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Stress Intensity and Displacement Coefficients for Radially Cracked Ring Segments Subject to Threepoint Bending

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STRESS INTENSITY AND DISPLACEMENT COEFFICIENTS FOR RADIALLY CRACKED RING SEGMENTS SUBJECTED TO THREE POINT RADIAL LOADING

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SUMMARY

The boundary collocation method was used to generate Mode I stress intensity and crack mouth displacement coefficients for internally and externally radially cracked ring segments (arc bend specimens) subjected to three point radial loading. Numerical results were obtained for ring segment outer-to-inner radius ratios (R_o/R_i) ranging from 1.10 to 2.50 and crack length-to-width ratios (a/W) ranging from 0.1 to 0.8. Stress intensity and crack mouth displacement coefficients were found to depend on the ratios R_o/R_i and a/W as well as the included angle between the directions of the reaction forces.

NOMENCLATURE

a	crack length
B	specimen thickness
E	Young's modulus
E'	$= E/(1 - \nu^2)$ for plane strain, $E' = E$ for plane stress
K	Mode I stress intensity factor
M	crack plane moment at nominal neutral axis position $M = P \tan \theta (R_i + R_o + a)/4$ for internally cracked segments $M = P \tan \theta (R_i + R_o - a)/4$ for externally cracked segments
P	applied load (Fig. 1)
R_i	ring segment inner radius
R_o	ring segment outer radius
V	total crack mouth displacement
W	ring segment width ($R_o - R_i$)
R, θ	polar coordinate system
θ_1	angle defining ring segment half span (Fig. 1)
θ_z	angle defining ring segment boundary BC

1185-24874²⁴

ν	Poisson's ratio
$x(R, \theta)$	Stress function

INTRODUCTION

There are many applications for tubular product forms, in particular high performance rolling element bearing races such as are used in jet engines, for which measurement of the plane strain fracture toughness, K_{Ic} , is highly important in the assessment of reliable endurance. It is often convenient and economical to test arc-shaped specimens machined from rings cut from bearing races or cylindrical blanks for this purpose. While there is a U.S. standard test method for testing arc-shaped specimens by loading them by means of pins inserted through holes bored through the wall thickness, this is impracticable for thin-walled tubes or rings because the greatest loading pin diameter that could be used would be too small to transmit the necessary load. For such thin-walled specimens an alternative test procedure of loading the arc-shaped specimens in three-point bending is appropriate and satisfactory, given only that an accurate fracture mechanics analysis is available. The purpose of this report is to provide the necessary results of fracture mechanics analysis in the form of stress intensity and crack mouth displacement coefficients for a sufficiently wide variety of combinations of the significant geometrical variables: ratio of outer to inner radius, R_o/R_i ; ratio of crack depth to wall thickness, $a/W = a/(R_o - R_i)$; and the included angle subtended by the support points at the center of curvature. The data is given here in tabular form for ready reference and convenience of interpolation.

METHOD

The analytical solution was obtained by the boundary collocation method (1) with the ring segment modelled as shown in Figure 1. The stress function boundary conditions along boundary BC, defined by the angle θ_2 less than θ_1 , were obtained from the known stress function solution to the bending of a curved bar by radial forces (2). From the boundary requirements along AB and CD, that the normal and shear stresses be zero, we obtained the stress function and its normal derivative compatible with that along boundary BC (see appendix).

RESULTS AND DISCUSSION

The primary results are given in tables 1 to 10 in the form of dimensionless stress intensity coefficients $KBW^{1/2}/P$, $KBW^{1/2}/P \tan \theta$ and $KBW^{3/2}/M$; and the crack mouth displacement coefficient $EBVW/6M$. Each table covers one value of R_o/R_i : 1.1, 1.25, 1.5, 2.0, or 2.5; tables 1 through 5 for internally cracked specimens, and 6 through 10 for external cracks. The major variable in each table is a/W , from 0.1 to 0.8 at intervals of 0.1. For each value of a/W results are given for values of the angle θ , at intervals of 9° from 90° down to 36° or less.

It is notable that the coefficient $KBW^{1/2}/P$ is a strong function of θ_1 , but the dependence of $KBW^{1/2}/P \tan \theta_1$ is much weaker, as is that of the other coefficients. The reason for this is that the bending moment is

proportional to $P \tan \theta_1$. Nevertheless, this weaker dependence of the coefficients on θ_1 is by no means negligible, and needs to be taken into consideration in the design of an efficient testing arrangement.

The coefficients given in Tables 1 through 10 are not well suited for direct interpolation since they all increase rapidly and indefinitely as a/W approaches unity. The following coefficient forms are much more suitable for least squares fitting: $KB(W - a)^{3/2}/PW \tan \theta_1$; $KB(W - a)^{3/2}/M(a/W)^{1/2}$; and $EBVW(W - a)^2/M(W + a)^2$. An example is given in Table 11 where values of $KB(W - a)^{3/2}/M(a/W)^{1/2}$ for internally and externally cracked curved bars with $R_0/R_i = 1.1$ and 2.5 are compared with those for a straight bar (reference 3). The results for the straight bar include the limit cases for $a/W = 0$ and 1.0 , obtained by asymptotic analysis, and illustrate very clearly the advantages of this particular form of stress intensity coefficient for interpolation purposes.

Table 11 also serves to show the trend of the stress intensity coefficient with specimen curvature. In dimensionless terms the curvature can be defined as the ratio of specimen depth, $R_0 - R_i$, to the radius of curvature of the cracked surface, R_i for the inner surface, and $-R_0$ for the outer surface. The general trend is for the stress intensity coefficient to decrease as the curvature decreases, as illustrated particularly by the results for $a/W = 0.1$. For the other values of a/W there is an anomaly in this trend insofar as the stress intensity coefficient for zero curvature (straight bar) is slightly lower than both that for slightly positive curvature, 0.1 , and for slightly negative curvature, -0.091 . There is no apparent mechanical explanation for this anomaly, and it seems most likely to be due to the (unavoidably) different boundary conditions used in the collocation analysis for the curved bars compared with those for the straight bar.

Apart from this anomaly, the effect of curvature diminishes with increasing relative crack depth from a factor of 1.88 over the range of curvature considered for $a/W = 0.1$, to a factor of 1.16 for $a/W = 0.8$. At all crack lengths the effect is stronger for external than for internal cracks.

APPENDIX

The results presented herein were obtained by plane elasto-static boundary collocation analysis of a homogeneous isotropic body. The analytical technique is described in detail by Gross and Mendelson (1) and Gross and Srawley (4). The boundary conditions to be satisfied by the stress function and its normal derivative were obtained from the known solution to a curved bar subjected to an end radial load (2). For a ring-segment containing an internal radial crack as shown in figure 1, we have the following stress function boundary conditions:

along arc AB

$$X(R_i, \theta) = 0$$

$$\left. \frac{\partial X}{\partial n} \right|_{R_i, \theta} = 0$$

along line BC

$$x(R, \theta_z) = \frac{-P \sin(\theta_1 - \theta_z)}{\left[(R_i^2 - R_o^2) + (R_i^2 + R_o^2) \ln(R_o/R_i) \right] 2 \cos \theta_1}$$

$$x \left[\frac{R^3}{2} - \frac{R_i^2 R_o^2}{2R} - R \left((R_i^2 + R_o^2) \ln \frac{R}{R_i} + \left(\frac{R_i^2 - R_o^2}{2} \right) \right) \right]$$

$$\frac{\partial x}{\partial n} \Big|_{R, \theta_z} = \frac{P \cos(\theta_1 - \theta_z)}{\left[(R_i^2 - R_o^2) + (R_i^2 + R_o^2) \ln \left(\frac{R_o}{R_i} \right) \right] 2 \cos \theta_1}$$

$$x \left[\frac{R^2}{2} - \frac{R_i^2 R_o^2}{2R^2} - (R_i^2 + R_o^2) \ln \frac{R}{R_i} - \left(\frac{R_i^2 - R_o^2}{2} \right) \right]$$

along arc CD

$$x(R_o, \theta) = PR_o \frac{\sin(\theta_1 - \theta_z)}{2 \cos \theta_1}$$

$$\frac{\partial x}{\partial n} \Big|_{R_o, \theta} = \frac{P \sin(\theta_1 - \theta_z)}{2 \cos \theta_1}$$

