6045	4.2371	4.5727	4.7350	4.8045	4.8233	4.3291
157.5	0.4567	0.5658	0.6919	0.8407	1.0168	1.2139	1.3477	1.3148	1.2366	1.1721	1.1292	1.1059	1.0986	0.9459
180.0	0.5269	0.6359	0.7545	0.8782	0.9939	1.0679	1.0713	1.0787	1.0730	1.0739	1.0759	1.0770	1.0772	0.9726

INSIDE AXIAL STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	1.9555	2.0139	1.9407	1.6351	1.0709	0.5424	0.3451	0.2561	0.2178	0.1711	0.1329	0.1092	0.1013	0.1070
22.5	1.5160	1.5661	1.5908	1.5775	1.4748	1.1257	0.5120	0.2233	0.0714	-0.0402	-0.1117	-0.1503	-0.1624	-0.1054
45.0	0.5420	0.5549	0.6654	0.9514	1.4546	1.9953	1.6437	1.0351	0.8644	0.8338	0.8568	0.8857	0.8977	1.1871
67.5	-0.3171	-0.3654	-0.3619	-0.2807	-0.0384	0.6680	2.3954	3.5885	4.4136	4.9599	5.2895	5.4611	5.5138	5.2009
90.0	-0.7166	-0.7985	-0.9143	-1.0969	-1.3834	-1.8013	-1.9900	-2.0147	-2.3535	-2.7565	-3.0925	-3.3061	-3.3786	-3.9271
112.5	-0.7334	-0.7880	-0.8805	-1.0306	-1.2834	-1.7818	-3.1820	-4.3561	-4.9701	-5.2579	-5.3737	-5.4114	-5.4191	-4.7217
135.0	-0.5948	-0.5894	-0.5889	-0.5898	-0.5843	-0.5383	-0.0350	0.7098	1.1338	1.4252	1.6063	1.7028	1.7328	1.7084
157.5	-0.4655	-0.4127	-0.3484	-0.2663	-0.1545	0.0117	0.4271	0.6911	0.7451	0.7678	0.7777	0.7822	0.7835	0.6539
180.0	-0.4168	-0.3478	-0.2651	-0.1646	-0.0421	0.0989	0.3484	0.5014	0.5194	0.5368	0.5518	0.5621	0.5657	0.4826

INSIDE SHEAR STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0	0.0	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	0.1176	0.1661	0.2093	0.2092	0.1042	-0.0935	-0.1307	-0.0567	-0.0131	0.0074	0.0121	0.0079	0.0	0.0
45.0	0.1165	0.1538	0.1953	0.2469	0.3128	0.2938	-0.0767	0.0747	0.1224	0.1148	0.0832	0.0428	0.0	0.0
67.5	0.0243	0.0203	0.0235	0.0565	0.1640	0.4407	0.8579	0.5792	0.3692	0.2175	0.1161	0.0493	0.0	0.0
90.0	-0.0523	-0.0751	-0.0999	-0.1306	-0.1754	-0.2156	0.0827	-0.1552	-0.2314	-0.2129	-0.1529	-0.0783	0.0	0.0
112.5	-0.0658	-0.0818	-0.1034	-0.1391	-0.2064	-0.3631	-0.8904	-0.5623	-0.3167	-0.1637	-0.0765	-0.0291	0.0	0.0
135.0	-0.0426	-0.0476	-0.0539	-0.0611	-0.0663	-0.0568	0.0643	0.1197	0.1217	0.0979	0.0659	0.0327	0.0	0.0
157.5	-0.0175	-0.0176	-0.0164	-0.0116	0.0011	0.0317	0.0893	0.0634	0.0414	0.0272	0.0173	0.0087	0.0	0.0
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

DIAMETER EXPANSION FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
180.0	-103.88	-135.82	-171.31	-207.82	-240.71	-266.00	-286.70	-298.56	-310.86	-321.61	-329.69	-334.63	-336.28	-330.28

