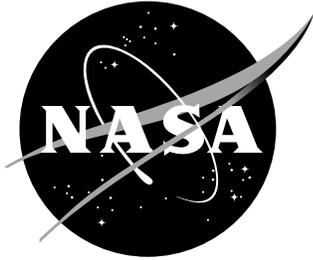


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# Fracture Test Results for 0.5, 0.7 and 0.9 Inch Thick 2324-T39 Aluminum Alloy Material

*William M. Johnston  
Analytical Services and Materials Inc., Hampton, Virginia*

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March 2001

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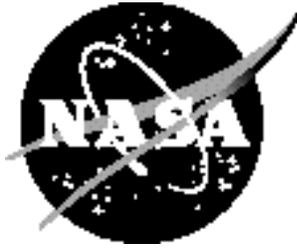
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# **FRACTURE TEST RESULTS FOR 0.5, 0.7 AND 0.9 INCH THICK 2324-T39 ALUMINUM ALLOY MATERIAL**

William M. Johnston  
Analytical Services and Materials Inc.  
Hampton, Virginia

## **Abstract**

*A summary of experimental data is presented for a series of fracture tests and tensile tests that were conducted on a 2324-T39 aluminum alloy material. Static tensile tests were performed to determine the stress-strain response for the material. For the fracture tests three thicknesses (B= 0.5, 0.7, and 0.9-inches) and two specimen types (middle crack tension and compact tension specimens) were used. The middle crack tension specimens were 12-inches wide, and the compact tension specimens were 2, 4, and 6-inches wide. The fracture tests were conducted in the L-T orientation (crack perpendicular to the rolling direction and load parallel to the rolling direction).*

## **Introduction**

The 2324-T39 aluminum alloy is being considered for use in the aircraft industry in applications where other 2000 series aluminum has been used in the past. Before this material can be applied to aircraft structures it is important that the fracture behavior be characterized. The 2324-T39 material was tested in a number of thicknesses and specimen widths. The results from this experimental program provide baseline fracture data on this material that can be used to quantify the materials performance. In addition this set of fracture test result along with the elastic-plastic tensile properties provide the information necessary for analysts to validate fracture methodology on this material for different thicknesses and widths.

The objective of this report is to provide a complete documentation of the experimental measurements made on the 2324-T39 aluminum alloy for the 0.5, 0.7, and 0.9 inch thick fracture tests and the 0.3 inch thick tensile test. The fracture behavior of 2324-T39 aluminum alloy was characterized through a series fracture tests on compact tension, C(T), and middle crack tension, M(T), specimens. The test procedures are discussed and the experimental measurements of failure stress, load versus crack extension and stress versus strain are reported.

## **Experimental Procedure**

Two types of fracture specimen were tested, compact tension, C(T), and middle crack tension, M(T). Three different specimen thicknesses were tested (B= 0.5, 0.7, and 0.9-inch). The specimens were configured in the L-T orientation, defined by orientating the crack perpendicular to the rolling direction and load parallel to the rolling direction. A schematic of a C(T) specimen is shown in Figure 1. Three different C(T) specimen sizes were tested with W = 2, 4, and 6-inches. The initial crack-length-to-width ratio for all of the C(T) specimens was  $a/W = 0.4$ . A schematic of a M(T) specimen is shown in Figure 2. The initial crack-length-to-width ratio of the M(T) specimens was  $2a/W = 1/3$  for the 0.5 and 0.7-inch thick specimens and  $2a/W = .39$  for the 0.9-inch-thick-specimen. The initial crack length for the 0.9-inch specimen was increased so the specimen could be tested to failure. All specimens were tested without guide plates and did not experience buckling. Experimental

measurements of load against crack extension were made during the fracture tests.

The M(T) and C(T) specimens were fatigue precracked at a stress-intensity factor range of approximately  $\Delta K = 8 \text{ ksi}(\text{in})^{1/2}$ . These specimens were fractured under displacement control, at a ramp rate in the range of 0.01-0.04 inch/minute. The failure load from each test was recorded. Crack extension was measured using an optical microscope on both surfaces of the specimen.

Three tensile tests were conducted on 0.3-inch thick standard 0.5-inch wide rectangular tension specimen. The tensile tests were conducted according to the ASTM E8 standard. Young's modulus, yield stress and ultimate tensile stress were calculated from the results. A linear piecewise function was fit to the data.