For a ring segment containing an external radial crack as shown in figure 1, we have the following stress function boundary conditions:

along arc AB

$$x(R_o, \theta) = 0$$

$$\frac{\partial x}{\partial n} \Big|_{R_o, \theta} = 0$$

along BC

$$x(R, \theta_z) = \frac{P \sin(\theta_1 - \theta_z)}{\left[(R_i^2 - R_o^2) + (R_i^2 + R_o^2) \ln \left(\frac{R_o}{R_i} \right) \right] 2 \cos \theta_1}$$

$$x \left[\frac{R^3}{2} - \frac{R_i^2 R_o^2}{2R} - R \left((R_i^2 + R_o^2) \ln \left(\frac{R}{R_o} \right) + \left(\frac{R_o^2 - R_i^2}{2} \right) \right) \right]$$

$$\frac{\partial x}{\partial n} \Big|_{R, \theta_z} = \frac{-P \cos(\theta_1 - \theta_z)}{\left[(R_i^2 - R_o^2) + (R_i^2 + R_o^2) \ln \left(\frac{R_o}{R_i} \right) \right] 2 \cos \theta_1}$$

$$x \left[\frac{R^2}{2} - \frac{R_i^2 R_o^2}{2R^2} - (R_i^2 + R_o^2) \ln \left(\frac{R}{R_o} \right) - \left(\frac{R_o^2 - R_i^2}{2} \right) \right]$$

along arc CD

$$x(R_i, \theta) = \frac{PR_i \sin(\theta_1 - \theta)}{2 \cos \theta_1}$$
$$\left. \frac{\partial x}{\partial n} \right|_{R_i, \theta} = \frac{-P \sin(\theta_1 - \theta)}{2 \cos \theta_1}$$

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TABLE 1 STRESS INTENSITY AND DISPLACEMENTS COEFFICIENTS FOR INTERNALLY CRACKED RING SEGMENTS WITH RATIO OF OUTER TO INNER RADIUS = 1.10

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.10000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			3.75075	0.59821
81.00	124.71982	19.75365	3.74477	0.59773
72.00	60.69350	19.72050	3.73848	0.59721
63.00	38.63155	19.68375	3.73152	0.59664
54.00	27.03290	19.64655	3.72333	0.59597
45.00	19.58611	19.58611	3.71301	0.59512
36.00	14.17572	19.51117	3.69880	0.59395
27.00	9.88199	19.39449	3.67668	0.59214
18.00	6.22953	19.17252	3.63460	0.58869
11.46	3.81178	18.80318	3.56459	0.58294

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.20000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			5.15325	1.24076
81.00	172.07825	27.25449	5.14236	1.23869
72.00	83.69402	27.19382	5.13091	1.23652
63.00	53.23891	27.12656	5.11822	1.23411
54.00	37.22768	27.04749	5.10311	1.23129
45.00	26.94785	26.94785	5.08451	1.22772
36.00	19.47913	26.81075	5.05863	1.22281
27.00	13.55194	26.59717	5.01834	1.21517
18.00	8.50995	26.19092	4.94168	1.20062
11.46	5.17240	25.51500	4.81415	1.17643

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.30000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			6.69004	2.22800
81.00	224.45135	35.54958	6.67598	2.22377
72.00	109.16805	35.47853	6.66119	2.21932
63.00	69.44414	35.38354	6.64430	2.21439
54.00	48.56006	35.28093	6.62553	2.20859
45.00	35.15163	35.15163	6.60125	2.20129
36.00	25.40987	34.97365	6.56783	2.19184
27.00	17.67873	34.69649	6.51578	2.17953
18.00	11.10228	34.16927	6.41677	2.14580
11.46	6.74397	33.29210	6.25204	2.09626

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.40000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			8.61745	3.77627
81.00	290.51636	46.01326	8.60062	3.76916
72.00	141.32294	45.91858	8.58292	3.76168
63.00	89.91431	45.81360	8.56330	3.75338
54.00	62.88721	45.69222	8.54024	3.74364
45.00	45.53473	45.53473	8.51117	3.73139
36.00	32.92743	45.32074	8.47117	3.71445
27.00	22.92223	44.98743	8.40087	3.68812
18.00	14.61131	44.35341	8.29036	3.63903
11.46	8.77748	43.29837	8.09320	3.55470

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.50000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			11.39689	6.41714
81.00	386.12549	61.15636	11.37793	6.40528
72.00	187.89017	61.04918	11.35800	6.39281
63.00	119.58269	60.93039	11.33590	6.37828
54.00	83.67133	60.79076	11.30992	6.36272
45.00	60.61451	60.61481	11.27718	6.34225
36.00	43.86327	60.37862	11.23212	6.31405
27.00	30.56920	59.95544	11.16195	6.27016
18.00	19.26056	59.27794	11.02846	6.18662
11.46	11.77483	58.08417	10.80637	6.04767

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.60000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			15.78401	11.08025
81.00	537.41431	85.11809	15.76262	11.06770
72.00	261.59753	84.99666	15.74013	11.05245
63.00	166.55112	84.86200	15.71519	11.03665
54.00	116.58469	84.70374	15.68588	11.01808
45.00	86.50026	84.50426	15.64805	10.99467
36.00	61.19649	84.22974	15.59811	10.96247
27.00	42.69933	83.80222	15.53193	10.91230
18.00	26.94871	83.92596	15.36532	10.81658
11.46	16.54918	81.63582	15.11775	10.65812

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.70000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			24.32671	22.67525
81.00	832.44800	131.84688	24.30353	22.64359
72.00	405.37549	131.71471	24.27917	22.61028
63.00	255.21680	131.56818	24.25217	22.57338
54.00	180.89106	131.50597	24.22208	22.52997
45.00	131.17896	131.17896	24.18044	22.47527
36.00	95.09003	130.88025	24.12537	22.40004
27.00	66.44974	130.41501	24.03763	22.29791
18.00	42.02684	129.53008	23.87650	22.05200
11.46	25.95904	128.05777	23.60509	21.68253

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.80000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			44.10413	55.84958
81.00	1536.51665	240.19237	44.07195	55.78879
72.00	738.66797	240.00800	44.03812	55.72931
63.00	470.64063	239.80362	44.00063	55.65352
54.00	329.73047	239.56339	43.95653	55.57059
45.00	239.25064	239.26064	43.90099	55.46555
36.00	173.53029	238.89198	43.82454	55.32103
27.00	121.36641	238.19501	43.70546	55.09559
18.00	76.99309	236.96059	43.47896	54.66765
11.46	47.62024	234.90674	43.16213	53.95517

TABLE 2 STRESS INTENSITY AND DISPLACEMENTS COEFFICIENTS FOR INTERNALLY CRACKED RING SEGMENTS WITH RATIO OF OUTER TO INNER RADIUS = 1.25

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.10000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			3.80999	0.58643
81.00	54.48929	8.63026	3.79352	0.58489
72.00	26.43990	8.59085	3.77620	0.58327
63.00	16.77475	8.54717	3.75700	0.58147
54.00	11.69349	8.49582	3.73442	0.57936
45.00	8.43111	8.43111	3.70598	0.57670
36.00	6.06085	8.34205	3.66683	0.57303
27.00	4.17981	8.20334	3.60586	0.56733
18.00	2.57969	7.93948	3.48988	0.55647

