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AN EVALUATION OF THE FATIGUE CRACK GROWTH AND FRACTURE TOUGHNESS PROPERTIES OF BERYLLIUM-COPPER ALLOY CDA172

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ABSTRACT

A series of fracture mechanics tests, using the Be-Cu alloy CDA172 in the round rod product form, was conducted in a laboratory air environment at room temperature. This report includes tensile data in both the L and C directions and K_{Ic} data in both the C-R and C-L orientations. Fracture toughness values were also derived from M(T) (center-cracked), PS(T) (surface-cracked) and CC01 (corner-cracked) specimens of varying thickness. Fatigue crack growth data were obtained for the C-R orientation at stress ratios of 0.1, 0.4, and 0.7 and for the C-L orientation at stress ratios of 0.1, 0.3, 0.4, and 0.7.

INTRODUCTION

The use of beryllium-copper alloys in aerospace applications has generally centered around the manufacture of parts such as gears, springs, bearings, and sleeves that require a high strength, corrosion resistant, or electrically conductive material. In addition, it is used for pins, bushings, and high strength structural parts which require the prevention of surface galling. Be-Cu alloys are governed by federal specification QQ-C-530c [1], and additional data may be found in references [2,3].

The objective of this study was to perform a series of fracture mechanics tests using the CDA172 beryllium-copper alloy. These tests included tensile, fracture toughness, and fatigue crack propagation tests of the round rod product. The data obtained will eventually be curve-fit and compared with life predictions made using the NASA/FLAGRO computer program [4].

EXPERIMENTAL PROCEDURE

Material

The material used for this investigation was beryllium-copper alloy CDA172, solution heat treated and aged for 3 hours at 600-625°F (AT condition). The material was obtained from the Martin Marietta Company in the 6 in. diameter round rod product.

Tensile Tests

Tensile tests were performed in accordance with ASTM test specification E8 [5], using a flat tensile specimen geometry (table 1, figure 1). All tensile tests were conducted in a laboratory air (LA) environment. The four specimens that were tested in the C direction were 4.0 in. long and

were cut from a round bar section, and the four specimens tested in the L direction were 4.5 in. long and machined from a single M(T) specimen.

Fracture Toughness Tests

Table 2 summarizes the fracture toughness tests included in this report, providing information about the number of specimens tested, dimensions, and specimen types. Plane strain fracture toughness (K_{Ic}) tests were conducted in LA conditions in both the C-R and C-L orientations using standard C(T) (compact tension) specimens (figure 2). All K_{Ic} tests were performed according to the procedures of ASTM standard E399 [6].

In addition, fracture toughness tests were conducted in the L-C orientation using M(T) (center-cracked) specimens (figure 3), PS(T) (surface-cracked) specimens (figure 4), and CC01 (corner-cracked) specimens (figure 5). A fatigue precrack was grown in each specimen at a low stress amplitude, and the crack length at which fracture initiated was measured directly from the fracture surface using an optical microscope. The resultant K_c values for the M(T) tests and K_{Ie} values for the part-through tests were calculated using NASA/FLAGRO.

Fatigue Crack Growth Tests

Constant load amplitude fatigue crack growth (FCG) tests were conducted according to the procedures in ASTM standard E647 [7]. C(T) specimens were tested in the C-R orientation at stress ratios of 0.1, 0.4, and 0.7 and in the C-L orientation at stress ratios of 0.1, 0.3, 0.4, and 0.7 (table 1). All FCG tests were performed in LA conditions at a frequency of 1-50 Hz. Since the effects of frequency on crack growth behavior are usually negligible in the absence of thermal and environmental effects, frequency was not necessarily kept constant for each test. Load measurement was accomplished using a 10 kip load cell, and crack length was monitored using an indirect d.c. potential method [8].

EXPERIMENTAL RESULTS

Tensile Results

Table 3 summarizes the results obtained from the tensile tests in the L and C directions. These results indicate good consistency among the tests in each direction and also agreement in the tensile properties of the two directions. The average yield strength was found to be 159 ksi, and the average ultimate strength was determined to be 179 ksi.

Fracture Toughness Results

The results from the plane strain fracture toughness tests are presented in table 4. Eight specimens were tested in the C-L orientation, and five specimens were tested in the C-R orientation. The K_{Ic} values in the two orientations were found to be comparable, and the 13 tests produced an average toughness of 25.5 ksi-$\sqrt{\text{in.}}$

Table 5 shows the fracture toughness results obtained from the 14 M(T) specimens that were tested in the L-C orientation. The average K_c value for each thickness is also indicated. The results for the surface-cracked and corner-cracked fracture toughness tests are summarized in table 6. Since the stress intensity factor varies around the boundary of a part-through crack, K_{Ie} was calculated in both the a and c directions. For the CC01 results, $K_{Ie(a)}$ values were found to be roughly equivalent to the $K_{Ie(c)}$ values. Figure 6 shows a comparison of the K_c versus thickness behavior determined from the M(T) fracture toughness tests with the baseline K_{Ic} data. Considerable scatter in the data exists at a thickness of 0.16 in., and the M(T) results at t = 0.35 are slightly higher than the K_{Ic} results. A curve fit of the data indicated A_k and B_k values of 0.35 and 0.50, respectively,

where these constants are defined by:

$$K_c/K_{Ic} = 1 + B_k e^{-(A_k t/t_0)^2} \quad (1)$$

where

$$t_0 = 2.5(K_{Ic}/\sigma_y)^2 \quad (2)$$

The parameter t_0 is often used to define the minimum thickness for obtaining plane strain behavior, and is explicitly required by ASTM standard E399 for a valid K_{Ic} test. However, figure 6 illustrates the difficulty in using t_0 to define the limit of this behavior for Be-Cu. The M(T) data indicate the plane stress-plane strain transition to be shallow over the entire range of thicknesses tested, while valid, repeatable K_{Ic} values were obtained from C(T) specimens tested at thicknesses greater than 0.1 in.

Figure 7 shows a plot of K_{Ie} versus thickness for the surface-cracked specimens, where K_{Ie} is assumed to be the critical stress intensity in the thickness direction, $K_{Ie(a)}$. Since little variation in this data exists, it was curve fit with a straight line, producing the constants $A_k = 1.0$ and $B_k = 0.0$. Figure 8 compares the K_{Ie} data for the PS(T) specimens with a correction factor for part-through data, $(a/Q)M_e^2$. This is a geometry factor for surface cracks that accounts for the influence of both the a/c and a/t ratios on stress intensity. Here, the elastic shape factor, Q, is a function of a/c, and the elastic magnification factor, M_e, is a function of a/c, a/t, and c/w [9]. Since the original $K_{Ie(a)}$ versus thickness data were found to be consistent over the range of t tested, reducing the data in this manner was not found to improve understanding of toughness in surface-cracked specimens significantly for this material.

Fatigue Crack Growth Results

Raw data from the 23 fatigue crack growth tests may be found in the appendix of this report. Figure 9 is a plot of the fatigue crack growth rate, da/dN, as a function of the stress intensity factor range, ΔK, for the data at the three stress ratios studied in the C-R orientation. Similarly, figure 10 compares the da/dN-ΔK data obtained at the four stress ratios tested in the C-L orientation. In both orientations, the data at R = 0.7 shows significantly faster crack growth rates than the data obtained at the lower stress ratios.

Figures 11 to 13 compare the FCG results from the two orientations at each of the three stress ratios. As expected from the fairly isotropic tensile and fracture toughness results, only a small variation was found to exist between the fatigue crack growth characteristics of the two orientations at the R values studied.

CONCLUSIONS

1. The tensile, fracture toughness, and fatigue crack growth properties of Be-Cu CDA172 round rod product were observed to be isotropic for the conditions tested.

2. The average tensile properties were determined to be σ_y = 159 ksi, σ_u = 179 ksi and the average plane strain fracture toughness value was found to be K_{Ic} = 25.5 ksi-$\sqrt{\text{in.}}$

3. The transition from plane stress to plane strain behavior was observed to be shallow, and t_0 did not provide an adequate parameter to define the thickness limit for plane strain fracture toughness in this material.

4. Crack growth rate (da/dN-ΔK) behavior of Be-Cu CDA172 was found to exhibit a significant stress ratio effect, similar to more ductile, lower strength alloys such as aluminum.

REFERENCES

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[3] Mil-Handbook 5E, June 1987, pp. 7.19-7.20.

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[5] "E8-87 Standard Test Methods of Tension Testing of Metallic Materials", *1988 Annual Book of ASTM Standards,* Vol. 3.01, American Society for Testing and Materials, 1988, pp. 121-136.

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[9] Newman, J.C., Jr., "Fracture Analysis of Surface- and Through-Cracked Sheets and Plates", *Engineering Fracture Mechanics,* Vol. 5, 1973, pp. 667-689.

SYMBOLS

a	length or half length (through crack) or depth (part-through crack)
AT	cold worked, solution heat treated, and precipitation hardened
Be-Cu	beryllium-copper alloy
c	half length of surface crack or length of corner crack
CC01	corner-cracked specimen [4]
C-L	specimen orientation [6]
C-R	specimen orientation [6]
C(T)	compact tension specimen [6]
da/dN	fatigue crack growth rate
d.c.	direct current
E	elastic modulus
FCG	fatigue crack growth
K	stress intensity factor
K_c	critical stress intensity factor

K_{Ic} . . . . plane strain fracture toughness
K_{Ie} . . . . elastic fracture toughness for a part-through crack
$K_{Ie(a)}$ . . . critical stress intensity factor based on a
$K_{Ie(c)}$ . . . critical stress intensity factor based on c
K_{max} . . . maximum stress intensity factor in a load cycle
K_{min} . . . minimum stress intensity factor in a load cycle
ΔK . . . . stress intensity factor range ($K_{max} - K_{min}$)
LA . . . . laboratory air conditions
L-C . . . . specimen orientation [6]
L-R . . . . specimen orientation [6]
M(T) . . . center-cracked specimen [6]
M_e . . . . combination of elastic magnification factors on stress intensity
N . . . . . number of applied fatigue cycles
n/a . . . . not applicable
PS(T) . . . part-through, surface-cracked specimen [6]
P_Q . . . . critical load for a K_{Ic} test
Q . . . . . elastic shape factor for a surface crack
R . . . . . stress ratio (K_{min} / K_{max})
R-C . . . . specimen orientation [6]
R-L . . . . specimen orientation [6]
σ_n . . . . net section stress
σ_u . . . . ultimate tensile strength
σ_y . . . . 2% offset tensile yield strength
t . . . . . specimen thickness
t_0 . . . . . thickness parameter for plane strain behavior ($2.5(K_{Ic}/\sigma_y)^2$) [6]
w . . . . . specimen width

Table 1.- Summary of Tensile and Fatigue Crack Growth Tests

Test Type	Orient.	R	t (in.)	No. of Tests
tensile	L	n/a	0.10	4
tensile	C	n/a	0.10	4
FCG	C-R	0.1	0.35	8
FCG	C-R	0.4	0.35	2
FCG	C-R	0.7	0.35	2
FCG	C-L	0.1	0.35	6
FCG	C-L	0.3	0.35	1
FCG	C-L	0.4	0.35	1
FCG	C-L	0.7	0.35	3

Table 2.- Summary of Fracture Toughness Tests

Spec. Code	Spec. Type	Result	Orient.	w (in.)	t (in.)	No. of Tests
BC-R	C(T)	K_{Ic}	C-R	2.00	0.35	5
BC-L	C(T)	K_{Ic}	C-L	2.00	0.35	2
BC-L	C(T)	K_{Ic}	C-L	1.60	0.20	3
BC-L	C(T)	K_{Ic}	C-L	1.60	0.10	3
F	M(T)	K_c	L-C	2.00	0.05	3
F	M(T)	K_c	L-C	2.00	0.10	3
F	M(T)	K_c	L-C	2.00	0.16	4
F	M(T)	K_c	L-C	2.00	0.35	4
A	PS(T)	K_{Ie}	L-C	1.58	0.20	2
B	PS(T)	K_{Ie}	L-C	1.46	0.20	2
C	PS(T)	K_{Ie}	L-C	1.36	0.15	2
D	PS(T)	K_{Ie}	L-C	1.23	0.10	1
G	PS(T)	K_{Ie}	L-C	0.60	0.35	3
E	CC01	K_{Ie}	L-C	1.00	0.40	1
H	CC01	K_{Ie}	L-C	0.60	0.35	3

Total fracture tests = 43

Table 3.- Summary of Tensile Properties of Be-Cu Alloy CDA172

Spec. ID	Failure Load (lb.)	σ_u (ksi)	σ_y (ksi)	E (10^6 psi)
L-1	6684	178.4	162.5	19.5
L-2	6624	180.3	156.3	19.4
L-3	6534	178.7	160.0	19.8
L-4	7026	180.4	157.3	19.0
L_{avg}	6717	179.5	159.0	19.4
C-1	6525	181.1	157.6	19.9
C-2	6404	180.8	160.3	20.1
C-3	6806	174.1	157.3	19.3
C-4	6352	181.6	162.1	20.2
C_{avg}	6522	179.4	159.3	19.9

Table 4.- Plane Strain Fracture Toughness Data from C(T) Specimens

Spec. ID	a (in.)	w (in.)	t (in.)	P_Q (lb.)	K_{Ic} (ksi-$\sqrt{in}$)
BC-R9	1.370	2.00	0.353	1075	26.12
BC-R10	1.197	2.00	0.353	920	25.11
BC-R11	1.133	2.00	0.353	1104	26.61
BC-R12	1.092	2.00	0.353	1121	25.16
BC-R13	1.139	2.00	0.353	1031	25.16
BC-L12	1.165	2.00	0.354	1050	26.77
BC-L13	1.226	2.00	0.354	852	24.47
BC-L20	0.813	1.60	0.100	332	26.0
BC-L21	0.811	1.60	0.100	339	26.1
BC-L22	0.813	1.60	0.100	350	26.0
BC-L23	0.813	1.60	0.200	608	23.8
BC-L24	0.828	1.60	0.200	631	25.4
BC-L25	0.818	1.60	0.200	621	24.5