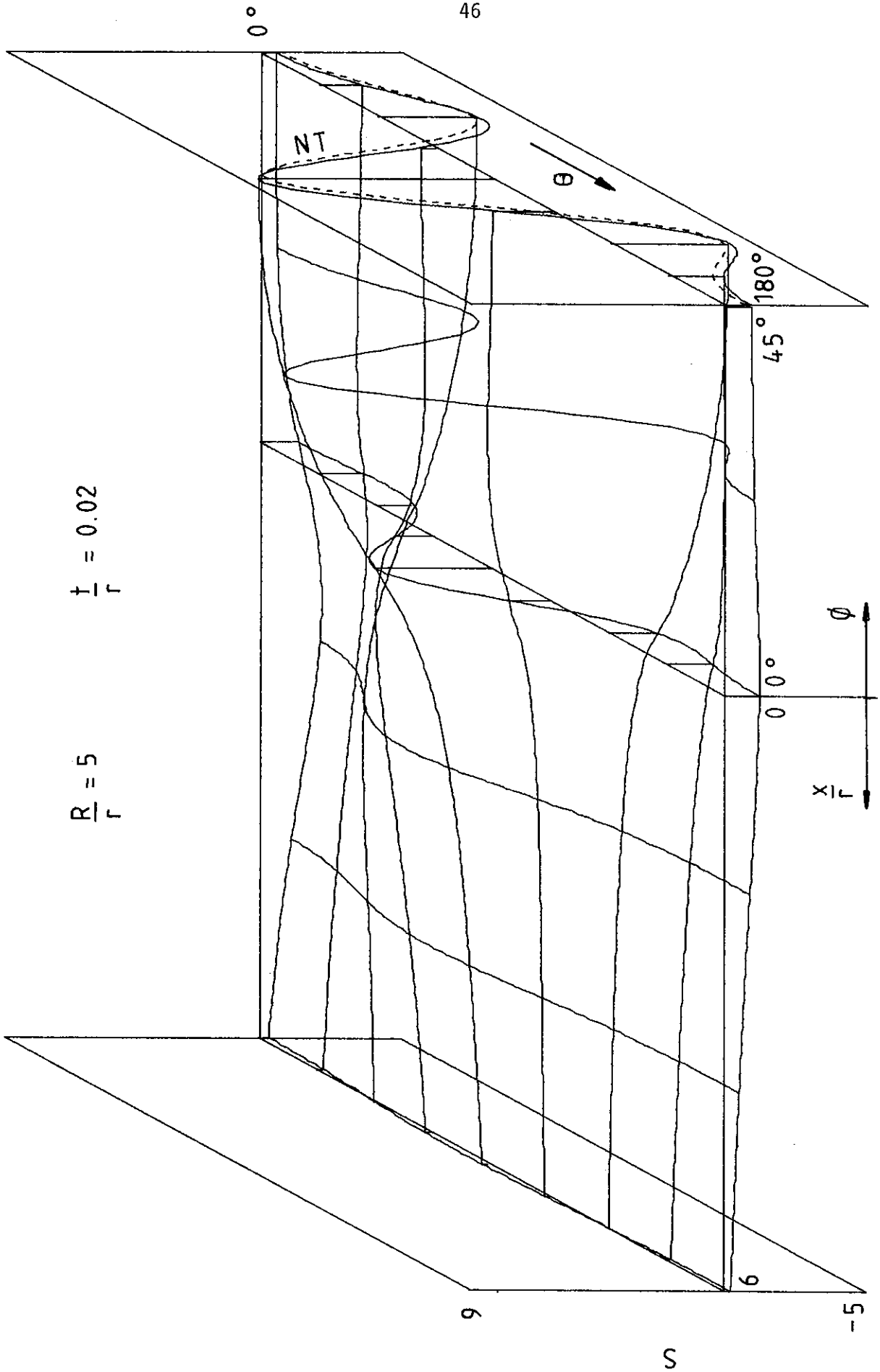
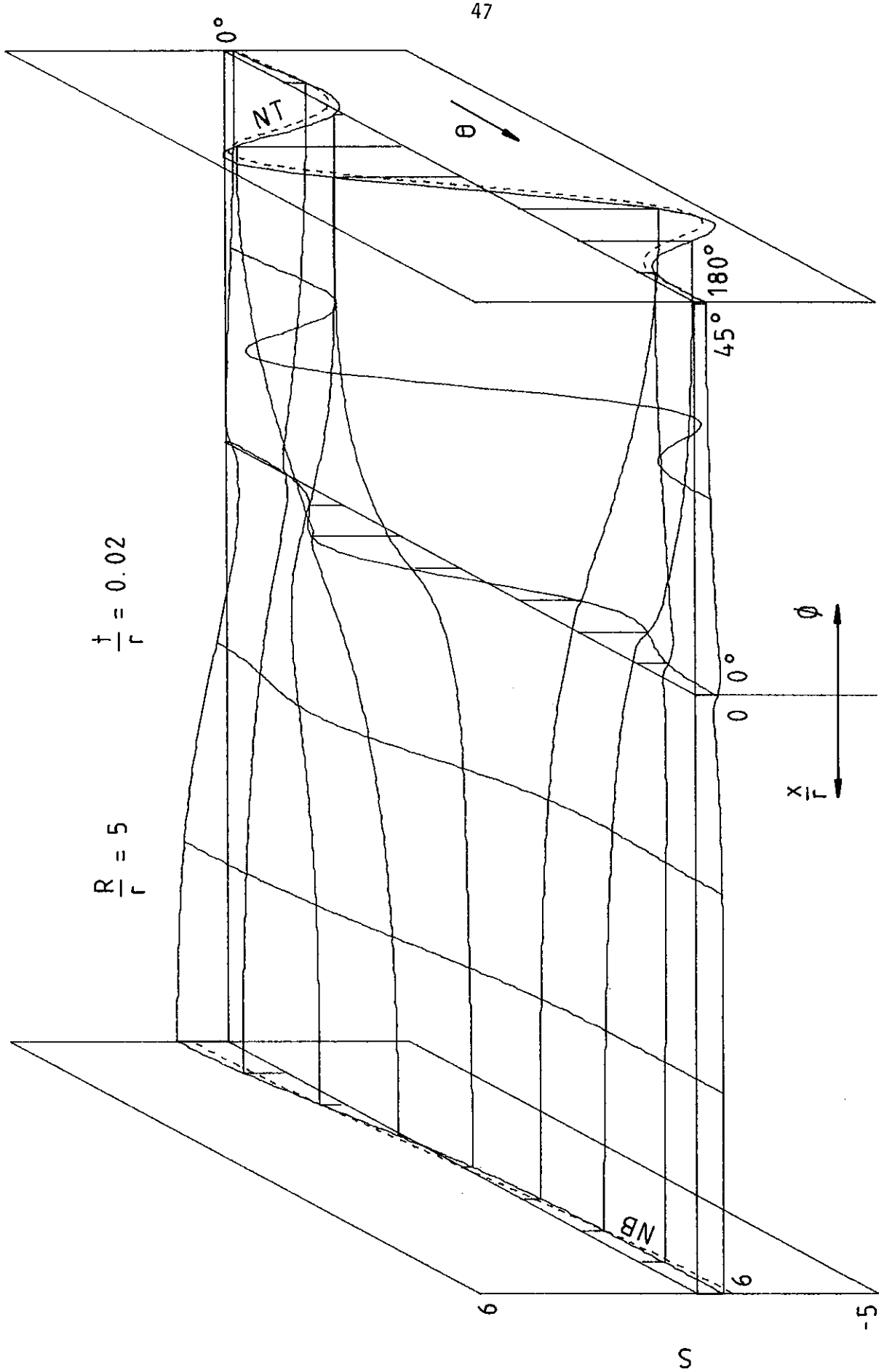


FIGURE A19



AXIAL STRESS

FIGURE A20

TABLE A19

R/r = 5.0 t/r = 0.02

OUTSIDE HOOP STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	-0.3647	-0.6920	-1.1466	-1.6933	-2.1344	-2.0454	-1.3491	-0.9230	-0.6930	-0.5808	-0.5355	-0.5214	-0.5187	-0.7486
22.5	-0.2403	-0.4319	-0.6842	-0.9943	-1.3454	-1.6658	-1.5913	-1.3715	-1.3335	-1.3703	-1.4257	-1.4689	-1.4848	-1.7219
45.0	0.0380	0.1184	0.2529	0.4102	0.4253	-0.0847	-1.3379	-2.1398	-2.6957	-3.0821	-3.3293	-3.4656	-3.5089	-3.3249
67.5	0.2687	0.5132	0.8478	1.2620	1.7153	2.0701	1.4459	0.6301	0.3789	0.3591	0.4240	0.4909	0.5175	1.3038
90.0	0.3105	0.5177	0.7675	1.0786	1.5410	2.4035	4.1397	5.5523	6.6336	7.4144	7.9328	8.2264	8.3212	8.0354
112.5	0.1716	0.2354	0.2893	0.3478	0.4527	0.7021	1.4962	2.0294	2.2432	2.2583	2.1987	2.1379	2.1137	1.1808
135.0	-0.0362	-0.0951	-0.1797	-0.2916	-0.4534	-0.7513	-1.6874	-2.6441	-3.2579	-3.6885	-3.9684	-4.1247	-4.1749	-3.9828
157.5	-0.2000	-0.3168	-0.4529	-0.6155	-0.8225	-1.1072	-1.6208	-1.8911	-1.9741	-1.9962	-1.9913	-1.9807	-1.9759	-1.6276
180.0	-0.2597	-0.3901	-0.5349	-0.7009	-0.8915	-1.0879	-1.2195	-1.1815	-1.0866	-1.0073	-0.9484	-0.9122	-0.8999	-0.7488

OUTSIDE AXIAL STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	1.3745	1.3221	1.1588	0.8126	0.2554	-0.2798	-0.1724	-0.0309	-0.0905	-0.1663	-0.2297	-0.2699	-0.2835	-0.3361
22.5	1.1723	1.1432	1.0661	0.9192	0.6744	0.2792	-0.0328	-0.1288	-0.3259	-0.4724	-0.5700	-0.6250	-0.6426	-0.5878
45.0	0.6757	0.6927	0.7652	0.9413	1.2324	1.4278	0.9308	0.5259	0.3099	0.2273	0.2068	0.2081	0.2107	0.5610
67.5	0.1208	0.1620	0.2808	0.5170	0.9219	1.6044	2.4645	3.0032	3.5465	3.9761	4.2781	4.4553	4.5135	4.5687
90.0	-0.3080	-0.2803	-0.2292	-0.1624	-0.0657	0.1985	1.3558	2.4226	2.9960	3.2852	3.4153	3.4648	3.4767	2.6695
112.5	-0.5617	-0.5620	-0.5853	-0.6542	-0.7967	-1.0837	-1.6911	-2.2870	-2.8481	-3.2980	-3.6206	-3.8130	-3.8768	-4.0627
135.0	-0.6831	-0.6977	-0.7373	-0.8098	-0.9329	-1.1674	-1.8992	-2.5683	-2.8800	-3.0453	-3.1259	-3.1604	-3.1697	-2.7148
157.5	-0.7314	-0.7433	-0.7616	-0.7820	-0.7997	-0.7985	-0.8587	-0.8975	-0.7745	-0.6658	-0.5829	-0.5314	-0.5140	-0.3891
180.0	-0.7437	-0.7515	-0.7562	-0.7509	-0.7230	-0.6407	-0.5823	-0.5846	-0.4810	-0.4044	-0.3510	-0.3189	-0.3082	-0.3233