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.20000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			5.33397	1.29359
81.00	77.05823	12.20483	5.30645	1.28843
72.00	37.35773	12.13827	5.27751	1.28301
63.00	23.67789	12.06450	5.24543	1.27700
54.00	16.48598	11.97776	5.20772	1.26993
45.00	11.86848	11.86848	5.16820	1.26103
36.00	8.51367	11.71806	5.09480	1.24878
27.00	5.85127	11.48377	4.99294	1.22970
18.00	3.58651	11.03813	4.79919	1.19340

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.30000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			6.85762	2.30433
81.00	100.14928	15.86209	6.82240	2.29474
72.00	48.55347	15.77600	6.78537	2.28465
63.00	30.77480	15.68055	6.74432	2.27347
54.00	21.42798	15.56836	6.69604	2.26133
45.00	15.42698	15.42698	6.63526	2.24377
36.00	11.06697	15.23259	6.55156	2.22098
27.00	7.60686	14.92930	6.42120	2.18547
18.00	4.66351	14.35281	6.17325	2.11794

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.40000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			8.78090	3.89351
81.00	129.68169	20.53954	8.74024	3.87347
72.00	62.98503	20.43906	8.69749	3.85240
63.00	39.89339	20.32770	8.65010	3.82904
54.00	27.79851	20.19681	8.59439	3.80158
45.00	20.03183	20.03183	8.52619	3.76697
36.00	14.38983	19.80478	8.42757	3.71935
27.00	9.91084	19.45113	8.27708	3.64516
18.00	6.10149	18.77846	7.99084	3.50406

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.50000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			11.56313	6.54220
81.00	172.71581	27.35547	11.51810	6.51223
72.00	83.84956	27.24306	11.47077	6.48071
63.00	53.22292	27.11841	11.41829	6.44578
54.00	37.12366	26.97191	11.35661	6.40471
45.00	26.78728	26.78728	11.27888	6.35296
36.00	19.27750	26.53319	11.17189	6.28173
27.00	13.31771	26.13744	11.00525	6.17078
18.00	8.24799	25.38466	10.68829	5.95976

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.60000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			16.08852	11.59285
81.00	243.05417	38.49599	16.03998	11.54623
72.00	118.10152	38.37349	15.98897	11.49720
63.00	75.04575	38.23769	15.93239	11.44286
54.00	52.40999	38.07803	15.86589	11.37897
45.00	37.87697	37.87697	15.78208	11.29846
36.00	27.31810	37.60013	15.66674	11.18766
27.00	18.93854	37.16898	15.48709	11.01509
18.00	11.81047	36.34888	15.14537	10.68683

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.70000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			24.59856	22.91747
81.00	375.79932	59.52086	24.54468	22.84224
72.00	182.76360	59.38344	24.48881	22.76311
63.00	116.24776	59.23116	24.42522	22.67502
54.00	81.27831	59.05211	24.35138	22.57230
45.00	58.82651	58.82651	24.25632	22.44240
36.00	42.51436	58.51601	24.13028	22.26360
27.00	29.54894	58.03232	23.93035	21.99511
18.00	18.55695	57.11240	23.55150	21.45537

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.80000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			44.51508	56.30098
81.00	687.53125	108.89435	44.44666	56.18556
72.00	354.59961	108.71802	44.37448	56.07315
63.00	212.98755	108.52254	44.29488	55.86530
54.00	149.05222	108.29276	44.20113	55.67972
45.00	108.00322	108.00322	44.08292	55.44935
36.00	78.17937	107.60471	43.92026	55.12401
27.00	54.51105	106.98398	43.66692	54.62270
18.00	34.37758	105.80333	43.10503	53.66916

TABLE 3 STRESS INTENSITY AND DISPLACEMENTS COEFFICIENTS FOR INTERNALLY CRACKED RING SEGMENTS WITH RATIO OF OUTER TO INNER RADIUS = 1.50

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.10000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000				
θ_1	AVERAGE KB-W/P	VALUES KB-W/PTAN θ_1	KB-W**1.5/M	EBVM/6M
90.00			4.07204	0.63060
81.00	32.51706	5.15020	4.03937	0.62720
72.00	15.71590	5.10540	4.00502	0.62362
63.00	9.92661	5.05786	3.96695	0.61965
54.00	6.88300	5.00079	3.92219	0.61498
45.00	4.92385	4.92888	3.86579	0.60910
36.00	3.50913	4.82990	3.78816	0.60101
27.00	2.38241	4.67574	3.66725	0.58840

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.20000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000				
θ_1	AVERAGE KB-W/P	VALUES KB-W/PTAN θ_1	KB-W**1.5/M	EBVM/6M
90.00			5.57158	1.35877
81.00	45.29822	7.17453	5.51887	1.34660
72.00	21.85918	7.10549	5.46345	1.33381
63.00	13.78667	7.02262	5.40201	1.31962
54.00	9.53658	6.92873	5.32979	1.30295
45.00	6.81043	6.81043	5.23879	1.28194
36.00	4.82976	6.64760	5.11353	1.25302
27.00	3.25789	6.39398	4.91845	1.20798

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.30000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000				
θ_1	AVERAGE KB-W/P	VALUES KB-W/PTAN θ_1	KB-W**1.5/M	EBVM/6M
90.00			7.08236	2.39357
81.00	58.70255	9.29758	7.01704	2.37352
72.00	28.33490	9.20657	6.94836	2.35244
63.00	17.07993	9.10570	6.87222	2.32907
54.00	12.36970	8.98711	6.78273	2.30160
45.00	8.83768	8.83768	6.66995	2.26699
36.00	6.27153	8.63902	6.51473	2.21934
27.00	4.25501	8.31168	6.27297	2.14513

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.40000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000				
θ_1	AVERAGE KB-W/P	VALUES KB-W/PTAN θ_1	KB-W**1.5/M	EBVM/6M
90.00			9.00246	3.95934
81.00	76.11835	12.05596	8.93034	3.92034
72.00	36.78937	11.95360	8.85451	3.87934
63.00	23.23752	11.84812	8.77046	3.83358
54.00	16.11292	11.70472	8.67184	3.78064
45.00	11.53863	11.53563	8.54713	3.71310
36.00	8.21521	11.30727	8.37575	3.62042
27.00	5.57773	10.94692	8.10883	3.47606

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.50000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000				
θ_1	AVERAGE KB-W/P	VALUES KB-W/PTAN θ_1	KB-W**1.5/M	EBVM/6M
90.00			11.77301	6.69004
81.00	101.52071	16.07927	11.69404	6.63300
72.00	49.13556	15.96513	11.61100	6.57303
63.00	31.08490	15.83356	11.51896	6.50655
54.00	21.59511	15.68978	11.40975	6.42950
45.00	15.50230	15.50230	11.27440	6.32991
36.00	11.07560	15.24426	11.03673	6.19437
27.00	7.56255	14.84235	10.79443	5.98326

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.60000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000				
θ_1	AVERAGE KB-W/P	VALUES KB-W/PTAN θ_1	KB-W**1.5/M	EBVM/6M
90.00			16.31090	11.76417
81.00	143.43523	22.71790	16.22707	11.68100
72.00	69.53867	22.59447	16.13592	11.59354
63.00	44.07567	22.45766	16.04120	11.49659
54.00	30.83896	22.29483	15.92633	11.39218
45.00	22.09418	22.09418	15.78157	11.23500
36.00	15.84972	21.81525	15.58234	11.04134
27.00	10.89407	21.38080	15.27202	10.73347