## Experimental Results

The maximum load measured in the C(T) tests for all thicknesses (B= 0.5, 0.7, and 0.9 inch) are listed in Tables 1-3, respectively, and plotted in Figure 3. The maximum (failure) stresses calculated from the M(T) test results are listed in Tables 4 and plotted in Figure 4. The following sections describe the crack length and displacement measurements made for each of the specimen types.

### Compact Tension Tests

Optical measurements of crack extension at the surface and the corresponding applied load were recorded for each of the tests. The crack extension measurements were made on the front and back surface of the specimens. These measurements are shown in Figure 5-7 for each specimen size and listed in Tables 5-17.

### Middle Crack Tension Tests

Optical measurements of crack extension and the corresponding applied stress were recorded for all of the tests. The experimental setup allowed total crack extension (both left and right tips) measurement on one side of the specimen, but on the other side only one crack tip was measured. The crack extension ( $\Delta a$ ) results reported for the front of the panels represents an average of the left and right crack extensions. The stresses reported are nominal stress in the M(T) specimens and is defined by:

$$\sigma = \frac{F}{W \cdot B} \quad (1)$$

where F is the applied load. The results for 12 inch wide M(T) specimens are shown in Figure 8 and listed in Tables 20-22 for each specimen thickness.

### Static Tension Tests

The results from the static tests are presented in Figure 9. This figure shows the stress-strain results from the three tensile tests along with a piecewise linear fit. Data for the linear fit is shown in the two columns of data on Figure 9. The material has a Young's modulus of 10.48 Mpsi. The yield stress and ultimate stress for the material were determined to be 66.0 ksi and 71.8 ksi respectively.

## Summary

Fracture and tensile tests were conducted on a 2324-T39 aluminum alloy. For the fracture tests

three different specimen thicknesses were used ( $B = 0.5, 0.7,$  and  $0.9$  inch) in the L-T orientation. Both middle crack tension M(T) specimens and compact tension C(T) specimens were tested. The width of the M(T) specimens were 12 inches and the width of the C(T) specimens were  $W = 2, 4,$  and 6 inches. Results in the form of load versus. crack extension and stress versus strain were reported.

Table 1. Failure Load Results from the C(T) Fracture Tests ( $B=0.90, a/W = 0.4$ )

Width (inch)	Failure Load (kips)	Crack Length (inch)
2.0	6.22	0.800
2.0	6.18	0.800
4.0	11.40	1.600
4.0	11.48	1.600
4.0	11.18	1.600
6.0	16.20	2.399
6.0	16.05	2.400
6.0	16.15	2.400

Table 2. Failure Load Results from the C(T) Fracture Tests ( $B=0.70, a/W = 0.4$ )

Width, W (inch)	Failure Load (kips)	Crack Length, a (inch)
2.0	5.29	0.801
2.0	5.27	0.800
2.0	5.12	0.813
4.0	10.15	1.600
4.0	9.98	1.599
4.0	10.03	1.599
6.0	14.85	2.400
6.0	14.60	2.403
6.0	14.95	2.400

Table 3. Failure Load Results from the C(T) Fracture Tests ( $B=0.50, a/W = 0.4$ )

Width, W (inch)	Failure Load (kips)	Crack Length, a (inch)
4.0	8.55	1.600
4.0	8.38	1.601
4.0	8.21	1.600
6.0	11.88	1.600
6.0	11.85	2.401
6.0	12.10	2.400

Table 4. Failure Stress Results for the 12-inch wide M(T) Fracture Test Specimens

Thickness, B (inch)	Failure Stress (ksi)	Crack Length, 2a (inch)
0.5	31.90	4.000
0.5	32.50	4.002
0.7	30.14	3.999
0.7	30.21	3.999
0.9	24.42	4.701
0.9	24.39	4.697

Table 5. Load and Crack Extension Results for 6-inch-Wide C(T) Test Specimens  
(Initial  $a/W=0.4$ )