Average K_{Ic} = 25.5 ksi-$\sqrt{in}$

Table 5.- Fracture Toughness Data from M(T) Specimens

Spec. ID	2a (in.)	w (in.)	t (in.)	σ_n / σ_y	K_c (ksi-$\sqrt{in}$)
F-2	0.846	2.00	0.054	0.30	36.0
F-3	0.842	2.00	0.053	0.31	37.2
F-4	0.851	2.00	0.051	0.31	37.2
t_{avg}=.053	0.846	2.00	0.053	0.31	36.8
F-5	0.933	2.00	0.095	0.31	37.5
F-6	0.928	2.00	0.107	0.28	33.3
F-8	0.913	2.00	0.103	0.29	34.1
t_{avg}=.102	0.925	2.00	0.102	0.29	35.0
F-9	0.796	2.00	0.170	0.32	38.5
F-10	0.796	2.00	0.160	0.27	31.5
F-11	0.808	2.00	0.160	0.32	38.4
F-12	0.806	2.00	0.161	0.26	31.3
t_{avg}=.163	0.802	2.00	0.163	0.29	34.9
F-13	0.836	2.00	0.350	0.24	28.7
F-14	0.823	2.00	0.350	0.24	29.0
F-15	0.845	2.00	0.341	0.23	27.5
F-16	0.814	2.00	0.349	0.23	27.0
t_{avg}=.348	0.830	2.00	0.348	0.24	28.1

Table 6.- Fracture Toughness Data from PS(T) and CC01 Specimens

ID	Spec. Type	a (in.)	c (in.)	w (in.)	t (in.)	$K_{Ie(a)}$ (ksi-$\sqrt{in}$)	$K_{Ie(c)}$ (ksi-$\sqrt{in}$)
E-2	CC01	0.190	0.267	1.000	0.395	34.5	31.2
H-1	CC01	0.157	0.165	0.599	0350	27.6	27.7
H-2	CC01	0.214	0.217	0.599	0.344	31.9	32.6
H-3	CC01	0.262	0.365	0.600	0.349	43.5	39.7
G-1	PS(T)	0.066	0.076	0.601	0.349	25.9	26.8
G-2	PS(T)	0.097	0.107	0.599	0.344	26.8	28.7
G-3	PS(T)	0.125	0.144	0.599	0.349	28.9	30.7
A-1	PS(T)	0.107	0.270	1.581	0.191	27.3	20.8
A-2	PS(T)	0.092	0.185	1.578	0.196	29.3	24.4
B-1	PS(T)	0.073	0.108	1.463	0.204	30.8	27.5
B-2	PS(T)	0.076	0.126	1.463	0.203	29.8	26.7
C-1	PS(T)	0.076	0.178	1.356	0.152	27.5	21.5
C-2	PS(T)	0.077	0.187	1.356	0.151	29.0	22.2
D-2	PS(T)	0.061	0.0176	1.232	0.102	26.8	19.3

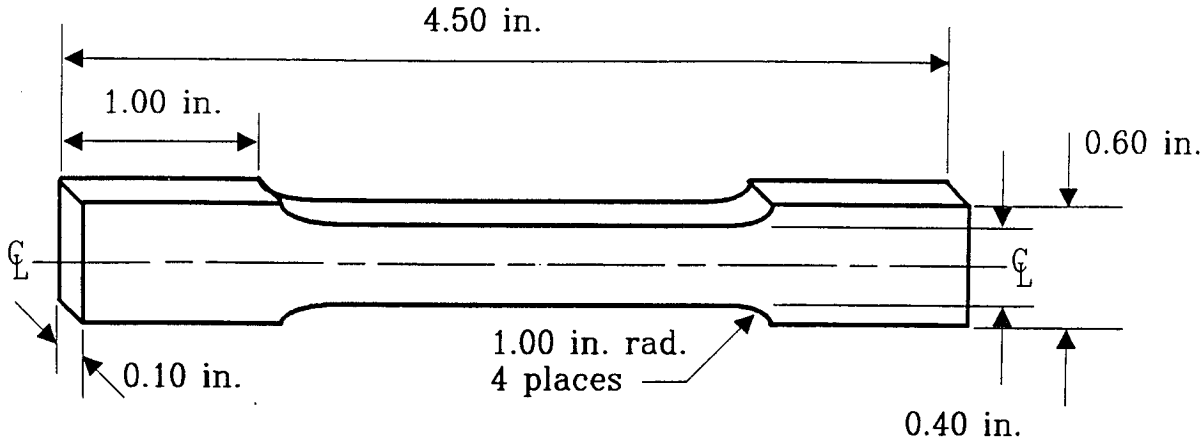

Figure 1.- Full scale schematic diagram showing the geometry and dimensions of the standard tensile test specimen.

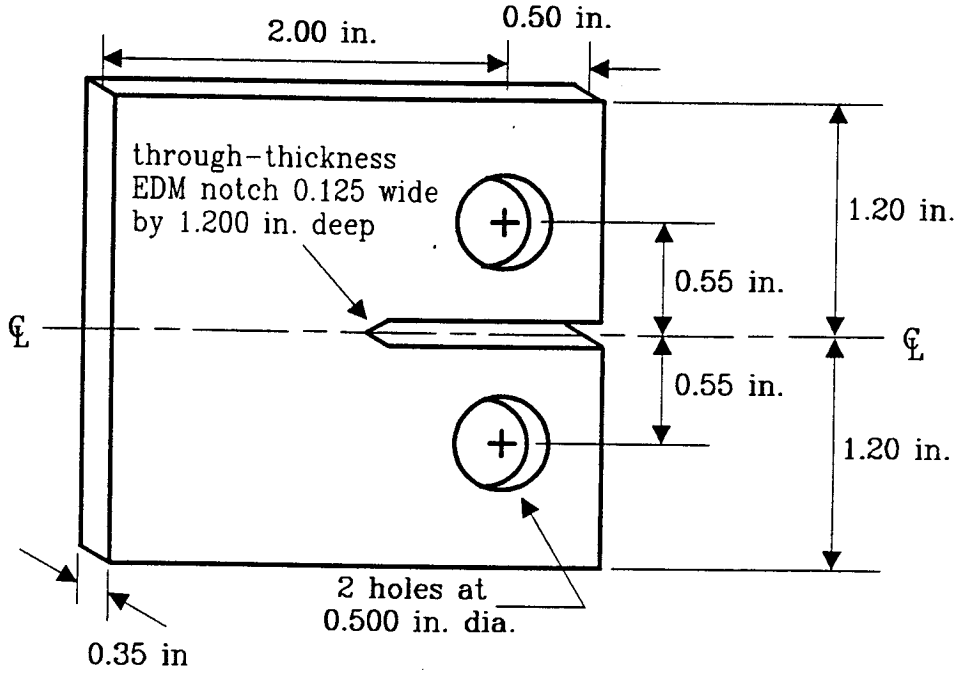

Figure 2.- Full scale schematic diagram showing the geometry and dimensions of the C(T) test specimen.

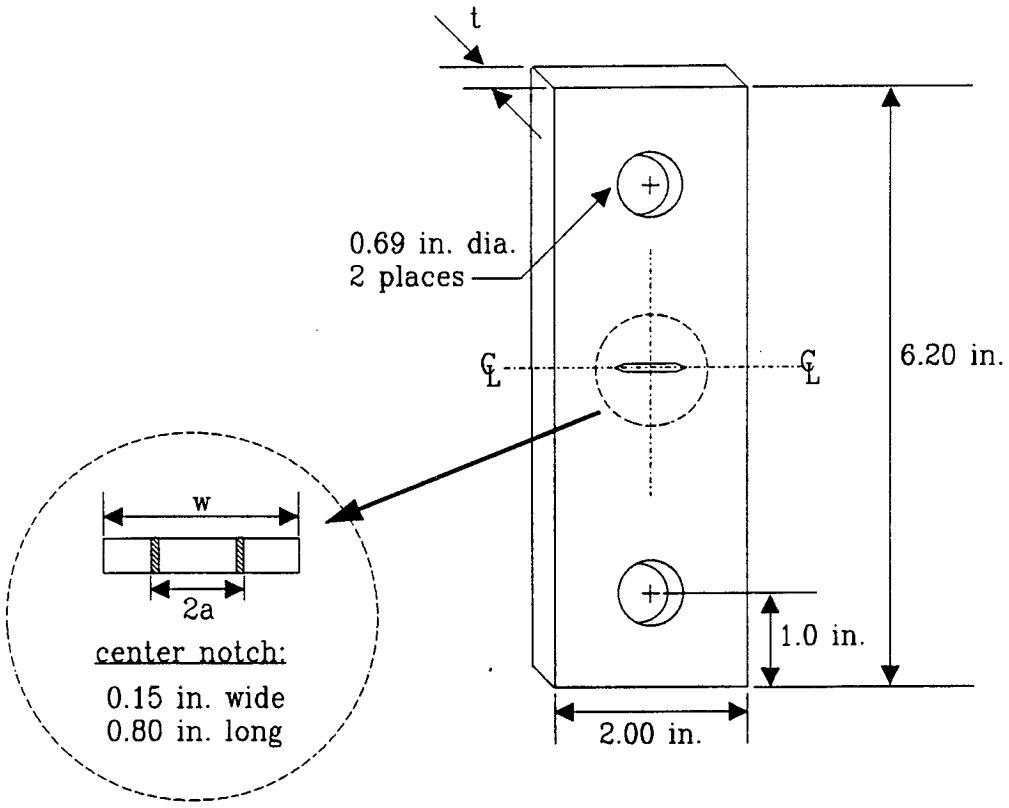

Figure 3.- Half scale schematic diagram of the M(T) specimen geometry, indicating the definition of the half crack length, a. See table 2 for a listing of t values tested.

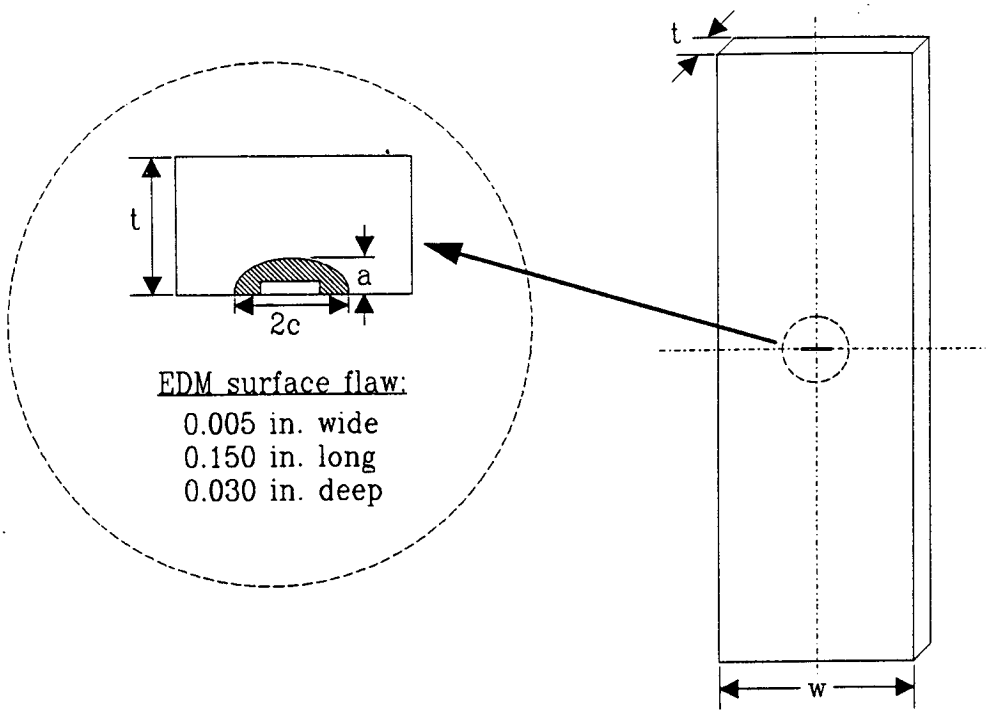

Figure 4.- Schematic diagram of the PS(T) specimen geometry, indicating the dimensions of the EDM notch and definitions of the crack depth, a, and half crack length, c. See table 2 for a listing of w and t values tested.

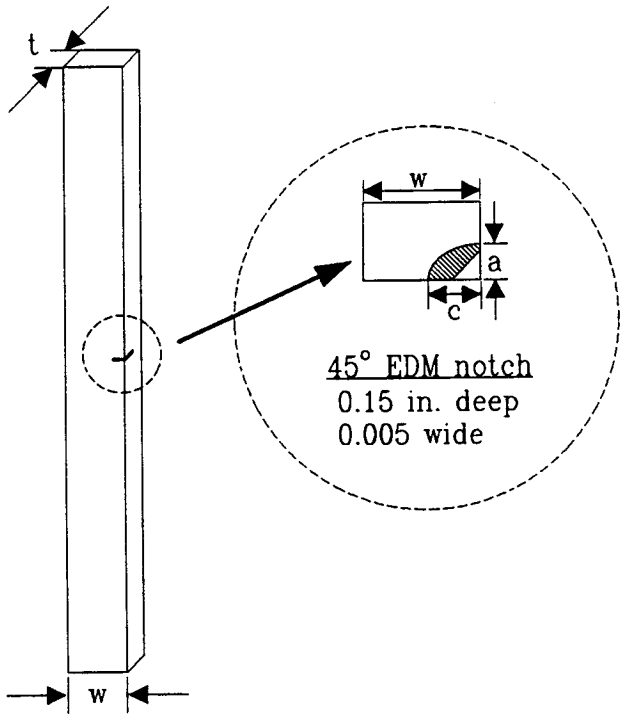

Figure 5.- Schematic diagram of the corner-cracked specimen geometry, indicating the dimensions of the EDM notch and the definitions of the crack lengths, a and c. See table 2 for a listing of w and t values tested.