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.70000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000				
θ_1	AVERAGE KB-W/P	VALUES KB-W/PTAN θ_1	KB-W**1.5/M	EBVM/6M
90.00			24.85602	23.15607
81.00	222.81348	35.29015	24.76500	23.02518
72.00	108.19237	35.15381	24.66933	22.88750
63.00	68.69662	35.00264	24.56325	22.73458
54.00	47.93248	34.82997	24.43857	22.56550
45.00	34.60109	34.60109	24.28145	22.32944
36.00	24.91527	34.29299	24.06522	22.01833
27.00	17.22655	33.81293	23.72838	21.53374

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.80000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000				
θ_1	AVERAGE KB-W/P	VALUES KB-W/PTAN θ_1	KB-W**1.5/M	EBVM/6M
90.00			45.15500	56.91649
81.00	412.46924	65.32869	45.05428	56.69568
72.00	200.58861	65.17516	44.94335	56.46352
63.00	127.57918	65.00593	44.81098	56.21618
54.00	89.19620	64.80481	44.66298	55.90363
45.00	64.55266	64.55266	44.51906	55.52242
36.00	46.64809	64.20563	44.27974	54.99773
27.00	32.43895	63.66504	43.90691	54.18047

TABLE 4 STRESS INTENSITY AND DISPLACEMENTS COEFFICIENTS FOR INTERNALLY CRACKED RING SEGMENTS WITH RATIO OF OUTER TO INNER RADIUS = 2.00

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.10000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			4.46437	0.69771
81.00	21.51981	3.40841	4.39794	0.69007
72.00	10.32339	3.35427	4.32809	0.68235
63.00	6.46536	3.29427	4.25067	0.67335
54.00	4.43708	3.22373	4.15965	0.66269
45.00	3.13484	3.13484	4.04495	0.64950
36.00	2.18871	3.01250	3.88709	0.63136
31.50	1.79517	2.92946	3.77995	0.61905

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.20000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			5.96029	1.47476
81.00	29.60886	4.68958	5.86198	1.45449
72.00	14.17856	4.60689	5.75862	1.43319
63.00	8.86163	4.51522	5.64403	1.40957
54.00	6.06635	4.40746	5.50933	1.38181
45.00	4.27168	4.27168	5.33959	1.34682
36.00	2.96776	4.08478	5.10598	1.29867
31.50	2.42542	3.95793	4.94741	1.26599

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.30000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			7.43880	2.56918
81.00	38.14632	6.04179	7.32338	2.52999
72.00	18.28653	5.94166	7.20201	2.48879
63.00	11.44332	5.83066	7.06747	2.44311
54.00	7.74563	5.70019	6.90932	2.38911
45.00	5.53577	5.53577	6.71002	2.32175
36.00	3.85756	5.30947	6.43572	2.22862
31.50	3.15952	5.15587	6.24955	2.16541

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.40000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			9.31607	4.20203
81.00	49.32607	7.81248	9.19116	4.13972
72.00	23.70073	7.70085	9.05982	4.07420
63.00	14.87090	7.57710	8.91424	4.00158
54.00	10.22576	7.43162	8.74309	3.91620
45.00	7.24831	7.24831	8.52743	3.80862
36.00	5.08290	6.99601	8.23060	3.66055
31.50	4.18222	6.82476	8.02913	3.50005

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.50000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			12.06770	6.93703
81.00	65.94565	10.44477	11.93638	6.84244
72.00	31.77524	10.32442	11.79934	6.74299
63.00	20.00095	10.19101	11.64666	6.63275
54.00	13.81085	10.03417	11.46763	6.50315
45.00	9.83655	9.83655	11.24177	6.33985
36.00	6.94904	9.56454	10.95090	6.11508
31.50	5.74802	9.37992	10.71990	5.96252

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.60000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			16.59865	12.08308
81.00	93.54697	14.81639	16.46265	11.94150
72.00	45.20398	14.68768	16.31963	11.79263
63.00	28.54613	14.54500	16.16109	11.62761
54.00	19.78859	14.37727	15.97474	11.43562
45.00	14.16591	14.16591	15.73991	11.18917
36.00	10.08079	13.87501	15.41668	10.85272
31.50	8.38162	13.67756	15.19729	10.62435

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.70000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			25.17603	23.54680
81.00	146.23829	23.15552	25.03299	23.33025
72.00	70.83725	23.01639	24.88260	23.10257
63.00	44.86960	22.86220	24.71590	22.85016
54.00	31.21761	22.63091	24.51990	22.59347
45.00	22.45250	22.45250	24.27295	22.19900
36.00	16.08426	22.13005	23.93306	21.66501
31.50	13.43548	21.92470	23.70235	21.31572

RING SEGMENT INTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.80000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			45.74254	57.42601
81.00	273.45142	43.31849	45.56997	57.12310
72.00	132.82497	43.15210	45.42953	56.75179
63.00	84.37096	42.95914	45.25171	56.33469
54.00	58.89618	42.78056	45.04271	55.84430
45.00	42.54010	42.54010	44.79930	55.22641
36.00	30.65712	42.19591	44.41675	54.37559
31.50	25.71442	41.96210	44.17064	53.79865

TABLE 5 STRESS INTENSITY AND DISPLACEMENTS COEFFICIENTS FOR INTERNALLY CRACKED RING SEGMENTS WITH RATIO OF OUTER TO INNER RADIUS = 2.5000

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.10000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000

θ_1	AVERAGE VALUES		KB-W**1.5/M	EBW/W*6M
	KB*W/P	KB*W/PTAN θ_1		
90.00			4.79007	0.75610
81.00	18.02173	2.85436	4.69082	0.74420
72.00	8.58937	2.79085	4.58645	0.73168
63.00	5.33920	2.72046	4.47076	0.71780
54.00	3.63048	2.63770	4.33476	0.70149
45.00	2.53342	2.53342	4.16339	0.68094
36.00	1.73636	2.38989	3.92751	0.65266

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.20000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000

θ_1	AVERAGE VALUES		KB-W**1.5/M	EBW/W*6M
	KB*W/P	KB*W/PTAN θ_1		
90.00			6.28751	1.58251
81.00	24.59546	3.89554	6.15924	1.55238
72.00	11.70578	3.80344	6.00365	1.52072
63.00	7.26429	3.70134	5.84269	1.48561
54.00	4.92926	3.58132	5.65323	1.44434
45.00	3.43008	3.43008	5.41449	1.39233
36.00	2.34066	3.22192	5.08591	1.32076

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.30000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000

θ_1	AVERAGE VALUES		KB-W**1.5/M	EBW/W*6M
	KB*W/P	KB*W/PTAN θ_1		
90.00			7.72773	2.71834
81.00	31.48398	4.98658	7.57263	2.66429
72.00	15.01661	4.87919	7.40956	2.60745
63.00	9.34233	4.76015	7.22878	2.54945
54.00	6.35918	4.62021	7.01627	2.47039
45.00	4.44388	4.44388	6.74850	2.37706
36.00	3.05234	4.20118	6.37993	2.24861

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.40000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000

θ_1	AVERAGE VALUES		KB-W**1.5/M	EBW/W*6M
	KB*W/P	KB*W/PTAN θ_1		
90.00			9.55208	4.41380
81.00	40.52454	6.41846	9.39058	4.32815
72.00	19.39676	6.30246	9.22077	4.23809
63.00	12.11665	6.17374	9.03254	4.13827
54.00	8.28926	6.02250	8.81126	4.02091
45.00	5.83191	5.83191	8.53243	3.87504
36.00	4.04655	5.56960	8.14865	3.66951

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.50000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000