OUTSIDE SHEAR STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0	0.0	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	-0.0857	-0.1006	-0.0993	-0.0540	0.0717	0.2438	0.2361	0.1588	0.0988	0.0551	0.0275	0.0110	0.0	0.0
45.0	-0.1053	-0.1207	-0.1253	-0.1086	-0.0537	0.0960	0.4030	0.1940	0.0743	0.0136	-0.0092	-0.0097	0.0	0.0
67.5	-0.0528	-0.0572	-0.0669	-0.0976	-0.1713	-0.2742	-0.1605	-0.2203	-0.2205	-0.1819	-0.1264	-0.0642	0.0	0.0
90.0	0.0226	0.0282	0.0236	-0.0031	-0.0704	-0.2377	-0.6996	-0.4464	-0.2688	-0.1535	-0.0807	-0.0341	0.0	0.0
112.5	0.0702	0.0790	0.0848	0.0908	0.1031	0.1216	0.0882	0.1751	0.1971	0.1725	0.1238	0.0640	0.0	0.0
135.0	0.0734	0.0808	0.0920	0.1131	0.1536	0.2399	0.4773	0.3656	0.2579	0.1724	0.1048	0.0493	0.0	0.0
157.5	0.0439	0.0480	0.0561	0.0702	0.0924	0.1252	0.1399	0.0869	0.0486	0.0262	0.0134	0.0056	0.0	0.0
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

DIAMETER EXPANSION FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
90.0	19.35	32.65	49.23	69.49	94.53	127.02	170.48	200.28	225.09	243.87	256.75	264.19	266.62	258.32

TABLE A20

R/r = 5.0 t/r = 0.02

INSIDE HOOP STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.3752	0.7154	1.1903	1.7624	2.2150	2.0789	1.2881	0.8548	0.6464	0.5552	0.5256	0.5210	0.5215	0.7491
22.5	0.2468	0.4448	0.7060	1.0272	1.3928	1.7281	1.5482	1.2985	1.2971	1.3619	1.4361	1.4900	1.5093	1.7356
45.0	-0.0398	-0.1257	-0.2701	-0.4400	-0.4548	0.1120	1.3328	2.0654	2.6812	3.1003	3.3643	3.5082	3.5537	3.3199
67.5	-0.2767	-0.5308	-0.8793	-1.3114	-1.7881	-2.1714	-1.5653	-0.8349	-0.5966	-0.6029	-0.6931	-0.7772	-0.8098	-1.6739
90.0	-0.3183	-0.5303	-0.7845	-1.1009	-1.5785	-2.4957	-4.4439	-6.0633	-7.2876	-8.1678	-8.7507	-9.0802	-9.1865	-8.8648
112.5	-0.1747	-0.2372	-0.2875	-0.3409	-0.4387	-0.6748	-1.6685	-2.4893	-2.7635	-2.8050	-2.7546	-2.6957	-2.6716	-1.6151
135.0	0.0381	0.1001	0.1887	0.3062	0.4780	0.8018	1.6368	2.4696	3.1346	3.6074	3.9181	4.0929	4.1491	3.9928
157.5	0.2045	0.3232	0.4609	0.6252	0.8339	1.1190	1.5597	1.8192	1.9430	1.9944	2.0097	2.0109	2.0101	1.6420
180.0	0.2649	0.3962	0.5414	0.7072	0.8957	1.0834	1.1622	1.1259	1.0607	1.0032	0.9601	0.9336	0.9246	0.7481

INSIDE AXIAL STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	1.5326	1.6741	1.7934	1.8138	1.6030	1.0866	0.4766	0.2067	0.0568	-0.0611	-0.1410	-0.1860	-0.2005	-0.1621
22.5	1.2733	1.3581	1.4351	1.4836	1.4702	1.3215	0.7946	0.3876	0.2089	0.0999	0.0386	0.0084	-0.0005	0.1400
45.0	0.6472	0.6168	0.6013	0.6548	0.8752	1.3194	1.5625	1.4603	1.5414	1.6484	1.7412	1.8019	1.8229	2.0064
67.5	-0.0178	-0.1220	-0.2102	-0.2417	-0.1501	0.2107	1.2475	2.0773	2.5792	2.8937	3.0780	3.1726	3.2015	2.8580
90.0	-0.4661	-0.5618	-0.6587	-0.7698	-0.9285	-1.1553	-1.2504	-1.2751	-1.4447	-1.6546	-1.8376	-1.9583	-2.0002	-2.4121
112.5	-0.6458	-0.6836	-0.7338	-0.8235	-0.9990	-1.3617	-2.3202	-3.1613	-3.6849	-4.0154	-4.2118	-4.3143	-4.3460	-3.9197
135.0	-0.6535	-0.6325	-0.6190	-0.6208	-0.6432	-0.6965	-0.6605	-0.3993	-0.2295	-0.0681	0.0585	0.1378	0.1646	0.3945
157.5	-0.6097	-0.5524	-0.4911	-0.4185	-0.3210	-0.1698	0.3110	0.7432	0.9345	1.0619	1.1420	1.1857	1.1996	1.0297
180.0	-0.5879	-0.5190	-0.4406	-0.3422	-0.2099	-0.0233	0.3708	0.6035	0.6570	0.6863	0.7024	0.7106	0.7131	0.5388

INSIDE SHEAR STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0	0.0	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	0.0444	0.0853	0.1442	0.2107	0.2327	0.1060	-0.1102	-0.0132	0.0300	0.0403	0.0333	0.0182	0.0	0.0
45.0	0.0550	0.0963	0.1508	0.2166	0.2900	0.3451	0.1861	0.2149	0.1977	0.1539	0.1025	0.0507	0.0	0.0
67.5	0.0278	0.0363	0.0415	0.0507	0.0997	0.2793	0.6698	0.4346	0.2724	0.1613	0.0875	0.0378	0.0	0.0
90.0	-0.0122	-0.0321	-0.0617	-0.0978	-0.1345	-0.1531	0.0497	-0.0844	-0.1371	-0.1335	-0.1005	-0.0531	0.0	0.0
112.5	-0.0371	-0.0610	-0.0897	-0.1260	-0.1856	-0.3180	-0.6815	-0.4902	-0.3262	-0.2050	-0.1177	-0.0531	0.0	0.0
135.0	-0.0377	-0.0509	-0.0636	-0.0783	-0.0998	-0.1344	-0.1872	-0.0691	0.0050	0.0352	0.0372	0.0224	0.0	0.0
157.5	-0.0218	-0.0256	-0.0279	-0.0291	-0.0255	-0.0018	0.1032	0.1016	0.0866	0.0673	0.0459	0.0233	0.0	0.0
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

DIAMETER EXPANSION FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
180.0	-19.38	-32.95	-50.17	-70.98	-94.06	-116.09	-134.03	-143.54	-152.95	-160.90	-166.73	-170.24	-171.41	-167.11