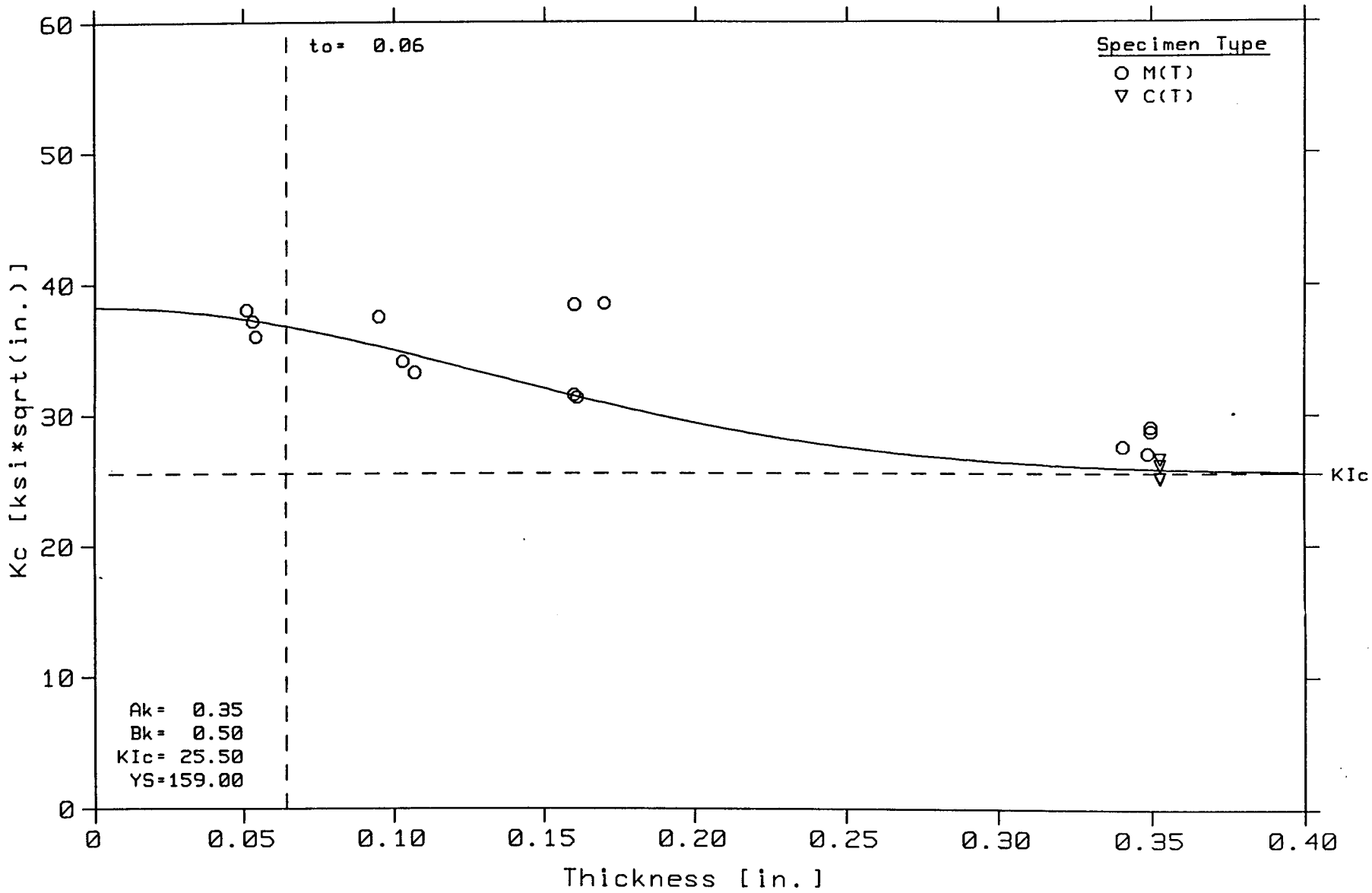

Figure 6.- Comparison of nominal K_{Ic} data with center-cracked K_c vs. thickness behavior.

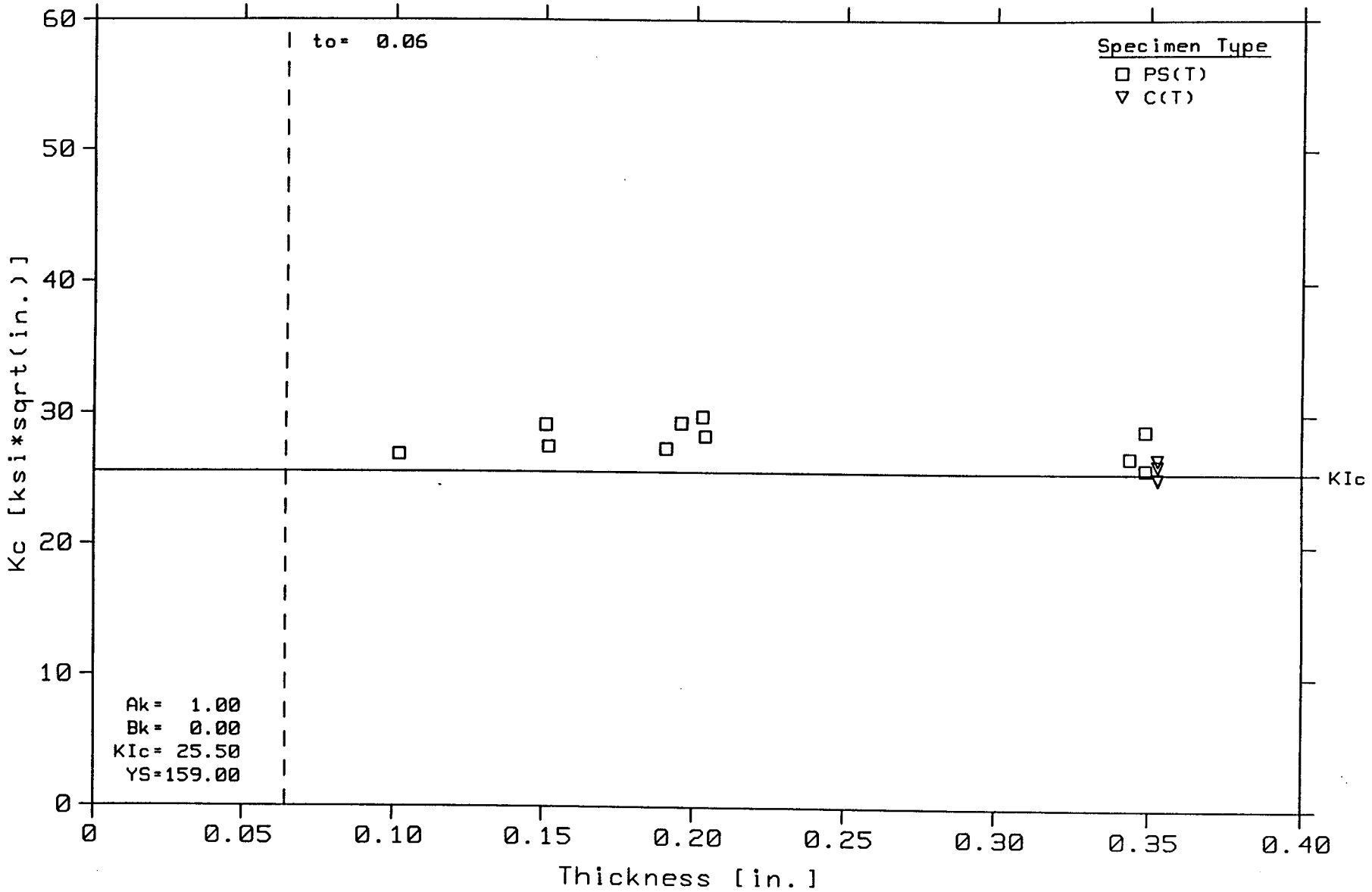

Figure 7.- Comparison of nominal K_{Ic} data with surface-cracked K_{Ie} vs. thickness behavior.

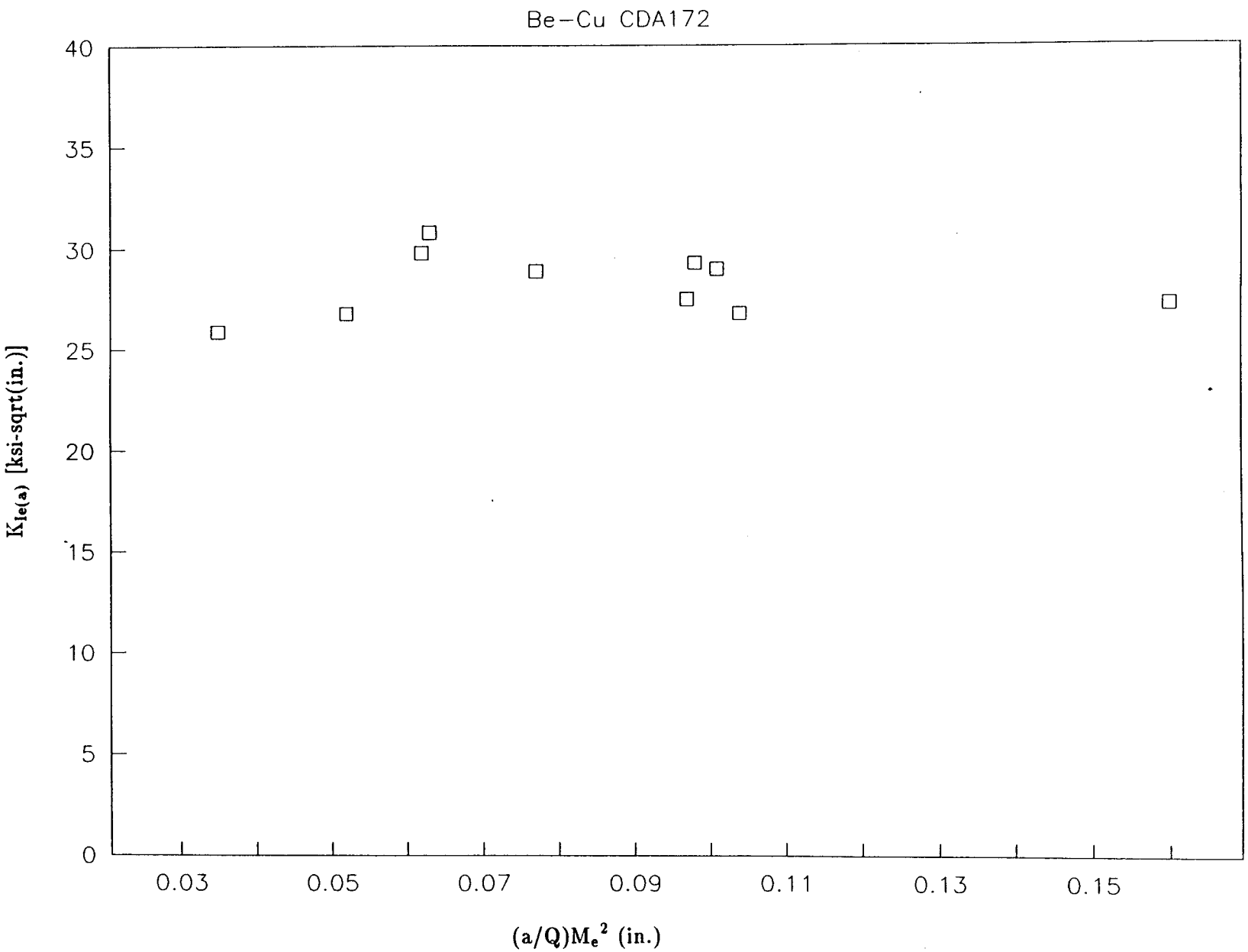

Figure 8.- Comparison of $K_{Ie(a)}$ versus $(a/Q)M_e^2$ for Be-Cu CDA172 PS(T) specimens.

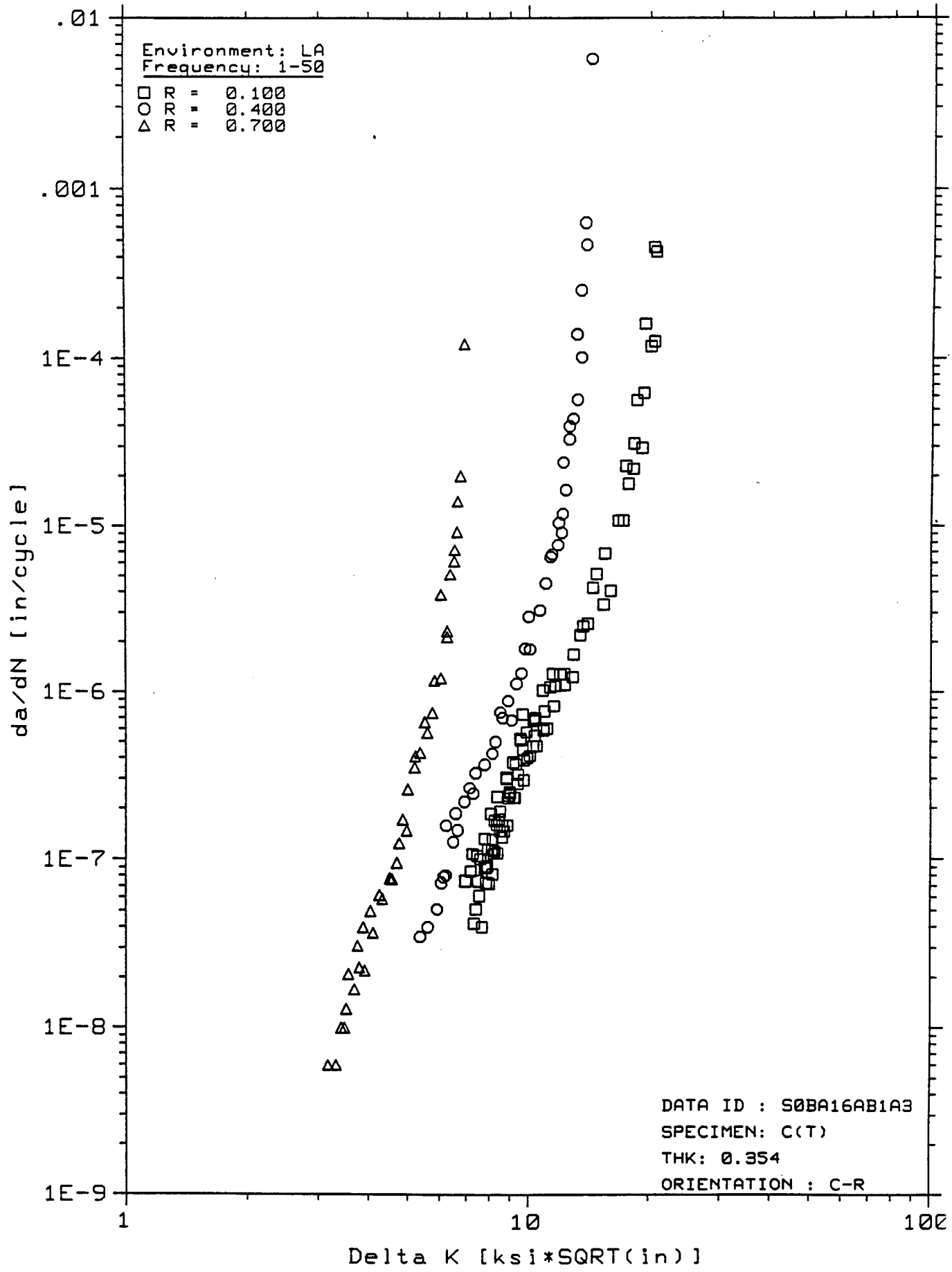

Figure 9.- Comparison of da/dN versus ΔK for Be-Cu CDA172 round rod tested at stress ratios of 0.1, 0.4, and 0.7 in the C-R orientation.