θ_1	AVERAGE VALUES		KB-W**1.5/M	EBW/W*6M
	KB*W/P	KB*W/PTAN θ_1		
90.00			12.26336	7.18902
81.00	54.12383	8.57238	12.09934	7.06174
72.00	26.00696	8.45018	11.92686	6.92791
63.00	16.31856	8.31473	11.73568	6.77957
54.00	11.22507	8.15549	11.51093	6.60517
45.00	7.95484	7.95484	11.22772	6.38543
36.00	5.57888	7.67867	10.83792	6.08297

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.60000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000

θ_1	AVERAGE VALUES		KB-W**1.5/M	EBW/W*6M
	KB*W/P	KB*W/PTAN θ_1		
90.00			16.77895	12.37014
81.00	76.91956	12.18287	16.60921	12.18474
72.00	37.09203	12.05194	16.43073	11.93981
63.00	23.36541	11.90682	16.23285	11.77372
54.00	16.15549	11.73621	16.00026	11.51969
45.00	11.52124	11.52124	15.70721	11.19960
36.00	8.15569	11.22535	15.30382	10.75904

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.70000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000

θ_1	AVERAGE VALUES		KB-W**1.5/M	EBW/W*6M
	KB*W/P	KB*W/PTAN θ_1		
90.00			25.36823	23.87317
81.00	120.63765	19.10712	25.19066	23.59549
72.00	58.36980	18.96547	25.00394	23.30356
63.00	36.91376	18.80849	24.79697	22.97932
54.00	25.63366	18.62995	24.55365	22.59946
45.00	18.39139	18.39139	24.24706	22.12006
36.00	13.12959	18.07132	23.82506	21.46024

RING SEGMENT INTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.80000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000

θ_1	AVERAGE VALUES		KB-W**1.5/M	EBW/W*6M
	KB*W/P	KB*W/PTAN θ_1		
90.00			45.83170	57.85904
81.00	225.74921	35.75513	45.63515	57.41141
72.00	109.54468	35.59319	45.42850	56.94072
63.00	69.50310	35.41370	45.19916	56.41901
54.00	48.45232	35.20267	44.93004	55.80562
45.00	36.43677	34.93677	44.59064	55.03278
36.00	25.11713	34.57079	44.12357	53.96904

TABLE 6 -STRESS INTENSITY AND DISPLACEMENT COEFFICIENTS FOR EXTERNALLY CRACKED RING SEGMENTS WITH RATIO OF OUTER TO INNER RADIUS = 1.10000

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.10000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000

θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVW/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			3.40499	0.52013
81.00	112.14354	17.76175	3.39938	0.51952
72.00	54.57024	17.73093	3.39348	0.51888
63.00	34.73186	17.69675	3.38694	0.51818
54.00	24.30222	17.65659	3.37926	0.51734
45.00	17.60599	17.60599	3.36957	0.51630
36.00	12.74092	17.53635	3.35624	0.51486
27.00	8.87995	17.42786	3.33548	0.51261
18.00	5.59562	17.22153	3.29599	0.50835
11.46	3.42155	16.87819	3.23028	0.50124

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.20000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000

θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVW/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			4.85435	1.17330
81.00	160.02080	25.34473	4.87399	1.17107
72.00	77.82833	25.28809	4.86310	1.16873
63.00	49.50742	25.22527	4.85102	1.16613
54.00	34.61803	25.15146	4.83682	1.16308
45.00	25.05843	25.05843	4.81893	1.15924
36.00	18.11301	24.91042	4.79321	1.15399
27.00	12.60109	24.73099	4.75597	1.14570
18.00	7.91235	24.51770	4.68302	1.13003
11.46	4.80864	23.72060	4.56166	1.10395

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.30000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000

θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVW/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			6.41563	2.13729
81.00	209.16878	33.12897	6.40174	2.13371
72.00	101.73145	33.05449	6.38735	2.12994
63.00	64.71107	32.97191	6.37139	2.12577
54.00	45.24840	32.87485	6.35264	2.12086
45.00	32.75258	32.75258	6.32900	2.11468
36.00	23.67383	32.58423	6.29647	2.10617
27.00	16.46859	32.32204	6.24581	2.09292
18.00	10.35933	31.82332	6.14946	2.06771
11.46	6.28301	30.99355	5.98910	2.02578

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.40000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000

θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVW/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			8.34409	3.66353
81.00	270.77344	42.88620	8.32743	3.65632
72.00	131.71265	42.79596	8.30990	3.64873
63.00	83.79558	42.69594	8.29048	3.64033
54.00	58.60410	42.57837	8.26765	3.63045
45.00	42.43021	42.43021	8.23358	3.61800
36.00	30.67917	42.22623	8.19928	3.60086
27.00	21.35552	41.99062	8.13761	3.57417
18.00	13.42084	41.30443	8.02029	3.52339
11.46	8.16946	40.29921	7.82510	3.43892

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.50000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000

θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVW/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			11.11270	6.27110
81.00	358.95313	56.85248	11.09318	6.25629
72.00	174.65050	56.74730	11.07265	6.24037
63.00	111.14409	56.63068	11.04990	6.23111
54.00	77.75601	56.49364	11.02316	6.21693
45.00	56.32038	56.32038	10.98965	6.19655
36.00	40.74677	56.05313	10.94356	6.16649
27.00	28.38737	55.71643	10.87061	6.12479
18.00	17.87334	55.00847	10.73337	6.04166
11.46	10.91375	53.83658	10.50471	5.90335

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.60000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000

θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVW/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			15.78628	11.10609
81.00	507.64087	80.40224	15.76514	11.08528
72.00	247.10435	80.28896	15.74294	11.06339
63.00	157.32967	80.16341	15.71832	11.03913
54.00	110.13236	80.01354	15.68939	11.01162
45.00	79.82985	79.82985	15.65292	10.97469
36.00	57.81330	79.57337	15.60273	10.92523
27.00	40.34174	79.17516	15.52455	10.84119
18.00	25.47913	78.41675	15.37584	10.70167
11.46	15.64085	77.15494	15.12844	10.45788

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.70000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000

θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVW/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			24.07573	22.41327
81.00	770.64966	122.05872	24.05095	22.37859
72.00	375.25122	121.92653	24.02482	22.34209
63.00	239.00693	121.78003	23.99602	22.30164
54.00	167.37883	121.60785	23.96213	22.25409
45.00	121.39081	121.39081	23.91933	22.19420
36.00	87.87858	121.09212	23.86049	22.11712
27.00	61.46245	120.62691	23.76880	21.93331
18.00	38.90648	119.74196	23.59447	21.73900
11.46	23.97559	118.26964	23.30437	21.53257

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.80000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.10000

θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVW/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			43.52396	55.19655
81.00	1386.59009	219.61391	43.48787	55.13080
72.00	675.31226	219.42223	43.44991	55.06168
63.00	430.22299	219.20975	43.40781	54.98935
54.00	301.37207	218.96007	43.35840	54.89502
45.00	218.64539	218.64539	43.29607	54.78154
36.00	158.54847	218.21222	43.21033	54.62531
27.00	110.84087	217.53760	43.07671	54.38196
18.00	70.26526	216.25432	42.82262	53.91919
11.46	43.48619	214.11931	42.39983	53.14922

TABLE 7 STRESS INTENSITY AND DISPLACEMENTS COEFFICIENTS FOR EXTERNALLY CRACKED RING SEGMENTS WITH RATIO OF OUTER TO INNER RADIUS = 1.25

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.10000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000

θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			3.23810	0.49616
81.00	45.29805	7.17449	3.22449	0.49453
72.00	21.98282	7.14264	3.21018	0.49288
63.00	13.94895	7.10734	3.19431	0.49085
54.00	9.72530	7.06584	3.17566	0.48865
45.00	7.01355	7.01355	3.15216	0.48582
36.00	5.04335	6.94157	3.11981	0.48193
27.00	3.47979	6.82947	3.06942	0.47587
18.00	2.14974	6.61622	2.97358	0.46433