B = 0.90			B = 0.90		
Load (kips)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)	Load (kips)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)
0.00	0.000	0.000	0.00	0.000	0.000
11.90	0.008	0.010	13.45	0.022	0.018
13.75	0.033	0.030	14.55	0.069	0.064
15.20	0.086	0.096	15.40	0.117	0.176
15.60	0.149	0.122	15.65	0.167	0.239
16.05	0.203	0.198	15.80	0.229	0.255
16.10	0.265	0.248	16.00	0.290	0.292
16.20	0.336	0.355	16.05	0.357	0.366
16.15	0.423	0.393	15.95	0.433	0.479
16.05	0.529	0.526	15.60	0.483	0.483
15.45	0.619	0.652	15.45	0.540	0.535
14.70	0.695	0.667	15.25	0.597	0.649
14.25	0.754	0.786	14.60	0.666	0.703
13.60	0.884	0.857	14.25	0.777	0.754
13.00	0.952	0.904	13.55	0.859	0.825
12.30	1.070	1.038	12.95	0.914	0.991
11.30	1.143	1.108	12.45	0.975	1.025
10.90	1.213	1.176	11.70	1.025	1.095
10.10	1.317	1.227	11.35	1.111	1.161
9.80	1.365	1.270	10.80	1.208	1.192
9.45	1.419	1.368	10.25	1.275	1.309
8.80	1.457	1.426	9.55	1.373	1.373
8.30	1.520	1.502	8.95	1.460	1.414
7.80	1.586	1.538	7.90	1.527	1.513
7.45	1.637	1.608	7.75	1.593	1.626
6.90	1.721	1.676			
6.45	1.819	1.755			
5.65	1.851	1.866			

Table 6. Load and Crack Extension Results for 6-inch-Wide C(T) Test Specimens  
(Initial  $a/W=0.4$ )

B = 0.90			B = 0.70		
Load (kips)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)	Load (kips)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)
0.00	0.000	0.000	0.00	0.000	0.000
13.10	0.012	0.025	11.33	0.006	0.027
14.35	0.065	0.052	12.95	0.033	0.095
15.10	0.098	0.087	13.45	0.073	0.147
15.80	0.160	0.145	14.43	0.139	0.278
15.85	0.192	0.193	14.53	0.175	0.291
16.00	0.234	0.222	14.73	0.296	0.347
16.10	0.304	0.282	14.80	0.344	0.447
16.15	0.381	0.331	14.85	0.400	0.489
16.05	0.453	0.438	14.60	0.451	0.554
15.75	0.504	0.491	14.50	0.512	0.661
15.50	0.565	0.554	14.18	0.555	0.751
15.25	0.618	0.609	13.98	0.598	0.799
14.70	0.727	0.699	13.95	0.647	0.851
14.35	0.828	0.783	13.53	0.701	0.887
13.60	0.900	0.801	13.30	0.742	0.941
13.30	0.996	0.942			
12.40	1.087	0.989			
11.75	1.152	1.070			
11.15	1.240	1.185			
10.35	1.303	1.220			
10.00	1.384	1.351			
8.90	1.538	1.446			
7.90	1.742	1.634			

Table 7. Load and Crack Extension Results for 6-inch-Wide C(T) Test Specimens  
(Initial  $a/W=0.4$ )

B = 0.70			B = 0.70		
Load (kips)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)	Load (kips)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)
0.00	0	0	0.00	0.000	0.000
11.00	0.014	0.012	11.23	0.013	0.015
12.40	0.027	0.058	12.75	0.040	0.075
13.15	0.064	0.12	14.00	0.085	0.172
13.60	0.115	0.16	14.85	0.147	0.231
13.98	0.185	0.225	14.90	0.188	0.303
14.33	0.235	0.276	14.93	0.245	0.346
14.50	0.323	0.388	14.95	0.307	0.440
14.60	0.374	0.472	14.90	0.391	0.518
14.45	0.429	0.495	14.73	0.442	0.581
14.40	0.473	0.612	14.43	0.503	0.658
14.23	0.546	0.674	14.23	0.571	0.700
13.93	0.63	0.804	14.00	0.614	0.727
13.33	0.699	0.86	13.88	0.664	0.867
12.98	0.737	0.904	13.53	0.727	0.911
12.65	0.793	0.95	13.10	0.819	1.048
12.48	0.84	1.028	12.48	0.861	1.095
12.13	0.918	1.138	12.23	0.916	1.156
11.55	1.013	1.262	11.85	0.963	1.199
			11.50	1.007	1.250
			11.25	1.057	1.290
			10.90	1.132	1.375
			10.30	1.165	1.417