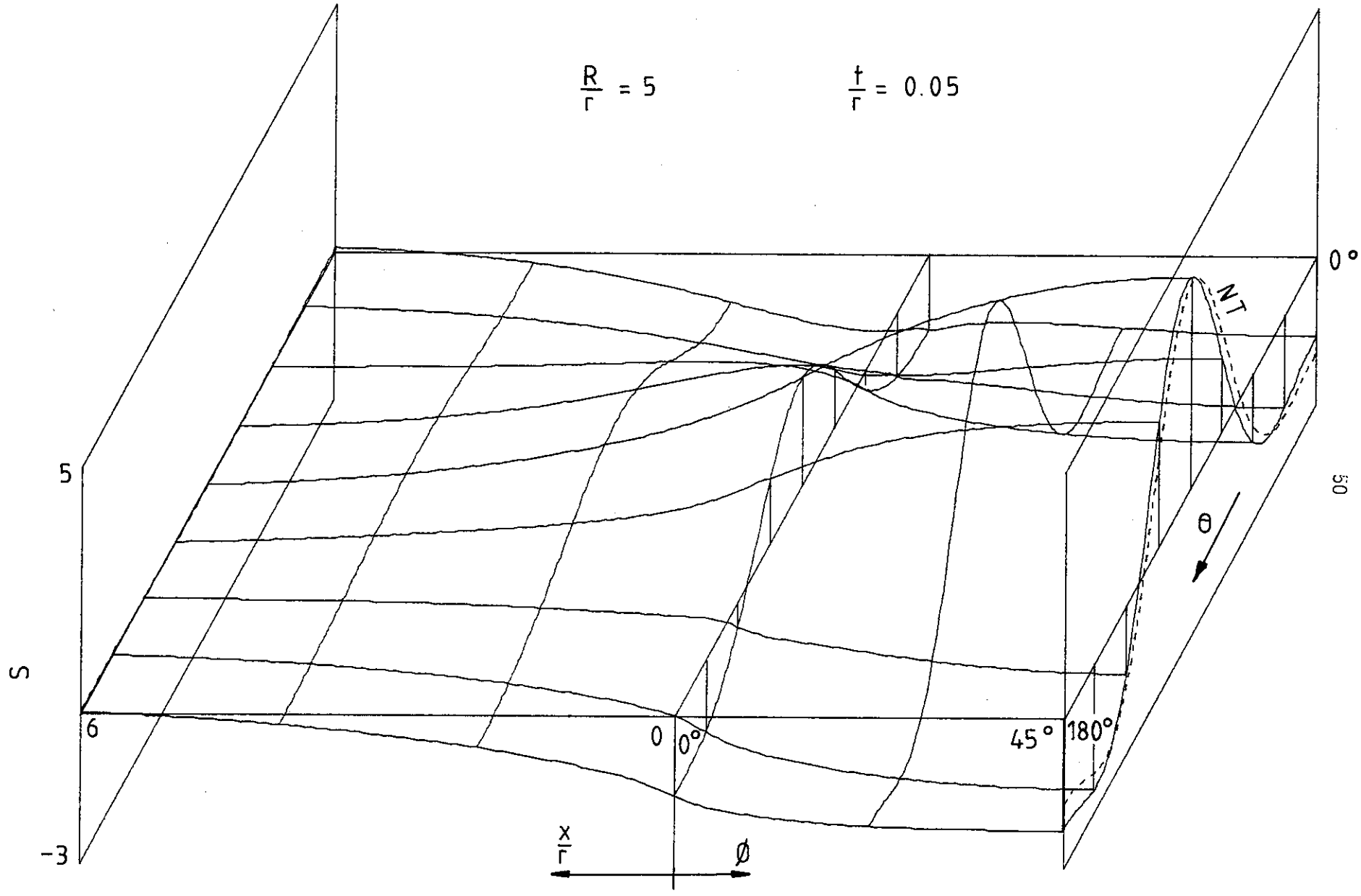


FIGURE A21

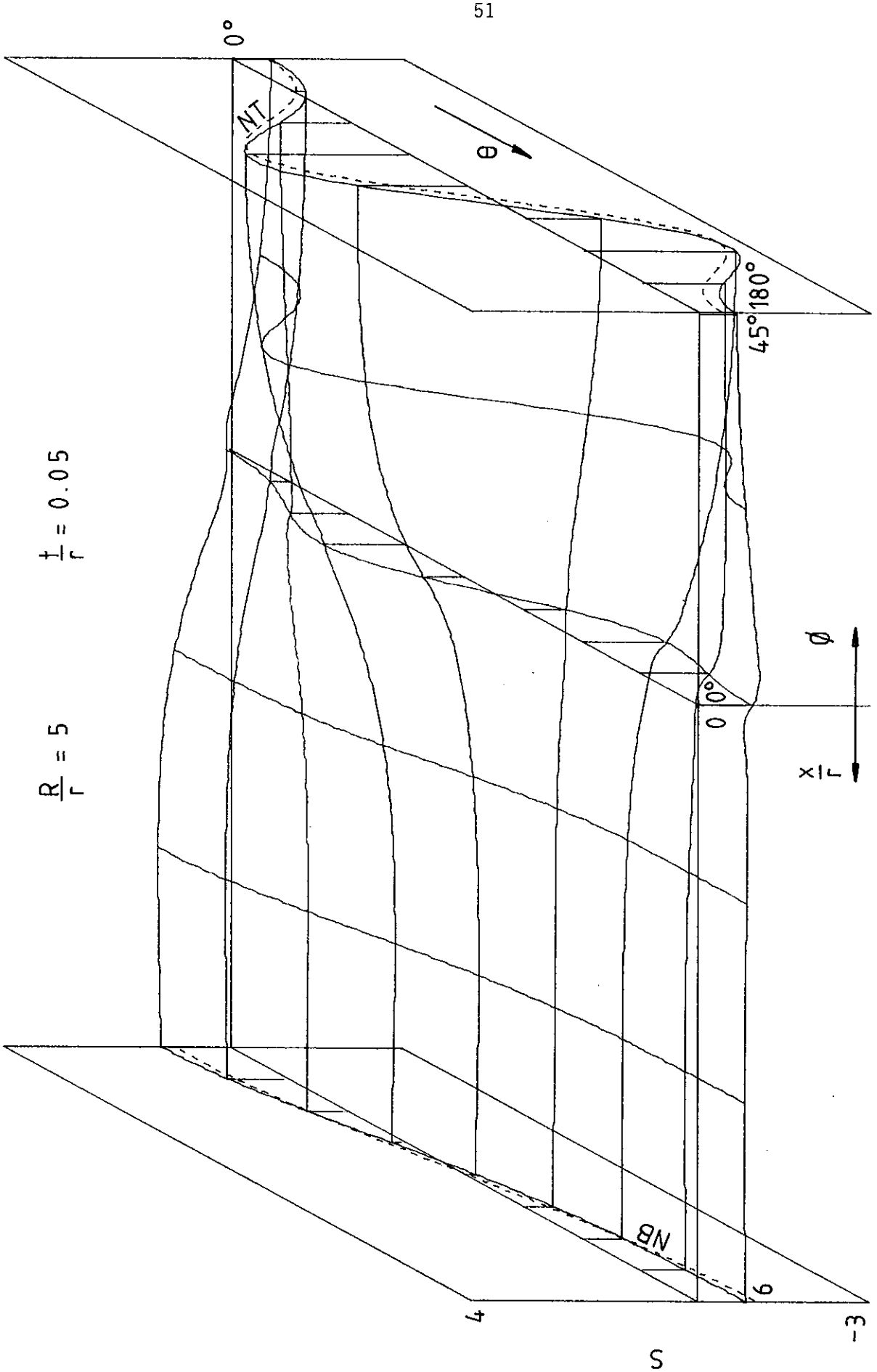


FIGURE A22

TABLE A21

R/r = 5.0 t/r = 0.05

OUTSIDE HOOP STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0568	-0.0386	-0.2237	-0.5399	-1.0002	-1.4653	-1.5214	-1.3763	-1.3911	-1.4669	-1.5476	-1.6047	-1.6250	-1.9001
22.5	0.0385	-0.0272	-0.1495	-0.3503	-0.6432	-1.0000	-1.2926	-1.4111	-1.5468	-1.6815	-1.7892	-1.8573	-1.8806	-2.0043
45.0	-0.0035	0.0001	0.0185	0.0666	0.1397	0.1180	-0.3864	-0.8649	-1.1125	-1.2610	-1.3475	-1.3925	-1.4065	-1.1647
67.5	-0.0412	0.0273	0.1630	0.3984	0.7490	1.1419	1.1871	1.0718	1.1394	1.2550	1.3639	1.4380	1.4641	1.8438
90.0	-0.0518	0.0384	0.1970	0.4436	0.8011	1.3335	2.1965	2.8592	3.3811	3.7754	4.0493	4.2099	4.2627	4.1482
112.5	-0.0321	0.0270	0.1168	0.2341	0.3876	0.6562	1.3273	1.8159	2.1450	2.3398	2.4495	2.5039	2.5202	1.9449
135.0	0.0034	-0.0001	-0.0169	-0.0592	-0.1346	-0.2397	-0.4844	-0.7980	-0.9901	-1.1582	-1.2855	-1.3646	-1.3914	-1.6195
157.5	0.0347	-0.0271	-0.1303	-0.2823	-0.4935	-0.7989	-1.4397	-1.9185	-2.1784	-2.3562	-2.4679	-2.5286	-2.5477	-2.2201
180.0	0.0469	-0.0383	-0.1736	-0.3621	-0.6123	-0.9596	-1.5723	-1.9147	-2.0677	-2.1549	-2.1974	-2.2147	-2.2190	-1.7172

OUTSIDE AXIAL STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	1.2202	1.2661	1.2854	1.2285	1.0037	0.5221	0.0995	-0.0596	-0.3001	-0.4695	-0.5791	-0.6399	-0.6594	-0.5706
22.5	1.0829	1.1129	1.1255	1.0951	0.9791	0.7194	0.3715	0.1897	-0.0016	-0.1229	-0.1955	-0.2335	-0.2452	-0.0882
45.0	0.7200	0.7148	0.7126	0.7325	0.8185	1.0009	1.0465	1.0321	1.0712	1.1271	1.1774	1.2111	1.2230	1.4157
67.5	0.2526	0.2187	0.2044	0.2479	0.4192	0.8165	1.4640	1.9242	2.2925	2.5552	2.7291	2.8279	2.8599	2.7620
90.0	-0.1889	-0.2274	-0.2435	-0.2162	-0.1211	0.0944	0.7468	1.2923	1.6047	1.7820	1.8752	1.9182	1.9304	1.4342
112.5	-0.5198	-0.5405	-0.5491	-0.5502	-0.5676	-0.6404	-0.7214	-0.8072	-0.9553	-1.1009	-1.2210	-1.2996	-1.3269	-1.6735
135.0	-0.7201	-0.7152	-0.7130	-0.7275	-0.7862	-0.9415	-1.4391	-1.9093	-2.2019	-2.4085	-2.5448	-2.6225	-2.6478	-2.4956
157.5	-0.8157	-0.7911	-0.7808	-0.7928	-0.8306	-0.8963	-1.1608	-1.4164	-1.4565	-1.4633	-1.4519	-1.4385	-1.4330	-1.1395