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.20000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000

θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			4.71146	1.15838
81.00	65.11728	10.31355	4.68797	1.15435
72.00	31.57458	10.25921	4.66328	1.15013
63.00	20.01662	10.19858	4.63590	1.14544
54.00	13.96024	10.12818	4.60371	1.13994
45.00	10.03896	10.03896	4.56516	1.13300
36.00	7.20450	9.91615	4.50734	1.12445
27.00	4.95507	9.72489	4.42040	1.10857
18.00	3.04159	9.36106	4.25503	1.08028

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.30000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000

θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			6.22256	2.11108
81.00	85.01143	13.46446	6.19056	2.10084
72.00	41.21610	13.39127	6.15691	2.09007
63.00	26.12259	13.31013	6.11960	2.07814
54.00	18.18654	13.21476	6.07575	2.06411
45.00	13.09487	13.09487	6.02649	2.04843
36.00	9.39358	12.92915	5.94444	2.02209
27.00	6.45645	12.67150	5.82598	1.98419
18.00	3.95798	12.18142	5.60065	1.91210

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.40000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000

θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			8.13824	3.60996
81.00	109.93261	17.41147	8.09836	3.59242
72.00	53.30965	17.32132	8.05644	3.57497
63.00	33.79892	17.22141	8.00996	3.55352
54.00	23.54155	17.10396	7.95934	3.52848
45.00	16.95955	16.95955	7.89449	3.49919
36.00	12.17121	16.75223	7.79174	3.45749
27.00	8.37402	16.43491	7.64416	3.39256
18.00	5.14393	15.83140	7.36344	3.26903

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.50000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000

θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			10.90292	6.15079
81.00	145.65404	23.06926	10.85613	6.13108
72.00	70.67824	22.96474	10.80694	6.10072
63.00	44.04340	22.84885	10.75241	6.06717
54.00	31.26122	22.71262	10.68331	6.02742
45.00	22.54097	22.54097	10.60753	5.97802
36.00	16.20531	22.30469	10.46435	5.90560
27.00	11.17733	21.93474	10.32118	5.80095
18.00	6.90026	21.23679	9.99360	5.60036

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.60000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000

θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			15.38266	11.07014
81.00	203.24219	32.19031	15.32873	11.02222
72.00	98.78525	32.12323	15.27003	10.97185
63.00	62.68436	31.93524	15.20918	10.91577
54.00	43.74706	31.76409	15.13530	10.85032
45.00	31.53558	31.58558	15.04220	10.76757
36.00	22.75493	31.31949	14.91400	10.65369
27.00	15.74452	30.90033	14.71447	10.47631
18.00	9.78110	30.10309	14.35482	10.13892

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.70000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000

θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			23.68000	22.12500
81.00	309.33740	48.9941	23.61160	22.04150
72.00	150.32420	48.8633	23.53690	21.96360
63.00	95.53210	48.67600	23.45030	21.88630
54.00	66.72620	48.47940	23.36360	21.74190
45.00	48.23170	48.23170	23.24220	21.59740
36.00	34.7946	47.89070	23.07990	21.39920
27.00	24.1109	47.35960	22.80190	21.09960
18.00	15.05950	46.34940	22.33710	20.50200

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.80000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.25000

θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			42.50757	54.32529
81.00	548.97927	86.95279	42.41597	54.16327
72.00	267.00522	86.75536	42.31969	53.99297
63.00	169.43762	86.53633	42.21591	53.80916
54.00	118.75310	86.27933	42.08745	53.58220
45.00	85.95517	85.95517	41.92934	53.30551
36.00	62.11559	85.50099	41.71169	52.91246
27.00	43.71490	84.81412	41.37273	52.31765
18.00	27.17327	83.49231	40.72794	51.17746

TABLE 8 STRESS INTENSITY AND DISPLACEMENTS COEFFICIENTS FOR EXTERNALLY CRACKED RING SEGMENTS WITH RATIO OF OUTER TO INNER RADIUS = 1.50

RING SEGMENT EXTERNAL CRACK CRACK TO WIDTH RATIO(C/W)=0.10000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			3.01690	0.46132
81.00	23.13881	3.66482	2.99189	0.45644
72.00	11.17926	3.63236	2.96519	0.45131
63.00	7.05828	3.59637	2.93581	0.44563
54.00	4.89175	3.55406	2.90128	0.43896
45.00	3.50076	3.50076	2.85776	0.43054
36.00	2.49014	3.42738	2.79787	0.41896
27.00	1.68811	3.31310	2.70457	0.40092

RING SEGMENT EXTERNAL CRACK CRACK TO WIDTH RATIO(C/W)=0.20000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			4.45059	1.08192
81.00	33.41852	5.29297	4.41081	1.07439
72.00	16.13560	5.24278	4.36899	1.06646
63.00	10.18036	5.18716	4.32262	1.05768
54.00	7.04948	5.12175	4.26812	1.04736
45.00	5.03934	5.03934	4.19944	1.03435
36.00	3.57888	4.92591	4.10492	1.01644
27.00	2.41985	4.74923	3.95769	0.98855

RING SEGMENT EXTERNAL CRACK CRACK TO WIDTH RATIO(C/W)=0.30000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			5.93413	2.02575
81.00	43.60915	6.90700	5.87830	2.01147
72.00	21.04529	6.83802	5.81960	1.99644
63.00	13.27033	6.76157	5.79452	1.97979
54.00	9.18278	6.67168	5.67823	1.96022
45.00	6.55842	6.55842	5.58164	1.93556
36.00	4.65171	6.40253	5.44897	1.90160
27.00	3.13854	6.15973	5.24232	1.84873

RING SEGMENT EXTERNAL CRACK CRACK TO WIDTH RATIO(C/W)=0.40000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			7.83115	3.47914
81.00	56.34752	8.92456	7.76049	3.45029
72.00	27.20398	8.83911	7.68618	3.41995
63.00	17.18185	8.74440	7.60382	3.38632
54.00	11.88239	8.63306	7.50701	3.34679
45.00	8.49276	8.49276	7.38501	3.29697
36.00	6.03005	8.29966	7.21709	3.22841
27.00	4.07564	7.99889	6.95556	3.12162

RING SEGMENT EXTERNAL CRACK CRACK TO WIDTH RATIO(C/W)=0.50000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			10.57264	5.97580
81.00	74.48868	11.79782	10.48696	5.92360
72.00	35.99805	11.69647	10.39686	5.86873
63.00	22.73508	11.58412	10.29700	5.80790
54.00	15.76239	11.45204	10.17959	5.73639
45.00	11.28562	11.28562	10.03166	5.64628
36.00	8.03305	11.05655	9.82804	5.52227
27.00	5.45180	10.69977	9.51090	5.32910

RING SEGMENT EXTERNAL CRACK CRACK TO WIDTH RATIO(C/W)=0.60000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			15.02785	10.76825
81.00	103.67545	16.42052	14.92777	10.67371
72.00	50.18102	16.30478	14.82254	10.57430
63.00	31.74811	16.17644	14.70589	10.46410
54.00	22.05736	16.02562	14.56877	10.33456
45.00	15.83556	15.83556	14.39598	10.17132
36.00	11.31514	15.57395	14.15813	9.99665
27.00	7.72770	15.16647	13.78770	9.59671

RING SEGMENT EXTERNAL CRACK CRACK TO WIDTH RATIO(C/W)=0.70000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			23.28165	21.71143
81.00	157.13904	24.88831	23.15192	21.55649
72.00	76.14708	24.76164	23.01546	21.39359
63.00	48.23920	24.57909	22.88426	21.23297
54.00	33.56717	24.38799	22.68651	21.00069
45.00	24.14719	24.14719	22.46251	20.73314
36.00	17.30315	23.81572	22.15417	20.36496
27.00	11.87171	23.29950	21.67397	19.79146