Table 8. Load and Crack Extension Results for 6-inch-Wide C(T) Test Specimens  
(Initial  $a/W=0.4$ )

B = 0.50			B = 0.50		
Load (kips)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)	Load (kips)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)
0.00	0.000	0.000	0.00	0.000	0.000
8.13	0.012	0.023	8.30	0.009	0.022
9.28	0.024	0.030	9.55	0.039	0.052
10.30	0.084	0.080	10.68	0.093	0.078
11.30	0.142	0.136	11.08	0.134	0.145
11.48	0.173	0.180	11.35	0.182	0.181
11.58	0.253	0.224	11.65	0.255	0.236
11.75	0.311	0.259	11.85	0.302	0.288
11.80	0.383	0.326	11.78	0.348	0.332
11.83	0.409	0.376	11.75	0.376	0.342
11.88	0.470	0.431	11.83	0.409	0.397
11.80	0.527	0.514	11.80	0.491	0.437
11.60	0.596	0.534	11.73	0.530	0.479
11.45	0.694	0.613	11.70	0.591	0.552
11.18	0.753	0.673	11.38	0.621	0.560
10.98	0.811	0.743	11.33	0.706	0.657
10.73	0.903	0.834	11.05	0.764	0.729
10.15	0.984	0.887	10.80	0.819	0.781
			10.63	0.916	0.835
			10.20	0.979	0.935
			9.73	1.034	0.997
			9.33	1.105	1.051
			9.00	1.176	1.108
			8.53	1.244	1.173

Table 9. Load and Crack Extension Results for 6-inch-Wide C(T) Test Specimens  
(Initial  $a/W=0.4$ )

B = 0.50		
Load (kips)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)
0.00	0.000	0.000
7.75	0.040	0.012
9.00	0.028	0.024
10.08	0.062	0.067
11.13	0.113	0.130
11.45	0.171	0.178
11.93	0.231	0.257
11.95	0.289	0.309
12.10	0.362	0.403
12.10	0.428	0.470
12.05	0.465	0.520
12.03	0.500	0.547
11.85	0.547	0.592
11.80	0.612	0.692
11.48	0.681	0.735
11.28	0.740	0.836
10.75	0.781	0.802
10.58	0.811	0.803
10.43	0.869	0.972
9.93	0.906	1.013

Table 10. Load and Crack Extension Results for 4-inch-Wide C(T) Test Specimens  
(Initial  $a/W=0.4$ )

B = 0.90			B = 0.90		
Load (kips)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)	Load (kips)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)
0.00	0.000	0.000	0.00	0.000	0.000
9.53	0.015	0.002	10.40	0.031	0.022
10.53	0.040	0.026	11.03	0.052	0.076
11.03	0.097	0.058	11.43	0.106	0.131
11.35	0.149	0.097	11.48	0.158	0.204
11.40	0.184	0.138	11.45	0.218	0.261
11.38	0.243	0.196	11.10	0.276	0.305
11.18	0.296	0.260	10.75	0.411	0.422
10.93	0.368	0.321	9.78	0.448	0.473
10.53	0.420	0.383	9.40	0.508	0.542
10.00	0.485	0.425	8.93	0.590	0.601
9.43	0.564	0.477			

Table 11. Load and Crack Extension Results for 4-inch-Wide C(T) Test Specimens  
(Initial  $a/W=0.4$ )

B = 0.90			B = 0.70		
Load (kips)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)	Load (kips)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)
0.00	0.000	0.000	0.00	0.000	0.000
10.25	0.018	0.015	7.50	0.018	0.005
10.85	0.050	0.054	8.40	0.034	0.011
11.18	0.101	0.102	9.30	0.067	0.037
11.15	0.166	0.196	9.93	0.119	0.073
11.03	0.232	0.259	10.15	0.157	0.138
10.90	0.262	0.354	10.13	0.189	0.182
10.55	0.306	0.408	10.03	0.251	0.234
10.20	0.352	0.460	9.95	0.291	0.301
9.80	0.442	0.541	9.90	0.335	0.338
9.23	0.480	0.589	9.73	0.411	0.368
8.73	0.535	0.638	9.45	0.479	0.414
8.33	0.595	0.661			
7.83	0.646	0.707			
7.55	0.693	0.799			
6.98	0.751	0.817			