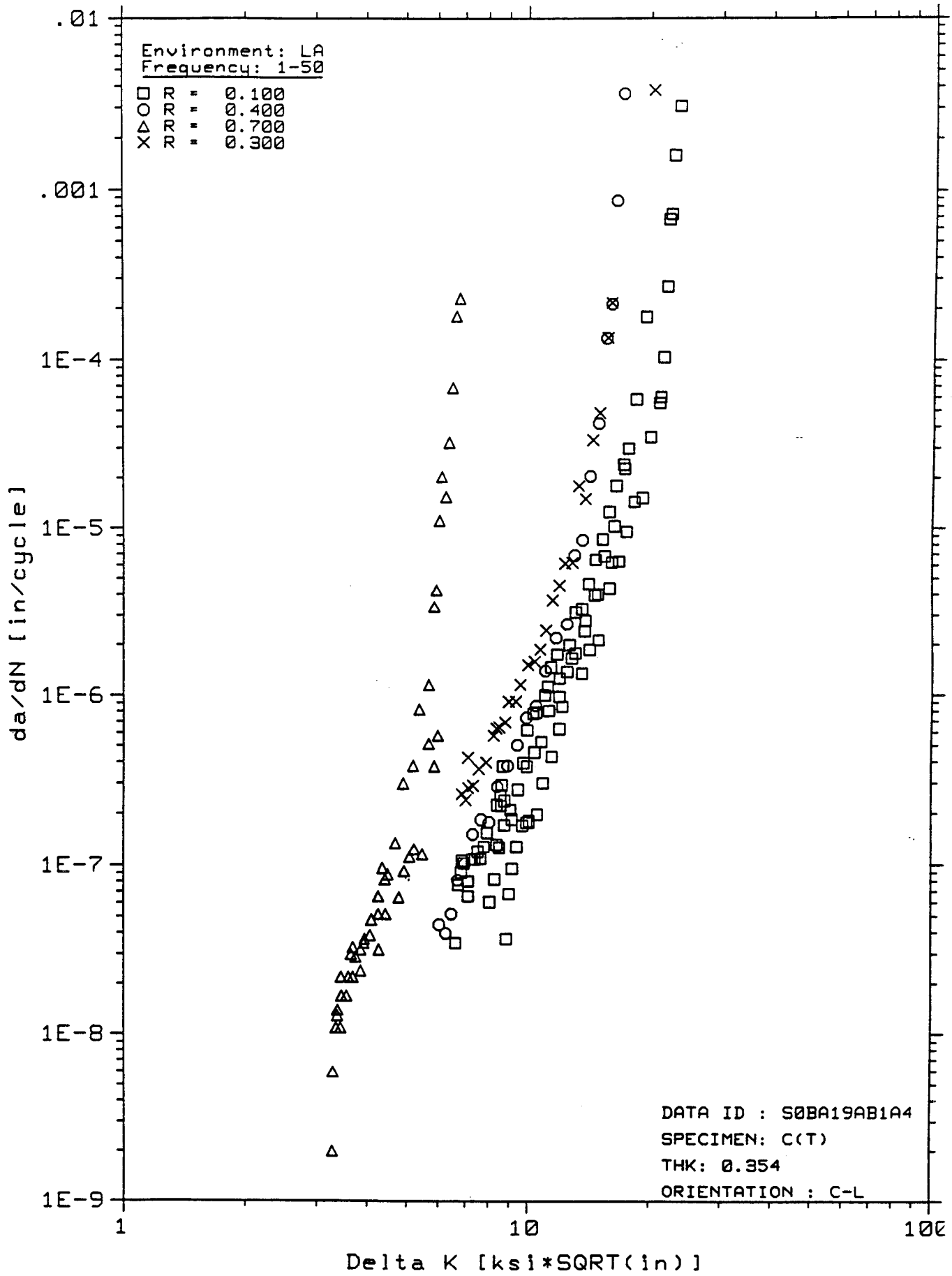

Figure 10.- Comparison of da/dN versus ΔK for Be-Cu CDA172 round rod tested at stress ratios of 0.1, 0.3, 0.4, and 0.7 in the C-L orientation.

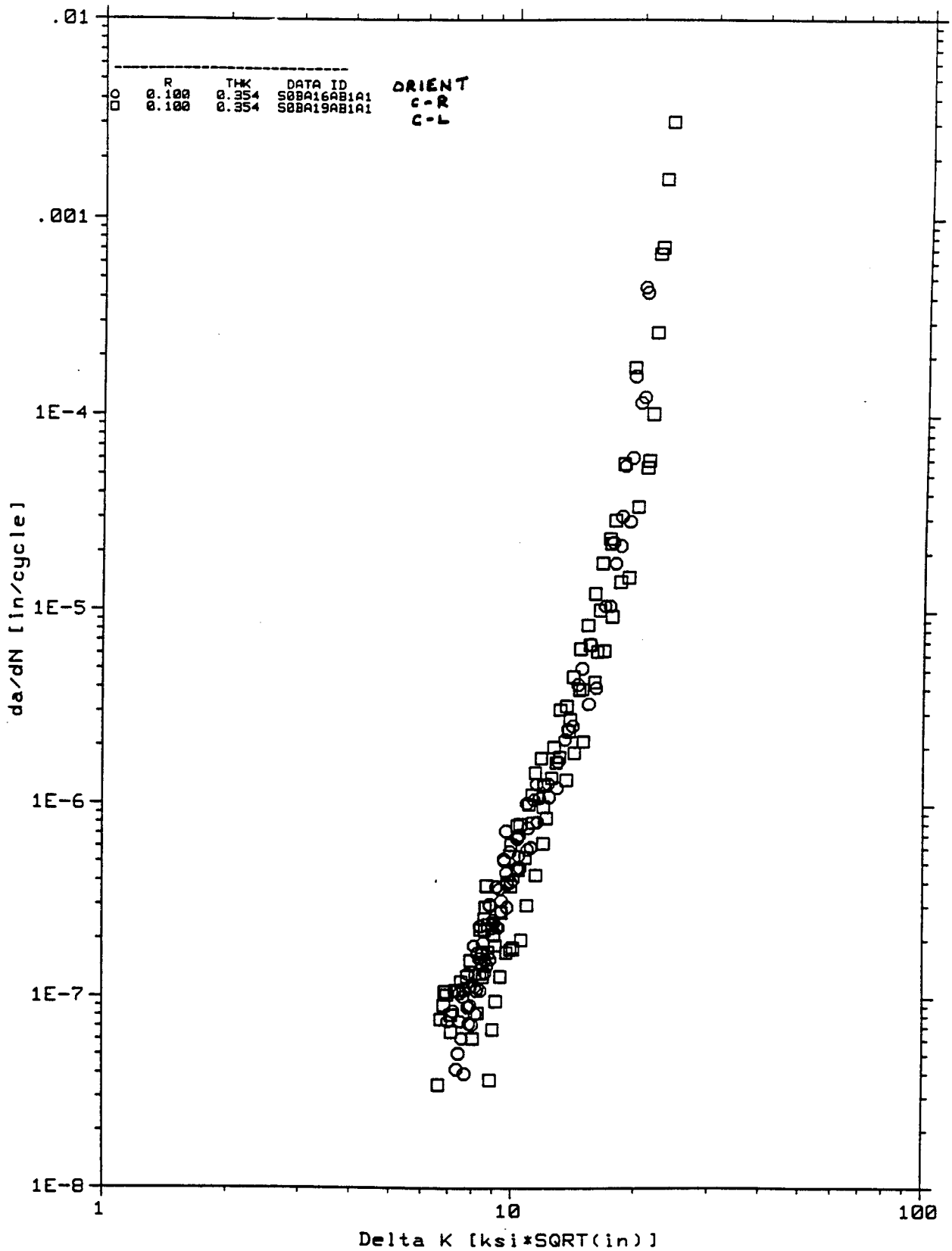

Figure 11.- Comparison of da/dN versus ΔK for Be-Cu CDA172 C(T) specimens tested in the C-L and C-R orientations at R. = 0.1.

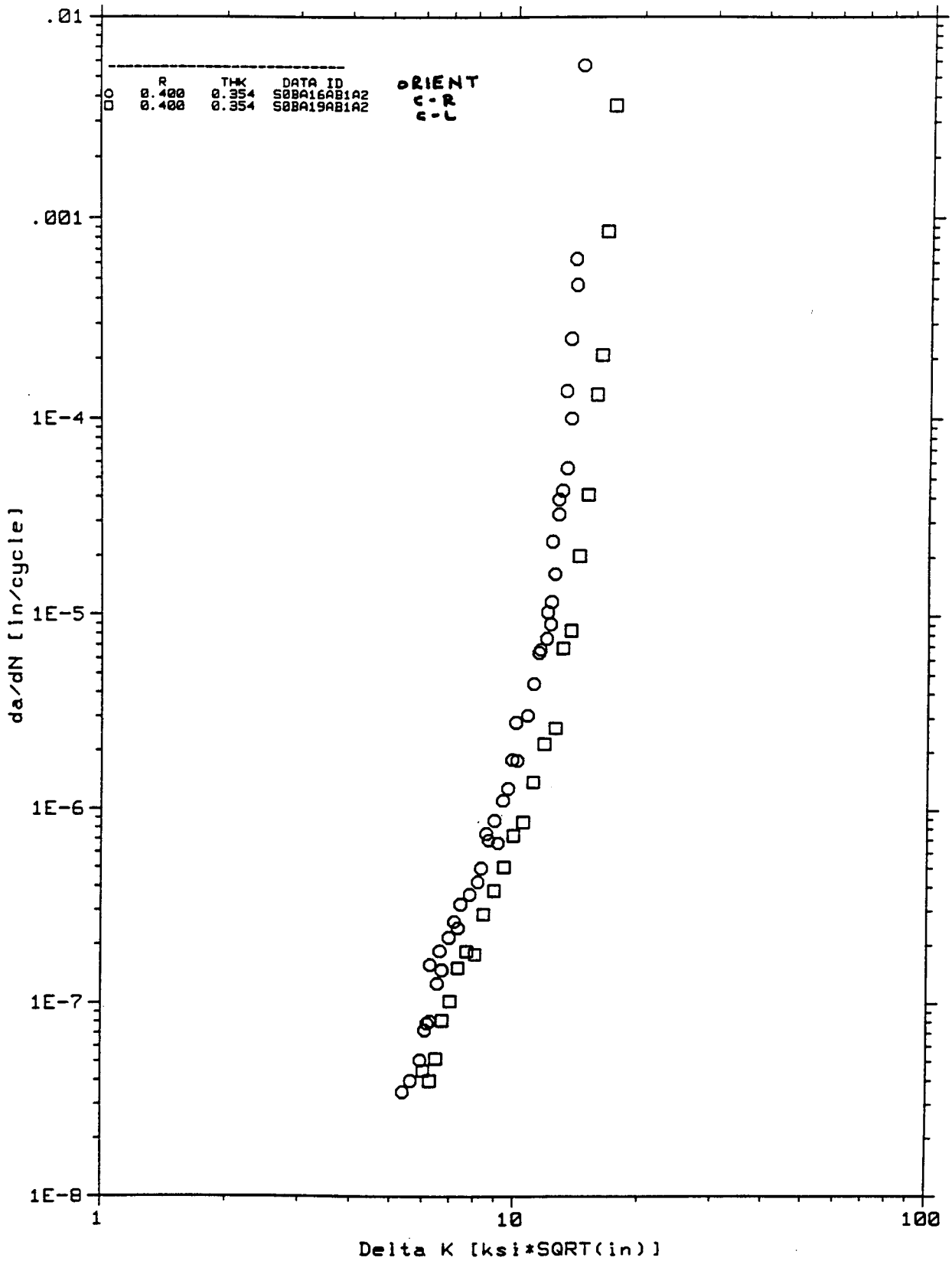

Figure 12.- Comparison of da/dN versus ΔK for Be-Cu CDA172 C(T) specimens tested in the C-L and C-R orientations at R = 0.4.