RING SEGMENT EXTERNAL CRACK CRACK TO WIDTH RATIO(C/W)=0.80000 OUTER TO INNER RADIUS RATIO(RO/RI)=1.50000				
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVM/6M
	KB-W/P	KB-W/PTAN θ_1		
90.00			41.73752	53.31734
81.00	275.45264	43.62735	41.54987	53.00175
72.00	133.63170	43.42014	41.35254	52.66997
63.00	84.76616	43.19048	41.13379	52.30214
54.00	59.07497	42.92049	40.87665	51.86980
45.00	42.58028	42.58025	40.55266	51.32500
36.00	30.59615	42.11200	40.10666	50.57503
27.00	21.08549	41.38266	39.41205	49.40706

TABLE 9 STRESS INTENSITY AND DISPLACEMENTS COEFFICIENTS FOR EXTERNALLY CRACKED RING SEGMENTS WITH RATIO OF OUTER TO INNER RADIUS = 2.00

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.10000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000

θ_1	AVERAGE VALUES		KB-W*1.5/M	EBW/6M
	KB-W/P	KB-W/PTANG θ_1		
90.00			2.70978	0.41853
81.00	12.24214	1.93896	2.67443	0.41362
72.00	5.88457	1.91201	2.63725	0.40865
63.00	3.69390	1.88213	2.59605	0.40272
54.00	2.54220	1.84701	2.54761	0.39599
45.00	1.80276	1.80276	2.48657	0.38750
36.00	1.26553	1.74186	2.40256	0.37582
31.50	1.04208	1.70051	2.34554	0.36789

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.20000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000

θ_1	AVERAGE VALUES		KB-W*1.5/M	EBW/6M
	KB-W/P	KB-W/PTANG θ_1		
90.00			4.05786	1.02187
81.00	17.66382	2.79767	3.99667	1.00769
72.00	8.47175	2.75264	3.93234	0.99279
63.00	5.30438	2.70271	3.86102	0.97626
54.00	3.63919	2.64402	3.77718	0.95683
45.00	2.70708	2.57026	3.67154	0.93235
36.00	1.79332	2.46829	3.52613	0.89665
31.50	1.47024	2.39929	3.42744	0.87578

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.30000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000

θ_1	AVERAGE VALUES		KB-W*1.5/M	EBW/6M
	KB-W/P	KB-W/PTANG θ_1		
90.00			5.50141	1.90659
81.00	23.06711	3.65347	5.41255	1.87819
72.00	11.05014	3.55940	5.31912	1.84833
63.00	6.90937	3.52049	5.21555	1.81523
54.00	4.73244	3.43832	5.09381	1.77632
45.00	3.33476	3.33476	4.94039	1.72729
36.00	2.31929	3.19223	4.72923	1.65981
31.50	1.89691	3.08544	4.58590	1.61400

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.40000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000

θ_1	AVERAGE VALUES		KB-W*1.5/M	EBW/6M
	KB-W/P	KB-W/PTANG θ_1		
90.00			7.36677	3.30554
81.00	29.74901	4.71177	7.24889	3.25656
72.00	14.25342	4.63121	7.12494	3.20507
63.00	8.91399	4.54190	6.98755	3.14800
54.00	6.10689	4.43692	6.82603	3.08090
45.00	4.30463	4.30463	6.62250	2.99635
36.00	2.99520	4.12254	6.38238	2.87998
31.50	2.45056	3.99895	6.15224	2.80100

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.50000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000

θ_1	AVERAGE VALUES		KB-W*1.5/M	EBW/6M
	KB-W/P	KB-W/PTANG θ_1		
90.00			10.05509	5.74891
81.00	39.09540	6.19209	9.90736	5.65547
72.00	18.75853	6.09502	9.75203	5.55721
63.00	11.75095	5.98740	9.57985	5.44829
54.00	8.06684	5.86090	9.37744	5.32026
45.00	5.70149	5.70149	9.12239	5.15993
36.00	3.98297	5.48209	8.77135	4.93687
31.50	3.26817	5.33317	8.53307	4.78615

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.60000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000

θ_1	AVERAGE VALUES		KB-W*1.5/M	EBW/6M
	KB-W/P	KB-W/PTANG θ_1		
90.00			14.40894	10.49678
81.00	53.90140	8.53713	14.22856	10.35985
72.00	25.92435	8.42334	14.03890	10.21586
63.00	16.28415	8.29719	13.82866	10.05626
54.00	11.21600	8.14890	13.58151	9.86863
45.00	7.96205	7.96205	13.27008	9.63221
36.00	5.59791	7.70486	12.86144	9.30680
31.50	4.61457	7.53030	12.55049	9.08594

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.70000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000

θ_1	AVERAGE VALUES		KB-W*1.5/M	EBW/6M
	KB-W/P	KB-W/PTANG θ_1		
90.00			22.59163	21.23659
81.00	81.17862	12.85741	22.36069	20.96230
72.00	39.14133	12.71779	22.11789	20.67386
63.00	24.65630	12.56302	21.84971	20.35413
54.00	17.04108	12.38109	21.53232	19.97826
45.00	12.15184	12.15184	21.13361	19.50467
36.00	8.59957	11.83629	20.58481	18.85280
31.50	7.12204	11.62212	20.21236	18.41034

RING SEGMENT EXTERNAL CRACK
CRACK TO WIDTH RATIO(A/W)=0.80000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.00000

θ_1	AVERAGE VALUES		KB-W*1.5/M	EBW/6M
	KB-W/P	KB-W/PTANG θ_1		
90.00			41.42943	52.68433
81.00	142.67728	22.59778	41.08693	52.10941
72.00	68.93938	22.39972	40.72681	51.50490
63.00	43.53107	22.18015	40.32758	50.83481
54.00	30.17313	21.92206	39.85831	50.04706
45.00	21.59685	21.59685	39.26700	49.05449
36.00	15.36581	21.14919	38.45308	47.68828
31.50	12.77407	20.84537	37.90067	46.76099

TABLE 10 STRESS INTENSITY AND DISPLACEMENTS COEFFICIENTS FOR EXTERNALLY CRACKED RING SEGMENTS WITH RATIO OF OUTER TO INNER RADIUS = 2.50

RING SEGMENT EXTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.10000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000					
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVW/6M	
	KB-W/P	KB-W/PTAN θ_1			
90.00			2.48465	0.38703	
81.00	8.61043	1.36375	2.44182	0.38129	
72.00	4.11979	1.13860	2.39678	0.37526	
63.00	2.57242	1.10172	2.34685	0.36857	
54.00	1.75893	1.27794	2.28816	0.36071	
45.00	1.23663	1.23663	2.21920	0.35003	
36.00	0.85716	1.17978	2.11241	0.33717	

RING SEGMENT EXTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.20000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000					
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVW/6M	
	KB-W/P	KB-W/PTAN θ_1			
90.00			3.77303	0.96481	
81.00	12.45324	1.97239	3.69708	0.94750	
72.00	5.93929	1.92979	3.61723	0.92931	
63.00	3.69475	1.88256	3.52871	0.90913	
54.00	2.51472	1.82705	3.42465	0.88541	
45.00	1.75710	1.75710	3.29353	0.85553	
36.00	1.20665	1.66081	3.11305	0.81440	