Table 12. Load and Crack Extension Results for 4-inch-Wide C(T) Test Specimens  
(Initial  $a/W=0.4$ )

B = 0.70			B = 0.70		
Load (kips)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)	Load (kips)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)
0.00	0.000	0.000	0.00	0.000	0.000
7.73	0.010	0.003	7.53	0.010	0.004
8.73	0.026	0.024	8.40	0.028	0.017
9.53	0.052	0.055	9.43	0.051	0.039
9.78	0.093	0.099	9.63	0.083	0.086
9.90	0.137	0.135	9.85	0.133	0.128
9.95	0.209	0.175	9.85	0.179	0.153
9.98	0.250	0.220	9.95	0.230	0.201
9.78	0.291	0.276	10.03	0.286	0.267
9.68	0.339	0.325	9.90	0.323	0.311
9.48	0.431	0.391	9.83	0.364	0.360
9.15	0.482	0.439	9.65	0.408	0.381
9.03	0.501	0.453	9.48	0.485	0.418
8.70	0.573	0.483	9.13	0.540	0.493
			8.78	0.596	0.548
			8.13	0.657	0.603
			8.03	0.693	0.658

Table 13. Load and Crack Extension Results for 4-inch-Wide C(T) Test Specimens  
(Initial  $a/W=0.4$ )

B = 0.50			B = 0.50		
Load (kips)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)	Load (kips)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)
0.00	0.000	0.000	0.00	0.000	0.000
6.07	0.007	0.002	6.63	0.011	0.004
7.00	0.025	0.011	7.11	0.028	0.020
7.83	0.060	0.042	7.84	0.055	0.061
8.10	0.100	0.094	8.08	0.102	0.074
8.38	0.140	0.149	8.28	0.142	0.113
8.52	0.194	0.179	8.37	0.196	0.147
8.55	0.267	0.251	8.38	0.234	0.222
8.35	0.315	0.282	8.33	0.282	0.258
8.32	0.372	0.314	8.28	0.335	0.324
8.16	0.473	0.382	8.17	0.386	0.367
7.85	0.540	0.467	7.98	0.434	0.426
7.46	0.641	0.507	7.75	0.477	0.462
7.12	0.685	0.541			
6.90	0.737	0.617			
6.52	0.784				

Table 14. Load and Crack Extension Results for 4-inch-Wide C(T) Test Specimens  
(Initial  $a/W=0.4$ )

B = 0.50		
Load (kips)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)
0	0.000	0.000
6.19	0.008	0.007
7.09	0.031	0.027
7.85	0.072	0.093
7.97	0.117	0.124
8.12	0.162	0.158
8.17	0.253	0.212
8.21	0.294	0.278
8.13	0.351	0.349
7.99	0.390	0.375
7.87	0.460	0.440
7.62	0.508	0.470
7.42	0.559	0.523
7.32	0.645	0.601
6.85	0.684	0.652
6.57	0.728	0.722

Table 15. Load and Crack Extension Results for 2-inch-Wide C(T) Test Specimens  
(Initial  $a/W=0.4$ )

B = 0.90			B = 0.90		
Load (kips)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)	Load (kips)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)
0.00	0.000	0.000	0	0.000	0.000
6.14	0.006	0.009	6.18	0.042	0.019
6.22	0.040	0.032	6.17	0.066	0.035
6.09	0.094	0.070	6.01	0.117	0.094
5.91	0.154	0.111	5.69	0.188	0.145
5.45	0.212	0.179	5.11	0.259	0.220
4.93	0.279	0.241	4.44	0.325	0.282
4.20	0.364	0.321	3.74	0.372	0.365
3.55	0.426	0.402	3.18	0.412	0.441
2.84	0.475	0.490	2.64	0.495	0.509
2.39	0.512	0.546	2.04	0.580	0.581
2.00	0.547	0.603	1.62	0.646	0.619
1.67	0.640	0.654	1.25	0.671	0.671
1.25	0.683	0.702	1.04	0.712	0.735
1.04	0.729	0.740	0.85	0.737	0.743
0.84	0.752	0.784	0.75	0.780	0.785
0.72	0.793	0.818	0.61	0.809	0.818
0.58	0.826	0.865	0.59	0.819	0.821
0.49	0.841	0.882	0.46	0.845	0.862

Table 16. Load and Crack Extension Results for 2-inch-Wide C(T) Test Specimens  
(Initial  $a/W=0.4$ )