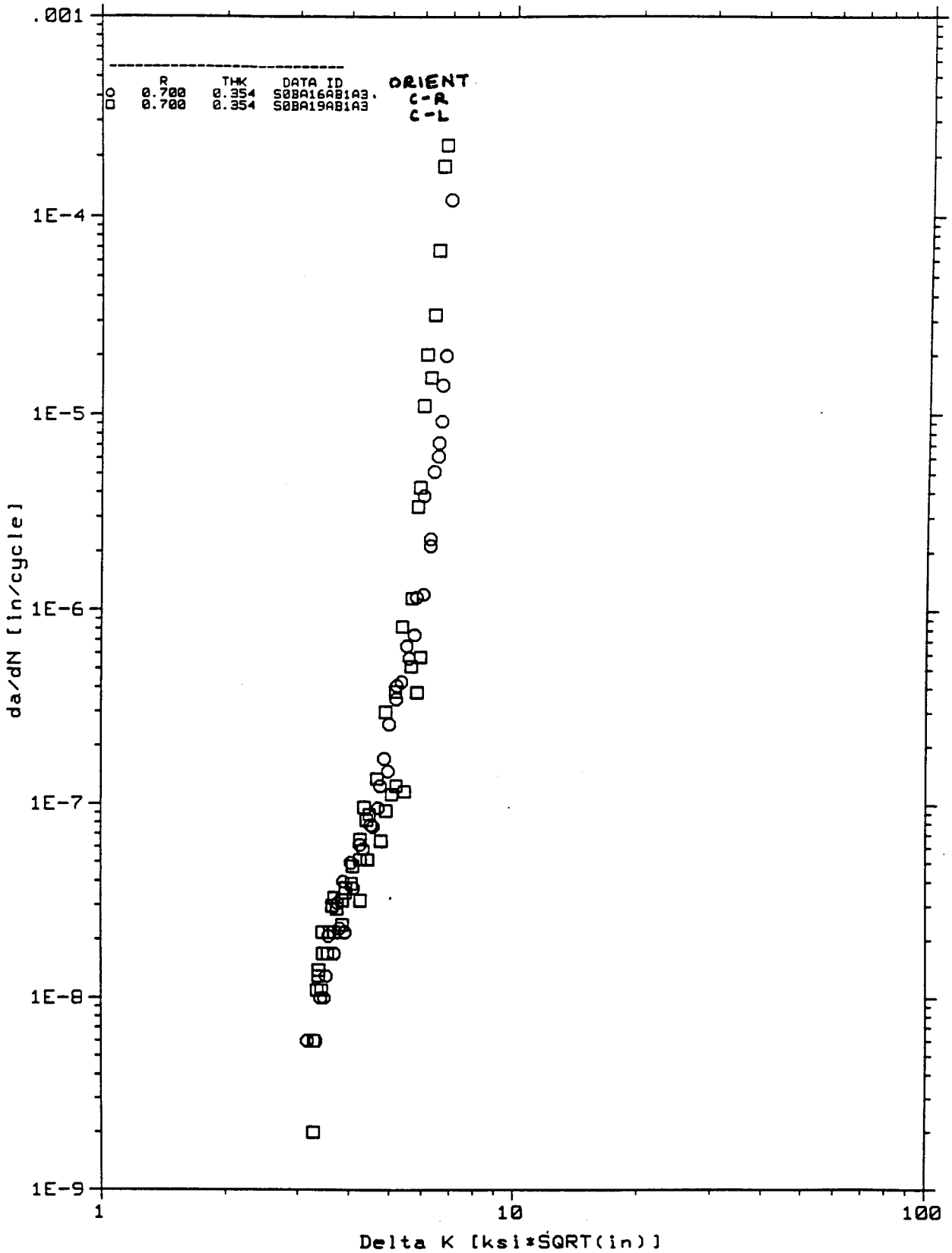

Figure 13.- Comparison of da/dN versus ΔK for Be-Cu CDA172 C(T) specimens tested in the C-L and C-R orientations at R = 0.7.

APPENDIX:

FATIGUE CRACK GROWTH DATA

MATERIAL DESCRIPTION: C17200
SPECIMEN NUMBER: BC-R1 TH: 0.353
SPECIMEN TYPE: 2 W: 2.000
YIELD STRENGTH: 130
TEMPERATURE: 75

REC NO.	AA (IN)	AB (IN)	A(AVG) (IN)	PMIN (LBS)	PMAX (LBS)	R	KILO-CYCLES	FREQENCY (HERTZ)	da/dN (xE6)	DELTA K (KSI SQRT IN)
1	1.0877	1.1014	1.0946	21.19	239.66	0.088	1. 75	1.0		
2	1.1455	1.1440	1.1448	81.44	802.00	0.102	3.906	1.0	17.731	17.76
3	1.1747	1.1648	1.1698	81.37	802.00	0.101	4.353	1.0	55.929	18.60
4	1.2022	1.1873	1.1948	81.31	800.78	0.102	4.510	1.0	159.233	19.48
5	1.2200	1.2200	1.2200	81.00	801.16	0.101	4.566	1.0	449.947	20.47

MATERIAL DESCRIPTION: C17200 BE-CU
SPECIMEN NUMBER: BC-R2 TH: 0.349
SPECIMEN TYPE: 2 W: 2.000
YIELD STRENGTH: 130
TEMPERATURE: 75

REC NO.	AA (IN)	AB (IN)	A(AVG) (IN)	PMIN (LBS)	PMAX (LBS)	R	KILO-CYCLES	FREQENCY (HERTZ)	da/dN (xE6)	DELTA K (KSI SQRT IN)
1	0.8089	0.7833	0.7961	59.91	598.50	0.100	3576.979	50.0		
2	0.8284	0.8138	0.8211	60.19	596.19	0.101	3795.446	50.0	0.114	8.13
3	0.8781	0.8641	0.8711	66.44	591.25	0.112	4135.586	50.0	0.147	8.52
4	0.8995	0.8927	0.8961	62.22	598.47	0.104	4234.752	50.0	0.252	9.01
5	0.9490	0.9432	0.9461	60.97	602.19	0.101	4404.461	5.0	0.295	9.77
6	0.9765	0.9657	0.9711	61.16	601.69	0.102	4464.961	5.0	0.413	10.12
7	1.0283	1.0139	1.0211	60.75	602.06	0.101	4549.945	5.0	0.588	10.95
8	1.0909	1.1015	1.0962	61.19	601.91	0.102	4618.226	5.0	1.100	12.37
9	1.1184	1.1240	1.1212	60.97	602.16	0.101	4638.618	5.0	1.226	12.93
10	1.1452	1.1472	1.1462	61.37	601.66	0.102	4650. 22	5.0	2.192	13.50
11	1.1728	1.1696	1.1712	61.12	599.37	0.102	4659.726	1.0	2.576	14.09
12	1.1988	1.1936	1.1962	61.25	600.78	0.102	4664.612	1.0	5.117	14.82
13	1.2216	1.2208	1.2212	61.59	600.22	0.103	4668.290	1.0	6.797	15.54
14	1.2834	1.2590	1.2712	61.44	600.16	0.102	4672.956	1.0	10.716	17.26
15	1.2980	1.2944	1.2962	61.50	600.41	0.102	4674.103	1.0	21.815	18.25
16	1.3247	1.3177	1.3212	61.16	600.22	0.102	4674.508	1.0	61.578	19.33
17	1.3578	1.3354	1.3466	61.37	600.31	0.102	4674.712	1.0	124.478	20.54

MATERIAL DESCRIPTION: CDA 172-AT BE-CU
SPECIMEN NUMBER: BC-R4 TH: 0.352
SPECIMEN TYPE: 2 W: 2.000
YIELD STRENGTH: 130
TEMPERATURE: 75

REC NO.	AA (IN)	AB (IN)	A(AVG) (IN)	PMIN (LBS)	PMAX (LBS)	R	KILO-CYCLES	FREQENCY (HERTZ)	da/dN (xE6)	DELTA K (KSI SQRT IN)
1	0.7652	0.8033	0.7842	280.47	700.50	0.400	2702.952	50.0		
2	0.7726	0.8159	0.7942	280.97	699.78	0.402	2839.177	50.0	0.073	6.08
3	0.7828	0.8257	0.8043	280.50	699.09	0.401	2965.320	50.0	0.079	6.16
4	0.7930	0.8355	0.8142	281.91	701.16	0.402	3028.275	20.0	0.159	6.25
5	0.8388	0.8696	0.8542	280.94	700.59	0.401	3242.319	20.0	0.187	6.60
6	0.8879	0.9005	0.8942	281.19	699.00	0.402	3423.842	20.0	0.220	6.94
7	0.9092	0.9194	0.9143	281.53	699.72	0.402	3499.478	20.0	0.265	7.15
8	0.9706	0.9785	0.9745	282.28	699.53	0.404	3663.917	20.0	0.366	7.79
9	0.9956	1.0137	1.0046	283.03	700.19	0.404	3734.538	20.0	0.426	8.15
10	1.0230	1.0466	1.0348	283.12	699.25	0.405	3774.507	20.0	0.754	8.53
11	1.0548	1.0749	1.0649	283.87	698.87	0.406	3808.571	20.0	0.884	8.93
12	1.0863	1.1037	1.0950	284.84	698.41	0.408	3835.409	20.0	1.122	9.36
13	1.1206	1.1296	1.1251	286.03	698.03	0.410	3851.912	20.0	1.825	9.83
14	1.1485	1.1619	1.1552	291.44	690.00	0.422	3862.497	2.0	2.845	10.04
15	1.1730	1.1777	1.1753	278.28	701.66	0.397	3866.948	2.0	4.511	11.07
16	1.1895	1.2013	1.1954	278.81	701.50	0.397	3869.928	2.0	6.738	11.49
17	1.2072	1.2237	1.2155	279.59	701.62	0.398	3871.856	2.0	10.414	11.94
18	1.2139	1.2371	1.2255	278.47	701.09	0.397	3872.708	2.0	11.784	12.20
19	1.2277	1.2434	1.2356	276.47	692.00	0.400	3873.128	2.0	23.903	12.24
20	1.2446	1.2466	1.2456	279.94	701.25	0.399	3873.384	2.0	39.216	12.67
21	1.2556	1.2556	1.2556	279.87	700.97	0.399	3873.615	2.0	43.460	12.94
22	1.2631	1.2682	1.2657	279.97	700.59	0.400	3873.688	2.0	137.525	13.20
23	1.2694	1.2820	1.2757	279.00	700.56	0.398	3873.728	2.0	250.983	13.52
24	1.2848	1.2879	1.2863	279.75	700.75	0.399	3873.745	2.0	625.274	13.84

MATERIAL DESCRIPTION: CDA172-AT BE-CU
SPECIMEN NUMBER: BC-R5 TH: 0.353
SPECIMEN TYPE: 2 W: 2.000
YIELD STRENGTH: 130
TEMPERATURE: 75

REC NO.	AA (IN)	AB (IN)	A(AVG) (IN)	PMIN (LBS)	PMAX (LBS)	R	KILO-CYCLES	FREQENCY (HERTZ)	da/dN (xE6)	DELTA K (KSI SQRT IN)
1	0.7551	0.7477	0.7514	525.84	749.00	0.702	3685.949	50.0		
									0.006	3.17
2	0.7855	0.7772	0.7814	526.75	749.69	0.703	8525.864	50.0		
									0.006	3.32
3	0.8180	0.8047	0.8114	526.25	750.44	0.701	13377.991	50.0		
									0.010	3.42
4	0.8472	0.8355	0.8413	527.62	749.41	0.704	16389.519	50.0		
									0.021	3.57
5	0.8789	0.8637	0.8713	527.97	750.50	0.703	17832.608	50.0		
									0.031	3.76
6	0.9102	0.8927	0.9014	525.34	750.22	0.700	18795.270	40.0		
									0.040	3.88
7	0.9395	0.9236	0.9315	528.00	749.94	0.704	19556.113	40.0		
									0.050	4.05
8	0.9682	0.9551	0.9616	526.62	748.34	0.704	20157. 81	40.0		
									0.062	4.26
9	0.9978	0.9858	0.9918	527.97	750.78	0.703	20645.904	40.0		
									0.078	4.53
10	1.0334	1.0304	1.0319	526.97	749.47	0.703	21161.441	40.0		
									0.125	4.78
11	1.0657	1.0586	1.0621	526.12	750.06	0.701	21402.694	35.0		
									0.149	4.99
12	1.0980	1.0866	1.0923	527.37	749.62	0.704	21605.314	10.0		
									0.412	5.24
13	1.1334	1.1114	1.1224	528.69	749.97	0.705	21678.404	10.0		
									0.571	5.61
14	1.1633	1.1417	1.1525	525.28	749.91	0.700	21731.172	10.0		
									1.175	5.84
15	1.1846	1.1606	1.1726	525.16	750.09	0.700	21748.254	10.0		
									3.873	6.06
16	1.1991	1.1862	1.1927	524.84	749.53	0.700	21753.442	10.0		
									2.153	6.29
17	1.2161	1.2094	1.2127	525.78	749.91	0.701	21762.772	10.0		
									5.143	6.40
18	1.2247	1.2208	1.2228	526.12	749.91	0.702	21764.719	10.0		
									6.152	6.55
19	1.2330	1.2326	1.2328	525.44	749.56	0.701	21766.356	10.0		
									14.100	6.68
20	1.2440	1.2417	1.2428	525.97	749.59	0.702	21767. 62	10.0		

MATERIAL DESCRIPTION: CDA 172-AT BE-CU
SPECIMEN NUMBER: BC-R6 TH: 0.353
SPECIMEN TYPE: 2 W: 2.000
YIELD STRENGTH: 130
TEMPERATURE: 75

REC NO.	AA (IN)	AB (IN)	A(AVG) (IN)	PMIN (LBS)	PMAX (LBS)	R	KILO-CYCLES	FREQENCY (HERTZ)	da/dN (xE6)	DELTA K (KSI SQRT IN)
1	0.7548	0.7665	0.7606	60.94	599.97	0.102	0. 1	55.0		
2	0.7737	0.7875	0.7806	60.09	600.37	0.100	504. 80	55.0	0.040	7.68
3	0.7953	0.8059	0.8006	60.25	600.28	0.100	776.617	55.0	0.073	7.88
4	0.8296	0.8315	0.8306	61.59	599.62	0.103	1005.481	55.0	0.131	8.17
5	0.8606	0.8605	0.8606	62.53	597.84	0.105	1183.470	55.0	0.168	8.47
6	0.8917	0.8897	0.8907	61.31	600.47	0.102	1372.397	55.0	0.159	8.89
7	0.9224	0.9192	0.9208	62.91	558.91	0.113	1529. 39	55.0	0.192	8.53
8	0.9525	0.9493	0.9509	68.56	594.50	0.115	1636.267	55.0	0.281	9.45
9	0.9834	0.9787	0.9810	64.69	595.69	0.109	1711.487	55.0	0.400	9.98
10	1.0129	1.0094	1.0111	65.66	600.16	0.109	1775.309	55.0	0.472	10.52
11	1.0438	1.0387	1.0413	60.03	601.03	0.100	1825.240	55.0	0.603	11.17
12	1.0757	1.0670	1.0714	65.00	600.31	0.108	1861.913	55.0	0.821	11.61
13	1.1017	1.1013	1.1015	60.78	600.09	0.101	1885.347	10.0	1.285	12.31
14	1.1328	1.1304	1.1316	60.50	601.09	0.101	1903.290	10.0	1.679	13.01
15	1.1631	1.1604	1.1617	61.06	601.12	0.102	1915.437	10.0	2.479	13.73
16	1.1950	1.1887	1.1918	61.16	600.25	0.102	1922.557	2.0	4.230	14.51
17	1.2344	1.2096	1.2220	61.75	601.41	0.103	1931.528	2.0	3.357	15.42
18	1.2521	1.2324	1.2422	61.44	600.66	0.102	1936.519	2.0	4.062	16.06
19	1.2733	1.2513	1.2623	61.00	601.03	0.101	1938.392	2.0	10.720	16.78
20	1.2918	1.2730	1.2824	61.59	601.22	0.102	1939.278	2.0	22.662	17.52
21	1.3060	1.2989	1.3025	61.34	600.69	0.102	1939.928	2.0	30.890	18.31
22	1.3253	1.3198	1.3226	62.00	601.06	0.103	1940.620	2.0	29.015	19.17
23	1.3501	1.3352	1.3426	61.31	600.94	0.102	1940.792	2.0	116.736	20.14
24	1.3651	1.3422	1.3537	61.00	600.09	0.102	1940.818	2.0	424.000	20.69