180.0	-0.8423	-0.8107	-0.7976	-0.8059	-0.8261	-0.8311	-0.8993	-0.9830	-0.8788	-0.7820	-0.6996	-0.6444	-0.6250	-0.3935

OUTSIDE SHEAR STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0	0.0	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	-0.0379	-0.0583	-0.0823	-0.1000	-0.0796	0.0371	0.2205	0.1039	0.0378	0.0058	-0.0055	-0.0053	0.0	0.0
45.0	-0.0526	-0.0788	-0.1085	-0.1327	-0.1285	-0.0482	0.1721	0.0432	-0.0259	-0.0490	-0.0449	-0.0258	0.0	0.0
67.5	-0.0356	-0.0503	-0.0653	-0.0808	-0.1052	-0.1570	-0.1741	-0.1741	-0.1611	-0.1313	-0.0918	-0.0470	0.0	0.0
90.0	0.0018	0.0060	0.0125	0.0151	-0.0075	-0.1052	-0.3585	-0.2410	-0.1555	-0.0984	-0.0579	-0.0268	0.0	0.0
112.5	0.0370	0.0549	0.0749	0.0923	0.0990	0.0804	-0.0281	0.0393	0.0762	0.0790	0.0618	0.0334	0.0	0.0
135.0	0.0500	0.0703	0.0908	0.1113	0.1391	0.1968	0.3367	0.2999	0.2473	0.1888	0.1269	0.0637	0.0	0.0
157.5	0.0346	0.0473	0.0592	0.0722	0.0947	0.1479	0.2773	0.2286	0.1725	0.1237	0.0797	0.0390	0.0	0.0
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

DIAMETER EXPANSION FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
90.0	-1.229	1.070	5.103	11.383	20.357	32.467	48.086	58.609	67.574	74.553	79.466	82.365	83.321	80.504

TABLE A22

R/r = 5.0 t/r = 0.05

INSIDE HOOP STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	-0.0628	0.0386	0.2374	0.5813	1.0864	1.5884	1.4876	1.2770	1.3343	1.4426	1.5447	1.6137	1.6378	1.9006
22.5	-0.0425	0.0274	0.1582	0.3746	0.6922	1.0804	1.2722	1.3241	1.5057	1.6719	1.7995	1.8784	1.9050	2.0037
45.0	0.0042	0.0003	-0.0206	-0.0767	-0.1647	-0.1427	0.3519	0.7707	1.0514	1.2162	1.3104	1.3586	1.3733	1.0762
67.5	0.0457	-0.0272	-0.1732	-0.4296	-0.8155	-1.2526	-1.3296	-1.2836	-1.3803	-1.5248	-1.6566	-1.7453	-1.7763	-2.2132
90.0	0.0568	-0.0390	-0.2078	-0.4700	-0.8505	-1.4286	-2.4420	-3.2474	-3.8620	-4.3239	-4.6434	-4.8304	-4.8919	-4.7591
112.5	0.0347	-0.0280	-0.1219	-0.2419	-0.3946	-0.6655	-1.5179	-2.2132	-2.6030	-2.8379	-2.9714	-3.0384	-3.0586	-2.3859
135.0	-0.0041	-0.0003	0.0187	0.0670	0.1546	0.2838	0.4065	0.5582	0.7711	0.9564	1.0990	1.1883	1.2187	1.5193
157.5	-0.0379	0.0277	0.1370	0.2969	0.5179	0.8375	1.3817	1.7879	2.0970	2.3125	2.4527	2.5312	2.5563	2.2301
180.0	-0.0510	0.0394	0.1819	0.3780	0.6349	0.9858	1.4993	1.8067	2.0060	2.1297	2.2000	2.2347	2.2449	1.7163