B = 0.70			B = 0.70		
Load (kips)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)	Load (kips)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)
0.00	0.000	0.000	0.00	0.000	0.000
1.70	0.001	0.000	4.53	0.061	0.000
4.26	0.003	0.002	5.15	0.242	0.044
4.68	0.004	0.016	5.27	0.813	0.169
5.14	0.019	0.018	5.15	0.136	0.226
5.25	0.051	0.025	4.78	0.180	0.316
5.26	0.063	0.029	4.28	0.255	0.319
5.29	0.089	0.050	3.62	0.318	0.427
5.26	0.111	0.063	3.11	0.356	0.477
5.17	0.151	0.087	2.75	0.444	0.515
5.00	0.210	0.134	2.31	0.494	0.572
4.72	0.281	0.173	1.60	0.588	0.686
4.24	0.334	0.237	1.37	0.647	0.735
3.80	0.396	0.304	1.11	0.684	0.770
3.31	0.410	0.350	1.01	0.724	0.788
3.80	0.437	0.380	0.86	0.746	0.827
2.76	0.468	0.425	0.64	0.798	0.848
2.63	0.528	0.463	0.52	0.844	0.874
2.17	0.563	0.537	0.41	0.855	0.940
1.72	0.606	0.585	0.31	0.886	0.996
1.53	0.626	0.634	0.17	0.928	1.024
1.27	0.678	0.677			
1.07	0.698	0.728			
0.89	0.726	0.747			
0.79	0.772	0.761			
0.69	0.802	0.778			
0.47	0.840	0.881			
0.44	0.879	0.895			

Table 17. Load and Crack Extension Results for 2-inch-Wide C(T) Test Specimens (Initial  $a/W=0.4$ )

B = 0.70		
Load (kips)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)
0	0.000	0.000
4.98	0.009	0.021
5.08	0.044	0.059
5.12	0.082	0.152
5.04	0.141	0.260
4.36	0.202	0.322
3.84	0.303	0.409
3.16	0.359	0.508
2.6	0.392	0.539
2.2	0.450	0.639
1.88	0.508	0.683
1.52	0.590	0.806
1.08	0.648	0.855
0.8	0.688	0.891

Table 18. Stress versus Crack Extension Results for 12-inch-Wide M(T) Test Specimens. (Initial  $2a/W = 1/3$ ,  $B=0.5$ )

Stress (ksi)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)	Stress (ksi)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)
1.15	0.000	0.000	0.00	0.000	0.000
18.85	0.020	0.010	18.65	0.014	0.010
31.90*			21.55	0.023	0.029
			23.85	0.039	0.033
			32.50*		

\* Failure Stress

**Note:** Due to testing problem, load versus crack extension data could not be taken.

Table 19. Stress versus Crack Extension Results for 12-inch-Wide M(T) Test Specimens.  
(Initial  $2a/W = 1/3$ ,  $B=0.7$ )

Stress (ksi)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)	Stress (ksi)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)
0.00	0.000	0.000	0.00	0.000	0.000
18.11	0.020	0.009	17.64	0.012	0.013
21.46	0.048	0.019	21.43	0.053	0.030
23.82	0.110	0.045	24.93	0.119	0.070
25.39	0.151	0.092	27.00	0.196	0.110
27.07	0.234	0.145	28.29	0.287	0.207
28.04	0.304	0.196	29.21	0.392	0.275
28.61	0.406	0.272	29.64	0.486	0.339
29.00	0.433	0.367	30.00	0.584	0.516
29.57	0.571	0.515	30.21	0.741	0.686
29.93	0.657	0.615			
30.14	0.770	0.791			

Table 20. Stress vs Crack Extension Results for 12-inch-Wide M(T) Test Specimens.  
(Initial  $2a/W = 1/3$ ,  $B=0.9$ )