MATERIAL DESCRIPTION: CDA 172-AT BE-CU
SPECIMEN NUMBER: BC-R7
SPECIMEN TYPE: 2
YIELD STRENGTH: 130
TEMPERATURE: 75

TH: 0.351
W: 2.000

REC NO.	AA (IN)	AB (IN)	A(AVG) (IN)	PMIN (LBS)	PMAX (LBS)	R	KILO-CYCLES	FREQENCY (HERTZ)	da/dN (xE6)	DELTA K (KSI SQRT IN)
1	0.7593	0.7781	0.7687	560.81	799.09	0.702	4454.369	50.0		
									0.010	3.49
2	0.7789	0.7983	0.7886	560.66	801.97	0.699	6376.539	50.0		
									0.013	3.52
3	0.7973	0.8199	0.8086	561.97	799.59	0.703	7905.270	50.0		
									0.017	3.69
4	0.8353	0.8418	0.8386	559.97	798.97	0.701	9628.410	50.0		
									0.023	3.80
5	0.8714	0.8658	0.8686	561.16	797.37	0.704	10938.930	50.0		
									0.022	3.92
6	0.9056	0.8916	0.8986	562.56	796.12	0.707	12287.924	50.0		
									0.037	4.11
7	0.9369	0.9206	0.9287	562.91	797.56	0.706	13096.378	50.0		
									0.059	4.34
8	0.9651	0.9527	0.9589	561.56	798.75	0.703	13606.632	50.0		
									0.077	4.59
9	0.9859	0.9920	0.9890	561.44	801.16	0.701	13998.999	5.0		
									0.096	4.72
10	0.9979	1.0202	1.0091	560.66	799.84	0.701	14208.210	5.0		
									0.173	4.88
11	1.0239	1.0344	1.0291	560.34	799.81	0.701	14324.479	5.0		
									0.261	5.02
12	1.0414	1.0570	1.0492	561.16	799.72	0.702	14401.282	5.0		
									0.353	5.22
13	1.0692	1.0696	1.0694	561.31	801.47	0.700	14458.436	5.0		
									0.432	5.38
14	1.0881	1.0908	1.0895	559.75	798.97	0.701	14504.934	5.0		
									0.660	5.53
15	1.1070	1.1121	1.1096	560.84	798.53	0.702	14535.369	5.0		
									0.753	5.77
16	1.1334	1.1259	1.1296	561.16	800.37	0.701	14562. 20	5.0		
									1.215	6.06
17	1.1531	1.1464	1.1497	559.28	801.78	0.698	14578.542	2.0		
									2.333	6.29
18	1.1755	1.1641	1.1698	559.47	801.72	0.698	14587.149	2.0		
									7.202	6.57
19	1.1936	1.1861	1.1899	558.00	801.66	0.696	14589.938	2.0		
									9.261	6.66
20	1.2011	1.1987	1.1999	559.47	801.62	0.698	14591. 19	2.0		
									19.918	6.80
21	1.2105	1.2094	1.2099	559.25	801.59	0.698	14591.524	2.0		
									121.860	6.94
22	1.2283	1.2121	1.2202	559.56	801.84	0.698	14591.608	2.0		

MATERIAL DESCRIPTION: CDA 172-AT BE-CU
SPECIMEN NUMBER: BC-R8
SPECIMEN TYPE: 2
YIELD STRENGTH: 130
TEMPERATURE: 75

TH: 0.353
W: 2.000

REC NO.	AA (IN)	AB (IN)	A(AVG) (IN)	PMIN (LBS)	PMAX (LBS)	R	KILO-CYCLES	FREQENCY (HERTZ)	da/dN (xE6)	DELTA K (KSI SQRT IN)
1	0.7244	0.7431	0.7337	258.72	652.44	0.397	906.993	50.0		
									0.035	5.38
2	0.7454	0.7623	0.7538	257.72	649.44	0.397	1479.121	50.0		
									0.040	5.62
3	0.7828	0.8048	0.7938	258.09	646.53	0.399	2475.968	50.0		
									0.051	5.93
4	0.8245	0.8631	0.8438	260.41	643.97	0.404	3447.266	50.0		
									0.081	6.24
5	0.8559	0.8916	0.8738	262.47	649.78	0.404	3815.238	50.0		
									0.127	6.51
6	0.8895	0.9182	0.9038	261.97	649.81	0.403	4052.365	50.0		
									0.149	6.68
7	0.9190	0.9489	0.9340	265.59	646.59	0.411	4255. 84	50.0		
									0.246	7.30
8	0.9964	1.0121	1.0042	269.66	644.25	0.419	4540.478	50.0		
									0.326	7.40
9	1.0145	1.0342	1.0243	273.75	642.22	0.426	4602. 32	50.0		
									0.501	8.30
10	1.0432	1.0657	1.0544	259.69	653.31	0.397	4662.181	5.0		
									0.698	8.64
11	1.0708	1.0983	1.0846	260.44	650.22	0.401	4705.320	5.0		
									0.675	9.11
12	1.1015	1.1279	1.1147	260.66	650.72	0.401	4749.968	10.0		
									1.295	9.63
13	1.1294	1.1601	1.1448	259.91	650.78	0.399	4773.230	10.0		
									1.807	10.12
14	1.1625	1.1873	1.1749	261.62	649.94	0.403	4789.894	2.0		
									3.100	10.71
15	1.1881	1.2220	1.2050	261.78	649.50	0.403	4799.608	2.0		
									6.491	11.39
16	1.2200	1.2503	1.2351	262.03	650.03	0.403	4804.249	2.0		
									7.669	11.88
17	1.2408	1.2700	1.2554	261.97	649.97	0.403	4806.893	2.0		
									9.061	12.14
18	1.2479	1.2830	1.2655	261.62	649.81	0.403	4808. 1	2.0		
									16.351	12.42
19	1.2594	1.2916	1.2755	261.94	650.28	0.403	4808.614	2.0		
									32.808	12.68
20	1.2657	1.3054	1.2855	261.84	649.81	0.403	4808.921	2.0		
									56.321	13.26
21	1.2826	1.3290	1.3058	261.87	649.41	0.403	4809.281	2.0		
									100.355	13.57
22	1.2893	1.3428	1.3160	262.31	649.69	0.404	4809.382	2.0		
									465.285	13.93
23	1.3034	1.3491	1.3263	261.00	649.09	0.402	4809.404	2.0		
									5708.695	14.31
24	1.3172	1.3582	1.3377	261.19	648.69	0.403	4809.407	2.0		

MATERIAL DESCRIPTION: CDA 172-AT BE-CU
SPECIMEN NUMBER: BC-R9 TH: 0.353
SPECIMEN TYPE: 2 W: 2.000
YIELD STRENGTH: 130
TEMPERATURE: 75

REC NO.	AA (IN)	AB (IN)	A(AVG) (IN)	PMIN (LBS)	PMAX (LBS)	R	KILO-CYCLES	FREQENCY (HERTZ)	da/dN (xE6)	DELTA K (KSI SQRT IN)
1	0.7716	0.7522	0.7619	55.28	552.66	0.100	897. 91	50.0		
									0.075	6.99
2	0.7905	0.7732	0.7819	54.56	545.59	0.100	1163.141	50.0		
									0.085	7.20
3	0.8212	0.8027	0.8119	56.06	542.22	0.103	1517.385	50.0		
									0.101	7.61
4	0.8527	0.8312	0.8420	56.59	549.97	0.103	1814.675	50.0		
									0.114	7.96
5	0.8858	0.8581	0.8719	55.41	551.12	0.101	2077.409	50.0		
									0.170	8.26
6	0.9125	0.8915	0.9020	55.00	548.34	0.100	2254.539	50.0		
									0.173	8.48
7	0.9385	0.9257	0.9321	57.97	542.66	0.107	2428.163	50.0		
									0.232	9.30
8	0.9944	0.9903	0.9924	58.28	544.34	0.107	2687.563	50.0		
									0.389	9.78
9	1.0247	1.0202	1.0225	58.94	546.94	0.108	2765. 13	50.0		
									0.471	10.31
10	1.0586	1.0468	1.0527	57.56	547.56	0.105	2829.157	40.0		
									0.545	10.42
11	1.0901	1.0755	1.0828	64.72	535.94	0.121	2884.461	40.0		
									0.764	11.01
12	1.1007	1.0850	1.0928	56.41	545.97	0.103	2897.610	40.0		

MATERIAL DESCRIPTION: CDA 172-AT BE-CU
SPECIMEN NUMBER: BC-R10 TH: 0.353
SPECIMEN TYPE: 2 W: 2.000
YIELD STRENGTH: 130
TEMPERATURE: 75

REC NO.	AA (IN)	AB (IN)	A(AVG) (IN)	PMIN (LBS)	PMAX (LBS)	R	KILO-CYCLES	FREQENCY (HERTZ)	da/dN (xE6)	DELTA K (KSI SQRT IN)
1	0.8921	0.8779	0.8850	52.97	497.87	0.106	1439.137	50.0		
									0.105	7.48
2	0.9072	0.9029	0.9051	52.44	497.19	0.105	1629.871	50.0		
									0.133	7.82
3	0.9320	0.9202	0.9261	49.84	500.81	0.100	1788.485	30.0		
									0.186	8.10
4	0.9612	0.9513	0.9562	50.87	498.19	0.102	1950.699	30.0		
									0.235	8.39
5	0.9938	0.9789	0.9864	52.75	495.59	0.106	2079.116	30.0		
									0.300	8.87
6	1.0232	1.0098	1.0165	52.37	499.09	0.105	2179.638	30.0		
									0.377	9.19
7	1.0507	1.0427	1.0467	54.78	496.03	0.110	2259.793	30.0		
									0.446	9.72
8	1.0787	1.0751	1.0769	53.91	497.78	0.108	2327.563	30.0		
									0.669	10.35
9	1.1082	1.1058	1.1070	51.31	500.44	0.103	2372.607	10.0		
									1.022	10.91
10	1.1401	1.1342	1.1371	51.37	500.16	0.103	2402. 85	10.0		
									1.284	11.53
11	1.1680	1.1665	1.1673	51.87	499.50	0.104	2425.538	10.0		

MATERIAL DESCRIPTION: CDA 172-AT BE-CU
SPECIMEN NUMBER: BC-R11
SPECIMEN TYPE: 2
YIELD STRENGTH: 130
TEMPERATURE: 75

TH: 0.353
W: 2.000

REC NO.	AA (IN)	AB (IN)	A(AVG) (IN)	PMIN (LBS)	PMAX (LBS)	R	KILO-CYCLES	FREQENCY (HERTZ)	da/dN (xE6)	DELTA K (KSI SQRT IN)
1	0.8211	0.8299	0.8255	58.00	582.59	0.100	13956.210	30.0		
									0.072	8.00
2	0.8281	0.8430	0.8355	56.56	580.00	0.098	14096.321	30.0		
									0.082	8.16
3	0.8363	0.8549	0.8456	54.78	581.53	0.094	14218.779	30.0		
									0.109	8.40
4	0.8543	0.8771	0.8657	55.31	582.75	0.095	14403.702	30.0		
									0.135	8.62
5	0.8732	0.8984	0.8858	55.41	581.56	0.095	14552.339	30.0		
									0.239	8.99
6	0.9045	0.9273	0.9159	55.44	581.56	0.095	14678.265	30.0		
									0.367	9.34
7	0.9346	0.9574	0.9460	55.94	579.50	0.097	14760.422	30.0		
									0.513	9.61
8	0.9576	0.9746	0.9661	56.62	579.34	0.098	14799.526	30.0		
									0.572	9.92
9	0.9795	1.0029	0.9912	58.50	578.12	0.101	14843.419	30.0		
									0.686	10.34
10	1.0126	1.0301	1.0213	60.53	577.59	0.105	14887.301	30.0		
									0.699	10.45
11	1.0440	1.0588	1.0514	69.97	567.78	0.123	14930.388	30.0		
									1.065	11.37
12	1.0730	1.0907	1.0818	63.19	578.41	0.109	14958.958	30.0		
									1.084	11.72
13	1.0876	1.1068	1.0972	61.47	579.00	0.106	14973.122	30.0		
									1.277	12.04
14	1.1064	1.1187	1.1126	66.66	563.97	0.118	14985.139	30.0		

MATERIAL DESCRIPTION: CDA 172-AT BE-CU
SPECIMEN NUMBER: BC-R12 TH: 0.353
SPECIMEN TYPE: 2 W: 2.000
YIELD STRENGTH: 130
TEMPERATURE: 75