INSIDE AXIAL STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	1.1023	1.1910	1.3070	1.4361	1.5233	1.4402	0.9339	0.4957	0.3137	0.2062	0.1477	0.1197	0.1115	0.2952
22.5	0.9901	1.0506	1.1278	1.2143	1.2859	1.2876	1.0299	0.7550	0.6661	0.6240	0.6079	0.6036	0.6031	0.7651
45.0	0.6880	0.6830	0.6728	0.6622	0.6795	0.7985	1.0491	1.1966	1.3225	1.4168	1.4822	1.5208	1.5336	1.5468
67.5	0.2825	0.2183	0.1335	0.0387	-0.0252	0.0431	0.4620	0.8406	1.0368	1.1449	1.2011	1.2269	1.2342	0.9868
90.0	-0.1257	-0.2073	-0.3086	-0.4228	-0.5387	-0.6415	-0.6757	-0.6946	-0.7607	-0.8503	-0.9321	-0.9879	-1.0075	-1.2547
112.5	-0.4603	-0.5115	-0.5705	-0.6370	-0.7271	-0.8975	-1.3353	-1.7277	-1.9909	-2.1851	-2.3189	-2.3973	-2.4232	-2.3170
135.0	-0.6880	-0.6831	-0.6736	-0.6626	-0.6660	-0.7241	-0.8944	-0.9658	-1.0308	-1.0539	-1.0585	-1.0568	-1.0556	-0.8242
157.5	-0.8124	-0.7573	-0.6908	-0.6161	-0.5336	-0.4324	-0.1112	0.2369	0.4017	0.5393	0.6394	0.7001	0.7205	0.6925
180.0	-0.8509	-0.7761	-0.6881	-0.5896	-0.4730	-0.3045	0.2017	0.6542	0.8694	1.0363	1.1519	1.2197	1.2421	1.0481

INSIDE SHEAR STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0	0.0	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	-0.0059	0.0093	0.0405	0.0969	0.1780	0.2293	0.1234	0.1297	0.1162	0.0888	0.0585	0.0289	0.0	0.0
45.0	-0.0073	0.0132	0.0518	0.1168	0.2116	0.3173	0.3477	0.2780	0.2146	0.1516	0.0954	0.0458	0.0	0.0
67.5	-0.0037	0.0092	0.0289	0.0547	0.0911	0.1766	0.4103	0.2733	0.1767	0.1090	0.0615	0.0274	0.0	0.0
90.0	0.0016	-0.0001	-0.0084	-0.0295	-0.0646	-0.0874	0.0246	-0.0264	-0.0515	-0.0531	-0.0417	-0.0226	0.0	0.0
112.5	0.0050	-0.0093	-0.0353	-0.0773	-0.1399	-0.2379	-0.4090	-0.3151	-0.2261	-0.1538	-0.0947	-0.0450	0.0	0.0
135.0	0.0050	-0.0130	-0.0399	-0.0750	-0.1202	-0.1937	-0.3466	-0.2359	-0.1370	-0.0728	-0.0340	-0.0125	0.0	0.0
157.5	0.0029	-0.0091	-0.0250	-0.0423	-0.0602	-0.0810	-0.0784	-0.0336	0.0030	0.0203	0.0226	0.0141	0.0	0.0
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

DIAMETER EXPANSION FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
180.0	1.229	-1.070	-5.112	-11.424	-20.383	-31.780	-44.379	-51.924	-58.646	-64.024	-67.852	-70.120	-70.868	-67.994