RING SEGMENT EXTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.30000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000					
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVW/6M	
	KB-W/P	KB-W/PTAN θ_1			
90.00			5.19167	1.81565	
81.00	16.30704	2.58278	5.07921	1.78107	
72.00	7.76394	2.52265	4.96097	1.74472	
63.00	4.82018	2.45600	4.82990	1.70442	
54.00	3.27256	2.37765	4.67582	1.65704	
45.00	2.27893	2.27893	4.48167	1.59735	
36.00	1.55701	2.14304	4.21443	1.51518	

RING SEGMENT EXTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.40000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000					
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVW/6M	
	KB-W/P	KB-W/PTAN θ_1			
90.00			7.03633	3.19583	
81.00	21.01578	3.32857	6.88432	3.13106	
72.00	10.00643	3.25128	6.72647	3.06295	
63.00	6.21287	3.16561	6.56729	2.98745	
54.00	4.21847	3.06490	6.33899	2.89869	
45.00	2.93800	2.93800	6.07652	2.78685	
36.00	2.00768	2.76333	5.71527	2.63292	

RING SEGMENT EXTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.50000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000					
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVW/6M	
	KB-W/P	KB-W/PTAN θ_1			
90.00			9.68712	5.62766	
81.00	27.47765	4.35203	9.49188	5.51062	
72.00	13.10449	4.25790	9.28660	5.38755	
63.00	8.15183	4.15356	9.05902	5.25113	
54.00	5.56806	4.03090	8.79151	5.09077	
45.00	3.87635	3.87635	8.45442	4.88869	
36.00	2.66178	3.66362	7.99045	4.61055	

RING SEGMENT EXTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.60000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000					
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVW/6M	
	KB-W/P	KB-W/PTAN θ_1			
90.00			13.95096	10.36590	
81.00	37.51105	5.94116	13.70510	11.04417	
72.00	17.94011	5.82910	13.44660	9.93203	
63.00	11.19646	5.70488	13.16004	9.69689	
54.00	7.65110	5.55884	12.82118	9.42047	
45.00	5.37484	5.37484	12.39870	9.07215	
36.00	3.72104	5.12156	11.81446	8.59273	

RING SEGMENT EXTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.70000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000					
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVW/6M	
	KB-W/P	KB-W/PTAN θ_1			
90.00			21.95084	21.01714	
81.00	55.78148	8.83490	21.62766	20.64525	
72.00	26.76378	8.69608	21.28783	20.25423	
63.00	16.76500	8.54220	20.91112	19.82074	
54.00	11.50836	8.36131	20.46831	19.31119	
45.00	8.13337	8.13337	19.91031	18.66910	
36.00	5.68130	7.81964	19.14229	17.78534	

RING SEGMENT EXTERNAL CRACK CRACK TO WIDTH RATIO(A/W)=0.80000 OUTER TO INNER RADIUS RATIO(RO/RI)=2.50000					
θ_1	AVERAGE VALUES		KB-W*1.5/M	EBVW/6M	
	KB-W/P	KB-W/PTAN θ_1			
90.00			41.35901	52.51659	
81.00	99.00940	15.68151	40.89049	51.71660	
72.00	47.68129	15.49259	40.39786	50.87549	
63.00	29.99486	15.28316	39.85175	49.94304	
54.00	20.69658	15.03697	39.20978	48.84691	
45.00	14.72674	14.72674	38.40088	47.46576	
36.00	10.38938	14.29975	37.28745	45.56473	

TABLE 11. - Values of the dimensionless stress intensity coefficient for radially cracked ring segments in three-point bending with $R_1 = 45^\circ$.

a/W	Internal Crack		Straight ^a Bar	External Crack	
			R_o/R_i		
	2.5	1.1	1.0	1.1	2.5
Dimensionless Curvature					
	$(R_o - R_i)/R_i$			$(R_o - R_i)/(-R_o)$	
	1.5	0.1	0	-0.091	-0.6
$KB(W - a)^{3/2}/M(a/W)^{1/2}$					
0.0			11.932		
0.1	11.241	10.025	9.147	9.097	5.978
0.2	8.663	8.134	7.519	7.710	5.270
0.3	7.216	7.059	6.506	6.767	4.792
0.4	6.270	6.254	5.825	6.054	4.465
0.5	5.614	5.639	5.325	5.495	4.227
0.6	5.130	5.111	4.927	5.112	4.049
0.7	4.762	4.749	4.596	4.698	3.910
0.8	4.459	4.390	4.321	4.330	3.840
0.9			4.110		
1.0			3.980		

^aReference 3

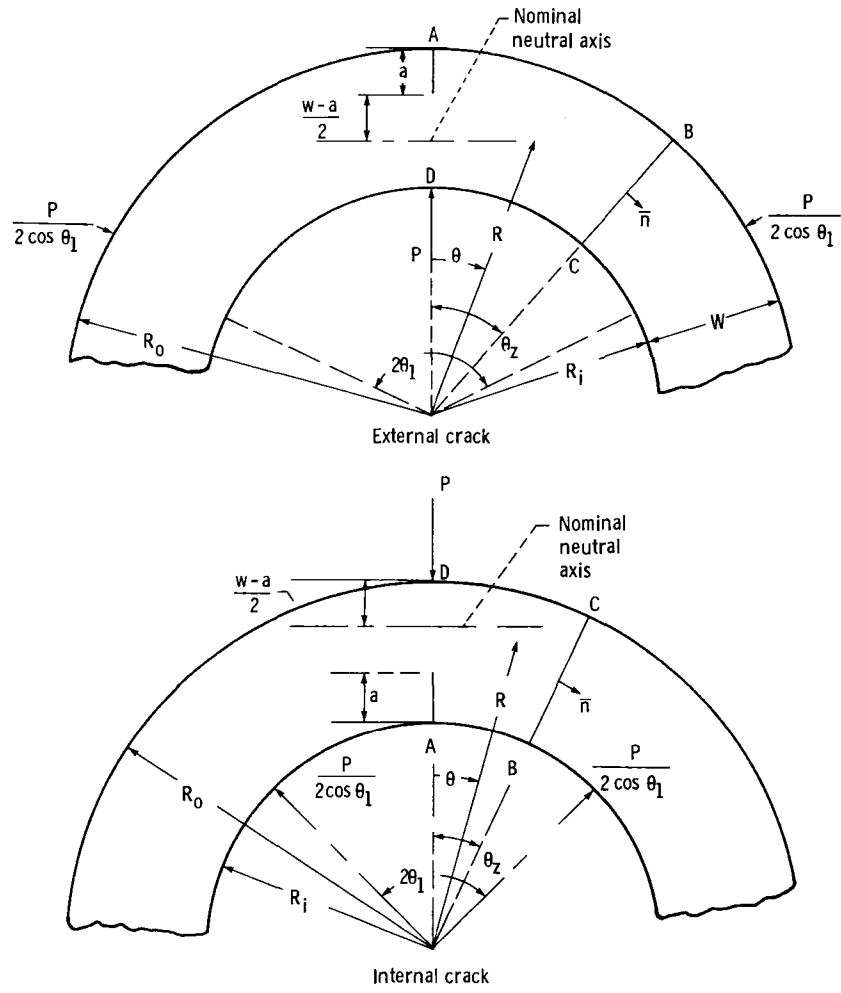


Figure 1. - Ring segment (ARC-BEND) specimen subjected to three point radial loading.

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16. Abstract The boundary collocation method was used to generate Mode I stress intensity and crack mouth displacement coefficients for internally and externally radially cracked ring segments (arc bend specimens) subjected to three point radial loading. Numerical results were obtained for ring segment outer-to-inner radius ratios (R_o/R_i) ranging from 1.10 to 2.50 and crack length-to-width ratios (a/W) ranging from 0.1 to 0.8. Stress intensity and crack mouth displacement coefficients were found to depend on the ratios R_o/R_i and a/W as well as the included angle between the directions of the reaction forces.			
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