REC NO.	AA (IN)	AB (IN)	A(AVG) (IN)	PMIN (LBS)	PMAX (LBS)	R	KILO-CYCLES	FREQENCY (HERTZ)	da/dN (xE6)	DELTA K (KSI SQRT IN)
									0.108	7.28
1	0.8821	0.8789	0.8805	49.97	497.75	0.100	24819.706	50.0		
									0.042	7.34
2	0.8937	0.8874	0.8905	50.84	496.37	0.102	25061.201	50.0		
									0.051	7.42
3	0.9041	0.8970	0.9006	51.03	494.56	0.103	25257.155	50.0		
									0.075	7.50
4	0.9137	0.9074	0.9106	51.37	493.78	0.104	25390.299	50.0		
									0.061	7.56
5	0.9254	0.9159	0.9206	52.81	492.37	0.107	25555. 24	50.0		
									0.089	7.82
6	0.9360	0.9254	0.9307	50.94	499.25	0.102	25667.515	50.0		
									0.089	7.88
7	0.9443	0.9372	0.9407	52.97	498.03	0.106	25780.944	50.0		
									0.091	7.95
8	0.9551	0.9464	0.9508	53.28	495.97	0.107	25891.123	50.0		
									0.108	8.22
9	0.9697	0.9620	0.9658	51.12	498.72	0.103	26030.359	50.0		
									0.112	8.28
10	0.9785	0.9732	0.9759	53.34	497.44	0.107	26120.385	50.0		
									0.160	8.37
11	0.9903	0.9815	0.9859	54.09	496.00	0.109	26182.960	50.0		
									0.159	8.64
12	1.0006	0.9913	0.9959	50.22	499.81	0.100	26246.298	30.0		
									0.147	8.74
13	1.0137	0.9982	1.0060	51.34	498.97	0.103	26314.583	30.0		
									0.306	8.85
14	1.0265	1.0055	1.0160	52.22	498.44	0.105	26347.422	30.0		
									0.230	8.96
15	1.0397	1.0124	1.0261	53.53	498.25	0.107	26391. 95	30.0		
									0.246	9.07
16	1.0543	1.0179	1.0361	54.37	497.31	0.109	26431.835	30.0		
									0.233	9.23
17	1.0669	1.0254	1.0461	54.37	498.00	0.109	26474.857	30.0		
									0.319	9.47
18	1.0771	1.0352	1.0562	52.47	500.37	0.105	26506.349	30.0		
									0.523	9.59
19	1.0834	1.0492	1.0663	54.03	499.87	0.108	26525.753	30.0		
									0.733	9.71
20	1.0909	1.0630	1.0769	55.00	498.47	0.110	26540.258	30.0		

MATERIAL DESCRIPTION: CDA 172-AT
SPECIMEN NUMBER: BC-R13
SPECIMEN TYPE: 2
YIELD STRENGTH: 130
TEMPERATURE: 75

TH: 0.353
W: 2.000

REC NO.	AA (IN)	AB (IN)	A(AVG) (IN)	PMIN (LBS)	PMAX (LBS)	R	KILO-CYCLES	FREQENCY (HERTZ)	da/dN (xE6)	DELTA K (KSI SQRT IN)
1	0.7598	0.7638	0.7618	57.87	548.41	0.106	1633.592	50.0		
									0.089	6.96
2	0.7772	0.7864	0.7818	54.81	543.53	0.101	1859.443	50.0		
									0.091	7.30
3	0.8052	0.8184	0.8118	56.94	549.97	0.104	2189.146	50.0		
									0.097	7.61
4	0.8322	0.8514	0.8418	58.28	552.06	0.106	2498.395	50.0		
									0.106	7.81
5	0.8602	0.8838	0.8720	58.31	544.44	0.107	2782.794	50.0		
									0.134	8.32
6	0.8936	0.9106	0.9021	52.81	549.22	0.096	3007.971	50.0		
									0.171	8.47
7	0.9241	0.9403	0.9322	57.75	542.22	0.107	3184.538	50.0		
									0.209	8.94
8	0.9543	0.9706	0.9624	57.97	546.81	0.106	3329.266	50.0		
									0.306	9.31
9	0.9836	1.0015	0.9926	60.06	546.69	0.110	3427.828	50.0		
									0.390	9.72
10	1.0167	1.0287	1.0227	61.25	546.25	0.112	3505. 85	50.0		
									0.459	9.95
11	1.0488	1.0570	1.0529	63.62	536.50	0.119	3570.885	50.0		
									0.832	10.93
12	1.0763	1.0897	1.0830	56.75	551.19	0.103	3607. 64	30.0		
									1.017	11.51
13	1.1019	1.1243	1.1131	61.22	546.00	0.112	3636.674	30.0		

MATERIAL DESCRIPTION: C17200 BE-CU
SPECIMEN NUMBER: BC-L3 TH: 0.354
SPECIMEN TYPE: 2 W: 2.000
YIELD STRENGTH: 130
TEMPERATURE: 75

REC NO.	AA (IN)	AB (IN)	A(AVG) (IN)	PMIN (LBS)	PMAX (LBS)	R	KILO-CYCLES	FREQENCY (HERTZ)	da/dN (xE6)	DELTA K (KSI SQRT IN)
1	0.7261	0.7559	0.7410	78.50	799.78	0.098	147.360	20.0		
2	0.7504	0.7816	0.7660	81.47	800.25	0.102	187.519	20.0	0.623	9.99
3	0.7757	0.8063	0.7910	80.56	801.25	0.101	219.500	20.0	0.782	10.35
4	0.8280	0.8540	0.8410	80.62	801.00	0.101	269.227	20.0	1.005	11.06
5	0.8548	0.8772	0.8660	80.28	800.75	0.100	286.227	20.0	1.471	11.45
6	0.8784	0.9036	0.8910	81.06	800.84	0.101	300.519	20.0	1.749	11.84
7	0.9294	0.9526	0.9410	81.75	801.03	0.102	325.499	20.0	2.002	12.71
8	0.9556	0.9764	0.9660	83.03	800.66	0.104	333.486	20.0	3.130	13.15
9	0.9821	0.9999	0.9910	84.00	800.00	0.105	341.132	20.0	3.270	13.63
10	1.0020	1.0300	1.0160	84.97	800.47	0.106	346.527	20.0	4.634	14.15
11	1.0284	1.0536	1.0410	85.97	800.12	0.107	350.402	20.0	6.452	14.70
12	1.0532	1.0788	1.0660	87.16	799.94	0.109	353.327	20.0	8.547	15.28
13	1.0800	1.1020	1.0910	88.62	798.69	0.111	355.339	20.0	12.425	15.87
14	1.1060	1.1260	1.1160	90.34	797.81	0.113	356.746	20.0	17.768	16.51
15	1.1351	1.1469	1.1410	91.78	796.75	0.115	357.800	20.0	23.719	17.20
16	1.1630	1.1690	1.1660	94.53	786.37	0.120	358.649	20.0	29.447	17.68
17	1.1851	1.1969	1.1910	96.47	784.84	0.123	359. 84	20.0	57.471	18.45
18	1.2225	1.2130	1.2178	62.62	786.37	0.080	359.236	1.0	176.129	19.45

MATERIAL DESCRIPTION: CDA 172-AT BE-CU
SPECIMEN NUMBER: BC-L4 TH: 0.352
SPECIMEN TYPE: 2 W: 2.000
YIELD STRENGTH: 130
TEMPERATURE: 75

REC NO.	AA (IN)	AB (IN)	A(AVG) (IN)	PMIN (LBS)	PMAX (LBS)	R	KILO-CYCLES	FREQENCY (HERTZ)	da/dN (xE6)	DELTA K (KSI SQRT IN)
1	0.7451	0.7685	0.7568	280.75	701.75	0.400	684. 66	50.0		
									0.045	6.03
2	0.7816	0.7919	0.7868	279.75	699.22	0.400	1351.279	50.0		
									0.040	6.26
3	0.8136	0.8200	0.8168	278.59	697.12	0.400	2104.642	50.0		
									0.052	6.47
4	0.8412	0.8522	0.8467	279.84	695.72	0.402	2686.529	50.0		
									0.082	6.70
5	0.8724	0.8811	0.8768	281.62	694.62	0.405	3052.194	50.0		
									0.103	7.00
6	0.9018	0.9120	0.9069	283.59	697.41	0.407	3345.737	50.0		
									0.153	7.31
7	0.9334	0.9405	0.9370	283.44	697.19	0.407	3542.270	50.0		
									0.186	7.67
8	0.9634	0.9708	0.9671	283.25	698.50	0.406	3703.949	50.0		
									0.180	8.04
9	0.9982	0.9962	0.9972	282.66	698.97	0.404	3870.844	50.0		
									0.289	8.43
10	1.0258	1.0289	1.0273	282.50	698.78	0.404	3975.217	50.0		
									0.383	8.94
11	1.0577	1.0573	1.0575	280.03	700.69	0.400	4053.853	2.0		
									0.508	9.44
12	1.0868	1.0884	1.0876	279.19	701.44	0.398	4113.165	2.0		
									0.738	9.93
13	1.1147	1.1207	1.1177	279.03	700.66	0.398	4153.957	2.0		
									0.868	10.49
14	1.1415	1.1541	1.1478	279.06	701.09	0.398	4188.641	2.0		
									1.399	11.07
15	1.1695	1.1864	1.1779	279.91	701.06	0.399	4210.174	2.0		
									2.209	11.75
16	1.2057	1.2104	1.2081	275.50	697.25	0.395	4223.811	2.0		
									2.661	12.51
17	1.2344	1.2419	1.2382	275.66	697.91	0.395	4235.129	2.0		
									6.848	13.03
18	1.2478	1.2687	1.2583	278.53	700.19	0.398	4238. 60	2.0		
									8.415	13.62
19	1.2738	1.2829	1.2783	276.59	698.59	0.396	4240.447	2.0		
									20.194	14.22
20	1.2931	1.3041	1.2986	276.44	697.75	0.396	4241.450	2.0		
									41.379	14.91
21	1.3151	1.3226	1.3189	276.19	697.91	0.396	4241.940	2.0		
									132.096	15.60
22	1.3270	1.3510	1.3390	276.25	696.97	0.396	4242. 92	2.0		
									208.664	16.02
23	1.3443	1.3545	1.3494	276.41	697.62	0.396	4242.142	2.0		
									853.022	16.43
24	1.3490	1.3703	1.3596	276.62	697.75	0.396	4242.155	2.0		
									3592.491	17.04
25	1.3604	1.3876	1.3740	276.62	697.06	0.397	4242.159	2.0		

MATERIAL DESCRIPTION: CDA172-AT BE-CU
SPECIMEN NUMBER: BC-L5 TH: 0.354
SPECIMEN TYPE: 2 W: 2.000
YIELD STRENGTH: 130
TEMPERATURE: 75

REC NO.	AA (IN)	AB (IN)	A(AVG) (IN)	PMIN (LBS)	PMAX (LBS)	R	KILO-CYCLES	FREQENCY (HERTZ)	da/dN (xE6)	DELTA K (KSI SQRT IN)
1	0.7645	0.7287	0.7466	551.91	799.84	0.690	1351.502	50.0		
									0.002	3.28
2	0.7656	0.7476	0.7566	562.78	801.31	0.702	5654.508	50.0		
									0.006	3.29
3	0.7714	0.7618	0.7666	563.53	800.25	0.704	7231. 62	50.0		
									0.011	3.35
4	0.7826	0.7705	0.7766	562.37	800.03	0.703	8110.600	50.0		
									0.014	3.39
5	0.7930	0.7802	0.7866	562.91	800.41	0.703	8802.849	50.0		
									0.017	3.46
6	0.8132	0.8000	0.8066	565.00	800.59	0.706	9947.846	50.0		
									0.022	3.60
7	0.8307	0.8224	0.8265	561.00	800.19	0.701	10863.723	50.0		
									0.024	3.86
8	0.8893	0.8838	0.8866	564.37	800.22	0.705	13321.760	50.0		
									0.032	4.28
9	0.9474	0.9462	0.9468	560.53	800.75	0.700	15187.371	30.0		
									0.052	4.45
10	0.9783	0.9756	0.9769	560.97	799.97	0.701	15761.907	30.0		
									0.065	4.80
11	1.0305	1.0238	1.0271	561.06	799.72	0.702	16539.840	30.0		
									0.093	4.94
12	1.0508	1.0437	1.0472	561.19	798.81	0.703	16754.913	30.0		
									0.113	5.10
13	1.0689	1.0657	1.0673	561.25	798.53	0.703	16932.210	30.0		
									0.125	5.23
14	1.0901	1.0846	1.0874	562.22	797.78	0.705	17092.287	30.0		
									0.117	5.48
15	1.1114	1.1023	1.1069	561.69	800.19	0.702	17259.532	10.0		
									0.518	5.68
16	1.1346	1.1193	1.1269	561.31	799.81	0.702	17298.276	10.0		
									0.382	5.87
17	1.1606	1.1334	1.1470	561.87	799.84	0.702	17350.886	10.0		
									0.579	5.98
18	1.1665	1.1476	1.1571	562.47	800.59	0.703	17368.242	10.0		

MATERIAL DESCRIPTION: CDA172-AT Be-Cu (R-L)
SPECIMEN NUMBER: BC-L6 TH: 0.354
SPECIMEN TYPE: 2 W: 2.000
YIELD STRENGTH: 130
TEMPERATURE: 75

REC NO.	AA (IN)	AB (IN)	A(AVG) (IN)	PMIN (LBS)	PMAX (LBS)	R	KILO-CYCLES	FREQENCY (HERTZ)	da/dN (xE6)	DELTA K (KSI SQRT IN)
1	0.7639	0.7730	0.7685	70.16	695.31	0.101	12540.407	55.0	0.037	8.87
2	0.7720	0.7850	0.7785	66.50	694.00	0.096	12809.909	55.0	0.068	9.01
3	0.7868	0.8002	0.7935	66.41	691.78	0.096	13030.435	55.0	0.096	9.17
4	0.8018	0.8153	0.8086	66.41	690.25	0.096	13187.316	55.0	0.129	9.42
5	0.8295	0.8379	0.8337	67.37	686.94	0.098	13382.752	55.0	0.172	9.74
6	0.8488	0.8588	0.8538	65.72	689.12	0.095	13499.342	55.0	0.178	9.96
7	0.8702	0.8775	0.8739	67.12	687.12	0.098	13612.437	55.0	0.183	10.11
8	0.8921	0.9059	0.8990	79.91	687.47	0.116	13749.846	55.0	0.179	10.11
9	0.9251	0.9330	0.9291	66.44	648.62	0.102	13918. 1	45.0	0.200	10.59
10	0.9667	0.9517	0.9592	66.56	650.44	0.102	14068.750	45.0	0.303	10.94
11	0.9960	0.9826	0.9893	69.03	645.53	0.107	14168.257	45.0	0.434	11.50
12	1.0234	1.0155	1.0194	69.66	648.00	0.107	14237.624	45.0	0.633	12.00
13	1.0525	1.0466	1.0496	70.62	645.53	0.109	14285.228	45.0	0.859	12.21
14	1.0824	1.0781	1.0803	80.19	636.53	0.126	14320.978	45.0	1.350	13.64
15	1.1198	1.1124	1.1161	66.31	650.66	0.102	14347.514	10.0	1.869	14.23
16	1.1450	1.1383	1.1417	67.19	649.50	0.103	14361.204	10.0	2.134	14.97
17	1.1734	1.1714	1.1724	65.37	644.25	0.101	14375.594	2.0	4.345	15.92
18	1.2053	1.2009	1.2031	65.31	645.62	0.101	14382.661	2.0	6.295	16.77
19	1.2320	1.2151	1.2236	65.97	652.66	0.101	14385.911	2.0	9.461	17.48
20	1.2482	1.2399	1.2440	65.91	652.09	0.101	14388. 77	2.0	14.274	18.27
21	1.2722	1.2572	1.2647	65.44	651.94	0.100	14389.524	2.0	15.053	19.13
22	1.2875	1.2828	1.2852	65.47	652.66	0.100	14390.883	2.0	34.547	20.02
23	1.3131	1.2990	1.3061	65.97	652.53	0.101	14391.487	2.0	54.851	21.03
24	1.3238	1.3305	1.3271	65.50	651.97	0.100	14391.873	2.0	102.363	21.54
25	1.3407	1.3340	1.3374	65.69	651.97	0.101	14391.971	2.0	265.741	21.90
26	1.3490	1.3364	1.3427	65.97	654.37	0.101	14391.993	2.0	664.353	22.10
27	1.3525	1.3435	1.3480	65.81	652.12	0.101	14392. 1	2.0	713.587	22.40
28	1.3604	1.3470	1.3537	65.91	651.97	0.101	14392. 7	2.0	1574.874	22.74
29	1.3690	1.3509	1.3600	66.00	651.50	0.101	14392. 13	2.0	3051.162	23.45
30	1.3840	1.3604	1.3722	64.66	651.31	0.099	14392. 15	2.0		