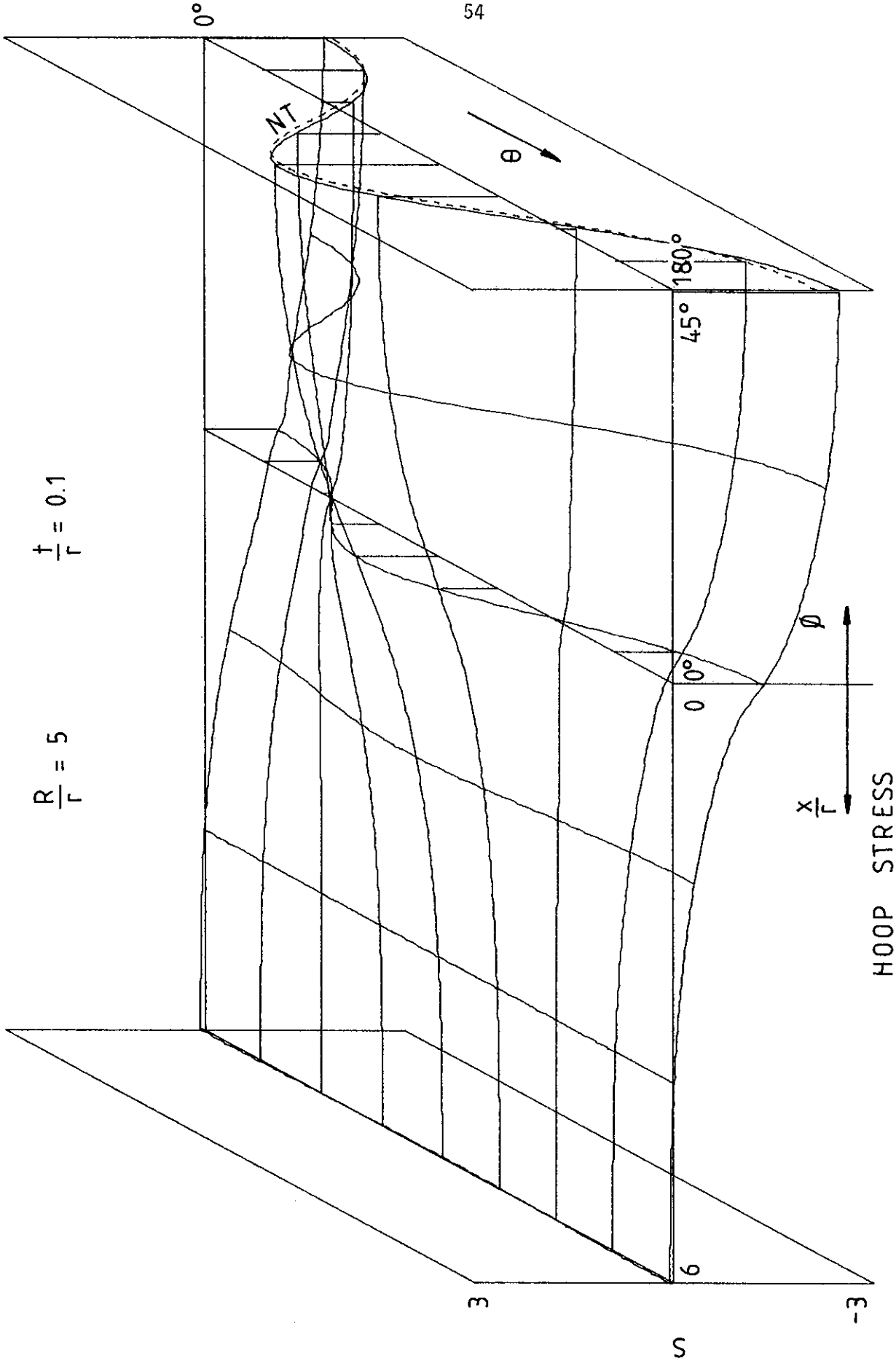


FIGURE A23

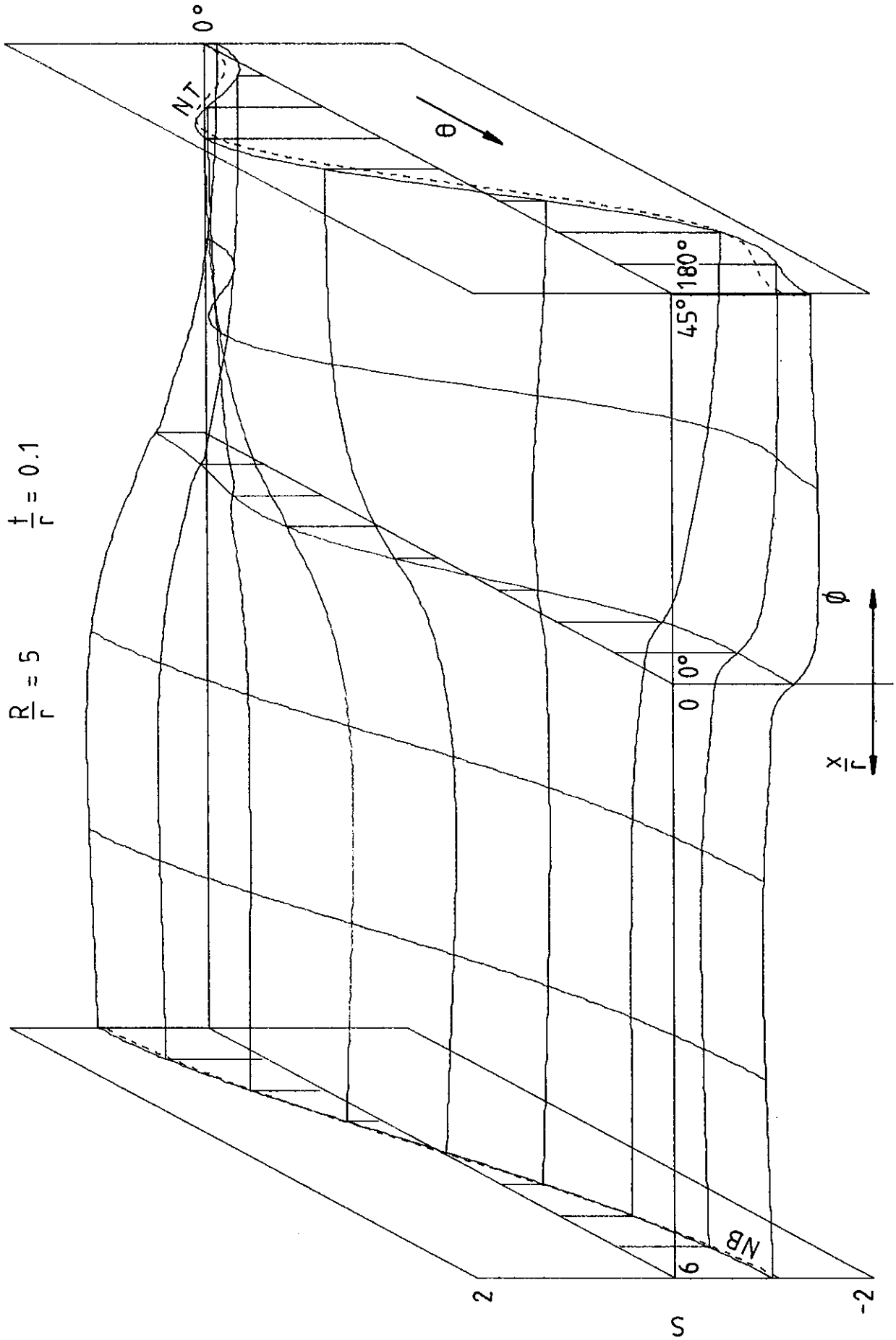

0°
N_T
θ
180°
45°
$\frac{t}{r} = 0.1$
$\frac{R}{r} = 5$
φ
0°
0
$\frac{x}{r}$
AXIAL STRESS
N_B
6
2
-2
S

FIGURE A24

TABLE A23

R/r = 5.0 t/r = 0.1

OUTSIDE HOOP STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0517	0.0416	-0.0087	-0.1343	-0.3783	-0.7440	-1.1093	-1.2921	-1.4472	-1.5932	-1.7041	-1.7723	-1.7952	-1.8737
22.5	0.0364	0.0292	-0.0057	-0.0913	-0.2561	-0.5143	-0.8551	-1.0731	-1.2216	-1.3479	-1.4396	-1.4946	-1.5128	-1.5312
45.0	-0.0002	-0.0003	0.0010	0.0078	0.0251	0.0306	-0.1466	-0.3320	-0.4036	-0.4444	-0.4662	-0.4765	-0.4795	-0.3864
67.5	-0.0366	-0.0295	0.0064	0.0972	0.2757	0.5447	0.7441	0.8283	0.9572	1.0748	1.1650	1.2208	1.2397	1.3368
90.0	-0.0513	-0.0411	0.0072	0.1232	0.3430	0.7057	1.2499	1.6384	1.9504	2.1827	2.3418	2.4337	2.4636	2.3883
112.5	-0.0360	-0.0287	0.0038	0.0771	0.2090	0.4396	0.8974	1.2133	1.4618	1.6246	1.7256	1.7795	1.7962	1.5639
135.0	0.0002	0.0003	-0.0010	-0.0076	-0.0258	-0.0497	-0.1005	-0.1950	-0.2135	-0.2424	-0.2690	-0.2874	-0.2940	-0.4198
157.5	0.0362	0.0289	-0.0046	-0.0830	-0.2285	-0.4690	-1.0053	-1.4166	-1.6377	-1.7934	-1.8936	-1.9485	-1.9658	-1.8049
180.0	0.0510	0.0407	-0.0059	-0.1125	-0.3063	-0.6272	-1.3345	-1.8276	-2.1010	-2.2839	-2.3959	-2.4543	-2.4721	-2.1632

OUTSIDE AXIAL STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	1.1061	1.1443	1.1860	1.2095	1.1594	0.9270	0.5131	0.2752	0.0820	-0.0299	-0.0917	-0.1220	-0.1310	0.0116
22.5	1.0095	1.0362	1.0651	1.0821	1.0544	0.9183	0.6461	0.4866	0.3632	0.2976	0.2654	0.2515	0.2478	0.3788
45.0	0.7417	0.7411	0.7398	0.7406	0.7568	0.8183	0.9078	0.9771	1.0310	1.0780	1.1143	1.1373	1.1452	1.2039
67.5	0.3611	0.3340	0.3041	0.2876	0.3268	0.5084	0.9430	1.2692	1.4827	1.6182	1.7004	1.7443	1.7581	1.6493
90.0	-0.0568	-0.0940	-0.1340	-0.1586	-0.1321	0.0078	0.4515	0.7947	0.9826	1.0790	1.1230	1.1395	1.1433	0.8777
112.5	-0.4414	-0.4669	-0.4936	-0.5117	-0.5117	-0.4953	-0.4032	-0.3529	-0.3594	-0.3984	-0.4432	-0.4774	-0.4901	-0.7144
135.0	-0.7417	-0.7411	-0.7398	-0.7403	-0.7540	-0.8166	-1.0545	-1.2911	-1.4208	-1.5237	-1.5944	-1.6363	-1.6503	-1.6442
157.5	-0.9292	-0.9032	-0.8756	-0.8580	-0.8694	-0.9362	-1.2250	-1.5093	-1.5842	-1.6248	-1.6356	-1.6346	-1.6330	-1.4255
180.0	-0.9926	-0.9562	-0.9180	-0.8928	-0.9005	-0.9555	-1.2012	-1.4502	-1.4643	-1.4528	-1.4215	-1.3927	-1.3814	-1.1114

OUTSIDE SHEAR STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0	0.0	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	-0.0091	-0.0210	-0.0393	-0.0626	-0.0786	-0.0456	0.0776	0.0114	-0.0229	-0.0309	-0.0259	-0.0143	0.0	0.0
45.0	-0.0129	-0.0294	-0.0545	-0.0862	-0.1121	-0.0925	0.0316	-0.0355	-0.0690	-0.0696	-0.0532	-0.0283	0.0	0.0
67.5	-0.0091	-0.0204	-0.0369	-0.0575	-0.0797	-0.1033	-0.1117	-0.1158	-0.1112	-0.0920	-0.0645	-0.0330	0.0	0.0
90.0	0.0000	0.0004	0.0018	0.0040	0.0005	-0.0384	-0.1637	-0.1137	-0.0765	-0.0512	-0.0315	-0.0150	0.0	0.0
112.5	0.0091	0.0208	0.0383	0.0605	0.0800	0.0744	-0.0019	0.0370	0.0576	0.0562	0.0425	0.0226	0.0	0.0
135.0	0.0129	0.0288	0.0520	0.0806	0.1114	0.1465	0.2099	0.2048	0.1806	0.1438	0.0985	0.0497	0.0	0.0
157.5	0.0091	0.0202	0.0360	0.0552	0.0778	0.1146	0.2140	0.1933	0.1580	0.1203	0.0801	0.0398	0.0	0.0
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

DIAMETER EXPANSION FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
90.0	-0.661	-0.516	0.132	1.667	4.551	9.199	15.652	20.011	23.687	26.474	28.384	29.487	29.846	28.768

TABLE A24

R/r = 5.0 t/r = 0.1

INSIDE HOOP STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	-0.0602	-0.0500	0.0054	0.1477	0.4300	0.8602	1.1131	1.1918	1.4044	1.5831	1.7141	1.7930	1.8192	1.8790
22.5	-0.0424	-0.0351	0.0033	0.1000	0.2887	0.5895	0.8469	0.9736	1.1716	1.3249	1.4326	1.4958	1.5166	1.5097
45.0	0.0003	0.0005	-0.0010	-0.0096	-0.0336	-0.0476	0.0884	0.2062	0.2979	0.3451	0.3691	0.3797	0.3826	0.2535
67.5	0.0426	0.0355	-0.0041	-0.1072	-0.3146	-0.6349	-0.8926	-1.0465	-1.2047	-1.3492	-1.4589	-1.5266	-1.5495	-1.6729
90.0	0.0597	0.0493	-0.0039	-0.1339	-0.3826	-0.7981	-1.4682	-1.9691	-2.3463	-2.6286	-2.8210	-2.9319	-2.9680	-2.8760
112.5	0.0418	0.0342	-0.0015	-0.0825	-0.2264	-0.4748	-1.0933	-1.5632	-1.8595	-2.0575	-2.1804	-2.2458	-2.2661	-1.9741
135.0	-0.0003	-0.0005	0.0009	0.0092	0.0338	0.0753	-0.0128	-0.0639	-0.0410	-0.0054	0.0278	0.0514	0.0599	0.2374
157.5	-0.0420	-0.0346	0.0023	0.0897	0.2522	0.5241	0.9435	1.2515	1.5105	1.7037	1.8311	1.9029	1.9259	1.7682
180.0	-0.0592	-0.0486	0.0026	0.1210	0.3348	0.6883	1.2813	1.6936	2.0114	2.2402	2.3851	2.4634	2.4879	2.1553

INSIDE AXIAL STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.9614	0.9918	1.0443	1.1220	1.2129	1.2646	1.0788	0.8372	0.7686	0.7449	0.7426	0.7465	0.7487	0.8759
22.5	0.8855	0.9070	0.9436	0.9977	1.0624	1.1106	1.0181	0.8812	0.8538	0.8521	0.8607	0.8695	0.8730	0.9630
45.0	0.6712	0.6710	0.6700	0.6679	0.6687	0.6940	0.7729	0.8408	0.8882	0.9198	0.9409	0.9530	0.9569	0.9476
67.5	0.3547	0.3331	0.2956	0.2400	0.1755	0.1474	0.2626	0.3975	0.4493	0.4630	0.4611	0.4559	0.4535	0.3451
90.0	-0.0122	-0.0422	-0.0933	-0.1682	-0.2606	-0.3439	-0.3881	-0.4129	-0.4589	-0.5185	-0.5727	-0.6094	-0.6222	-0.7305
112.5	-0.3719	-0.3928	-0.4276	-0.4778	-0.5433	-0.6300	-0.8148	-0.9808	-1.1033	-1.1983	-1.2689	-1.3120	-1.3265	-1.3302
135.0	-0.6712	-0.6710	-0.6700	-0.6679	-0.6678	-0.6872	-0.7630	-0.7989	-0.8537	-0.8760	-0.8881	-0.8937	-0.8953	-0.8310
157.5	-0.8683	-0.8472	-0.8116	-0.7598	-0.6947	-0.6233	-0.4268	-0.1913	-0.1017	-0.0091	0.0604	0.1032	0.1175	0.1343
180.0	-0.9370	-0.9073	-0.8576	-0.7858	-0.6939	-0.5809	-0.2443	0.1181	0.2762	0.4198	0.5240	0.5867	0.6076	0.5764

INSIDE SHEAR STRESS FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
0.0	0.0	0.0	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	-0.0103	-0.0080	0.0029	0.0311	0.0878	0.1672	0.1954	0.1443	0.1044	0.0696	0.0420	0.0196	0.0	0.0
45.0	-0.0145	-0.0112	0.0038	0.0409	0.1135	0.2251	0.3269	0.2335	0.1616	0.1043	0.0610	0.0278	0.0	0.0
67.5	-0.0101	-0.0077	0.0022	0.0244	0.0644	0.1361	0.2827	0.1931	0.1237	0.0736	0.0395	0.0168	0.0	0.0
90.0	0.0002	0.0003	-0.0005	-0.0050	-0.0180	-0.0328	0.0247	0.0051	-0.0075	-0.0134	-0.0129	-0.0078	0.0	0.0
112.5	0.0102	0.0079	-0.0026	-0.0282	-0.0781	-0.1612	-0.2621	-0.1979	-0.1333	-0.0860	-0.0506	-0.0232	0.0	0.0
135.0	0.0142	0.0108	-0.0031	-0.0338	-0.0881	-0.1788	-0.3309	-0.2410	-0.1465	-0.0816	-0.0400	-0.0155	0.0	0.0
157.5	0.0100	0.0075	-0.0020	-0.0219	-0.0547	-0.1068	-0.1884	-0.1332	-0.0729	-0.0327	-0.0102	-0.0014	0.0	0.0
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

DIAMETER EXPANSION FACTORS

Theta	x/r=6.0	5.0	4.0	3.0	2.0	1.0	phi=0.0	7.5	15.0	22.5	30.0	37.5	45.0	Without Tangents
180.0	0.661	0.516	-0.132	-1.668	-4.549	-9.136	-15.487	-19.670	-23.093	-25.699	-27.484	-28.512	-28.846	-27.652