MATERIAL DESCRIPTION: CDA172-AT BE-CU
SPECIMEN NUMBER: BC-L7 TH: 0.354
SPECIMEN TYPE: 2 W: 2.000
YIELD STRENGTH: 130
TEMPERATURE: 75

REC NO.	AA (IN)	AB (IN)	A(AVG) (IN)	PMIN (LBS)	PMAX (LBS)	R	KILO-CYCLES	FREQENCY (HERTZ)	da/dN (xE6)	DELTA K (KSI SQRT IN)
1	0.7802	0.7495	0.7648	562.81	800.47	0.703	997.870	50.0		
									0.013	3.38
2	0.8009	0.7687	0.7848	561.59	799.09	0.703	2576.793	50.0		
									0.011	3.44
3	0.8201	0.7896	0.8049	562.16	797.12	0.705	4439.925	50.0		
									0.017	3.56
4	0.8373	0.8123	0.8248	561.19	798.28	0.703	5626.713	50.0		
									0.022	3.69
5	0.8535	0.8362	0.8448	561.69	800.66	0.702	6515.865	50.0		
									0.029	3.75
6	0.8745	0.8551	0.8648	561.12	797.81	0.703	7208. 22	50.0		
									0.032	3.86
7	0.8962	0.8734	0.8848	563.16	799.56	0.704	7833.503	50.0		
									0.037	3.94
8	0.9147	0.8950	0.9049	563.53	798.19	0.706	8382.225	50.0		
									0.039	4.07
9	0.9314	0.9184	0.9249	564.34	800.16	0.705	8898. 25	50.0		
									0.052	4.27
10	0.9588	0.9513	0.9551	562.91	799.69	0.704	9480.908	50.0		
									0.097	4.37
11	0.9803	0.9700	0.9751	562.25	797.25	0.705	9687.302	50.0		
									0.089	4.50
12	1.0003	0.9901	0.9952	561.25	798.25	0.703	9913. 51	50.0		

MATERIAL DESCRIPTION: CDA172-AT BE-CU
SPECIMEN NUMBER: BC-L10 TH: 0.354
SPECIMEN TYPE: 2 W: 2.000
YIELD STRENGTH: 130
TEMPERATURE: 75

REC NO.	AA (IN)	AB (IN)	A(AVG) (IN)	PMIN (LBS)	PMAX (LBS)	R	KILO-CYCLES	FREQENCY (HERTZ)	da/dN (xE6)	DELTA K (KSI SQRT IN)
1	0.7637	0.7470	0.7553	564.06	804.00	0.702	1966.977	50.0		
									0.014	3.38
2	0.7910	0.7796	0.7853	562.16	798.97	0.704	4047.156	50.0		
									0.022	3.45
3	0.8094	0.8018	0.8056	563.19	798.91	0.705	4951.499	50.0		
									0.030	3.65
4	0.8524	0.8276	0.8400	562.03	800.00	0.703	6083.396	50.0		
									0.033	3.69
5	0.8714	0.8485	0.8600	565.59	799.53	0.707	6689.673	50.0		
									0.035	3.93
6	0.8968	0.8832	0.8900	560.00	798.97	0.701	7546.196	50.0		
									0.048	4.10
7	0.9269	0.9133	0.9201	561.56	800.50	0.702	8173.892	50.0		
									0.066	4.27
8	0.9609	0.9395	0.9502	560.00	798.50	0.701	8627.396	50.0		
									0.083	4.43
9	0.9932	0.9674	0.9803	562.31	799.12	0.704	8992.158	50.0		
									0.136	4.70
10	1.0076	1.0133	1.0105	560.94	800.59	0.701	9214.386	10.0		
									0.302	4.92
11	1.0430	1.0381	1.0406	559.75	799.19	0.700	9314. 54	10.0		
									0.385	5.20
12	1.0714	1.0702	1.0708	559.94	800.41	0.700	9392.437	10.0		
									0.830	5.39
13	1.1131	1.0887	1.1009	561.97	798.87	0.703	9428.735	10.0		
									1.161	5.69
14	1.1450	1.1170	1.1310	562.37	799.72	0.703	9454.687	5.0		
									3.405	5.86
15	1.1541	1.1281	1.1411	562.47	802.47	0.701	9457.637	5.0		
									4.276	5.94
16	1.1686	1.1336	1.1511	561.72	800.56	0.702	9459.983	5.0		
									11.105	6.04
17	1.1800	1.1422	1.1611	562.12	800.59	0.702	9460.888	5.0		
									20.241	6.12
18	1.1836	1.1588	1.1712	563.31	800.56	0.704	9461.384	5.0		
									15.398	6.27
19	1.1918	1.1706	1.1812	562.34	800.62	0.702	9462. 36	5.0		
									32.177	6.39
20	1.2033	1.1793	1.1913	561.91	800.34	0.702	9462.348	5.0		
									67.833	6.51
21	1.2159	1.1867	1.2013	561.87	799.87	0.702	9462.497	5.0		
									179.274	6.65
22	1.2194	1.2033	1.2113	561.66	800.06	0.702	9462.551	5.0		
									228.167	6.78
23	1.2269	1.2159	1.2214	562.19	800.00	0.703	9462.595	5.0		

MATERIAL DESCRIPTION: 1CDA 172-AT BE-CU
SPECIMEN NUMBER: BC-L11 TH: 0.353
SPECIMEN TYPE: 2 W: 2.000
YIELD STRENGTH: 130
TEMPERATURE: 75

REC NO.	AA (IN)	AB (IN)	A(AVG) (IN)	PMIN (LBS)	PMAX (LBS)	R	KILO-CYCLES	FREQENCY (HERTZ)	da/dN (xE6)	DELTA K (KSI SQRT IN)
1	0.7350	0.7377	0.7363	198.66	699.94	0.284	281.152	50.0	0.263	6.87
2	0.7562	0.7565	0.7563	200.78	699.59	0.287	357.150	50.0	0.242	7.03
3	0.7804	0.7722	0.7763	200.59	697.84	0.287	439.602	50.0	0.284	7.13
4	0.8008	0.7919	0.7964	204.66	696.16	0.294	510.153	50.0	0.294	7.32
5	0.8221	0.8106	0.8164	203.25	694.41	0.293	578. 96	50.0	0.369	7.57
6	0.8415	0.8312	0.8363	203.03	697.56	0.291	632.280	50.0	0.429	7.11
7	0.8601	0.8526	0.8563	204.34	656.56	0.311	678.874	50.0	0.402	7.90
8	0.8838	0.8688	0.8763	206.00	694.75	0.297	728.625	50.0	0.578	8.24
9	0.8956	0.8820	0.8888	200.31	701.19	0.286	750.264	50.0	0.636	8.37
10	0.9163	0.9015	0.9089	203.69	698.66	0.292	781.851	50.0	0.650	8.51
11	0.9352	0.9228	0.9290	206.69	695.69	0.297	812.724	50.0	0.694	8.81
12	0.9566	0.9415	0.9490	205.22	696.75	0.295	841.641	50.0	0.923	8.98
13	0.9765	0.9617	0.9691	207.12	693.44	0.299	863.384	50.0	0.924	9.36
14	0.9974	0.9810	0.9892	204.37	696.41	0.293	885.113	50.0	1.161	9.60
15	1.0180	1.0007	1.0094	205.25	694.03	0.296	902.494	50.0	1.520	10.03
16	1.0399	1.0190	1.0294	202.00	696.94	0.290	915.701	50.0	1.592	10.40
17	1.0611	1.0379	1.0495	200.00	696.94	0.287	928.311	50.0	1.878	10.76
18	1.0812	1.0580	1.0696	201.34	699.00	0.288	939. 4	50.0	2.449	11.11
19	1.1005	1.0789	1.0897	202.66	699.31	0.290	947.202	10.0	3.695	11.53
20	1.1190	1.1005	1.1098	201.50	699.72	0.288	952.636	10.0	4.527	11.96
21	1.1348	1.1249	1.1298	201.97	700.37	0.288	957. 71	10.0	6.120	12.36
22	1.1509	1.1489	1.1499	202.62	699.62	0.290	960.352	10.0	6.209	12.88
23	1.1789	1.1611	1.1700	200.37	699.31	0.287	963.586	5.0	17.690	13.33
24	1.2013	1.1789	1.1901	201.34	698.09	0.288	964.721	5.0	14.851	13.85
25	1.2226	1.1978	1.2102	201.25	697.47	0.289	966. 73	5.0	33.075	14.43
26	1.2367	1.2241	1.2304	201.16	697.66	0.288	966.686	5.0	47.833	15.02
27	1.2600	1.2418	1.2509	201.87	697.06	0.290	967.114	5.0	132.520	15.68
28	1.2812	1.2611	1.2712	201.97	696.87	0.290	967.267	5.0	213.255	16.01
29	1.2938	1.2690	1.2814	202.06	696.19	0.290	967.315	5.0	3762.033	20.22
30	1.3867	1.3793	1.3830	189.37	679.06	0.279	967.342	5.0	85235.594	25.65
31	1.4686	1.4678	1.4682	189.37	664.84	0.285	967.343	5.0		

MATERIAL DESCRIPTION: CDA 172-AT BE-CU
SPECIMEN NUMBER: BC-L12
SPECIMEN TYPE: 2
YIELD STRENGTH: 130
TEMPERATURE: 75

TH: 0.354
W: 2.000

REC NO.	AA (IN)	AB (IN)	A(AVG) (IN)	PMIN (LBS)	PMAX (LBS)	R	KILO-CYCLES	FREQENCY (HERTZ)	da/dN (xE6)	DELTA K (KSI SQRT IN)
1	0.7744	0.7823	0.7784	55.87	550.78	0.101	660.491	50.0		
									0.081	7.11
2	0.7892	0.7977	0.7934	56.09	549.16	0.102	847.488	50.0		
									0.066	7.13
3	0.7936	0.8033	0.7985	56.12	547.75	0.102	923.179	50.0		
									0.107	6.88
4	0.8081	0.8189	0.8135	56.09	521.03	0.108	1064.451	50.0		
									0.109	7.41
5	0.8313	0.8363	0.8338	55.81	543.03	0.103	1250.496	50.0		
									0.110	7.65
6	0.8553	0.8627	0.8590	57.78	543.97	0.106	1479.925	50.0		
									0.133	8.40
7	0.9234	0.9354	0.9294	61.00	544.62	0.112	2008. 80	50.0		
									0.212	9.09
8	0.9749	0.9842	0.9796	62.00	548.00	0.113	2244.908	50.0		
									0.380	9.98
9	1.0358	1.0438	1.0398	58.44	547.81	0.107	2403.520	50.0		

MATERIAL DESCRIPTION: CDA 172-AT BE-CU
SPECIMEN NUMBER: BC-L13 TH: 0.354
SPECIMEN TYPE: 2 W: 2.000
YIELD STRENGTH: 130
TEMPERATURE: 75

REC NO.	AA (IN)	AB (IN)	A(AVG) (IN)	PMIN (LBS)	PMAX (LBS)	R	KILO-CYCLES	FREQENCY (HERTZ)	da/dN (xE6)	DELTA K (KSI SQRT IN)
1	0.7582	0.7054	0.7318	54.37	547.03	0.099	582.266	50.0		
									0.035	6.63
2	0.7759	0.7078	0.7418	54.44	546.12	0.100	871.803	50.0		
									0.077	6.73
3	0.7883	0.7254	0.7568	54.22	544.09	0.100	1066.279	50.0		
									0.091	6.85
4	0.7988	0.7448	0.7718	52.97	541.94	0.098	1230.334	50.0		
									0.103	6.96
5	0.8122	0.7615	0.7869	54.31	541.09	0.100	1376.758	50.0		
									0.109	7.29
6	0.8345	0.7896	0.8121	55.16	548.72	0.101	1608.701	50.0		
									0.121	7.54
7	0.8604	0.8140	0.8372	54.87	548.69	0.100	1815.539	50.0		
									0.129	7.80
8	0.8840	0.8406	0.8623	54.56	547.72	0.100	2010.426	50.0		
									0.156	7.95
9	0.9051	0.8700	0.8875	59.00	544.78	0.108	2171.865	50.0		
									0.226	8.41
10	0.9293	0.8960	0.9127	55.44	551.50	0.101	2282.990	50.0		
									0.223	8.61
11	0.9502	0.9256	0.9379	58.91	548.78	0.107	2396.234	50.0		
									0.258	8.59
12	0.9551	0.9307	0.9429	61.31	546.28	0.112	2415.693	50.0		
									0.295	8.64
13	0.9606	0.9352	0.9479	60.84	544.97	0.112	2432.730	50.0		
									0.381	8.71
14	0.9679	0.9380	0.9529	61.72	546.16	0.113	2445.912	50.0		
									0.240	8.77
15	0.9724	0.9435	0.9580	61.75	543.28	0.114	2466.856	50.0		