Stress (ksi)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)	Stress (ksi)	Front $\Delta a$ (inch)	Back $\Delta a$ (inch)
0.00	0.000	0.000	0.00	0.000	0.000
14.44	0.005	0.009	15.42	0.020	0.010
16.50	0.019	0.032	17.03	0.023	0.038
17.92	0.036	0.069	18.81	0.078	0.073
20.14	0.116	0.106	20.33	0.123	0.092
20.44	0.135	0.171	20.92	0.142	0.142
21.33	0.190	0.235	22.08	0.228	0.202
22.06	0.223	0.265	22.61	0.282	0.242
22.50	0.272	0.312	23.06	0.332	0.302
23.44	0.410	0.419	23.58	0.385	0.371
23.92	0.532	0.489	23.97	0.522	0.437
24.19	0.603	0.568	24.28	0.664	0.572
24.42	0.829	0.805	24.39	0.973	0.673
			24.39	0.914	0.830

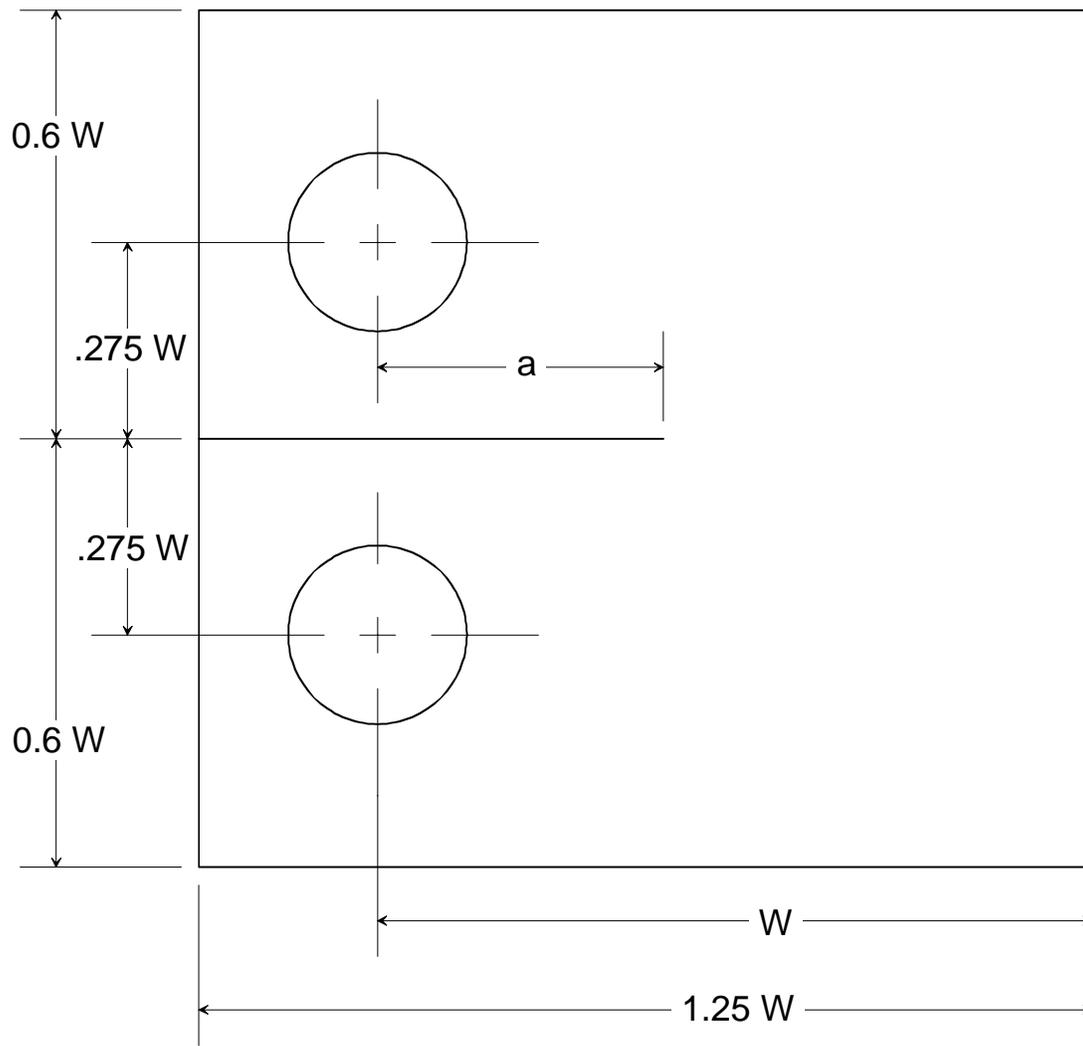


Figure 1. Schematic of a compact tension specimen ( $W$  = specimen width).

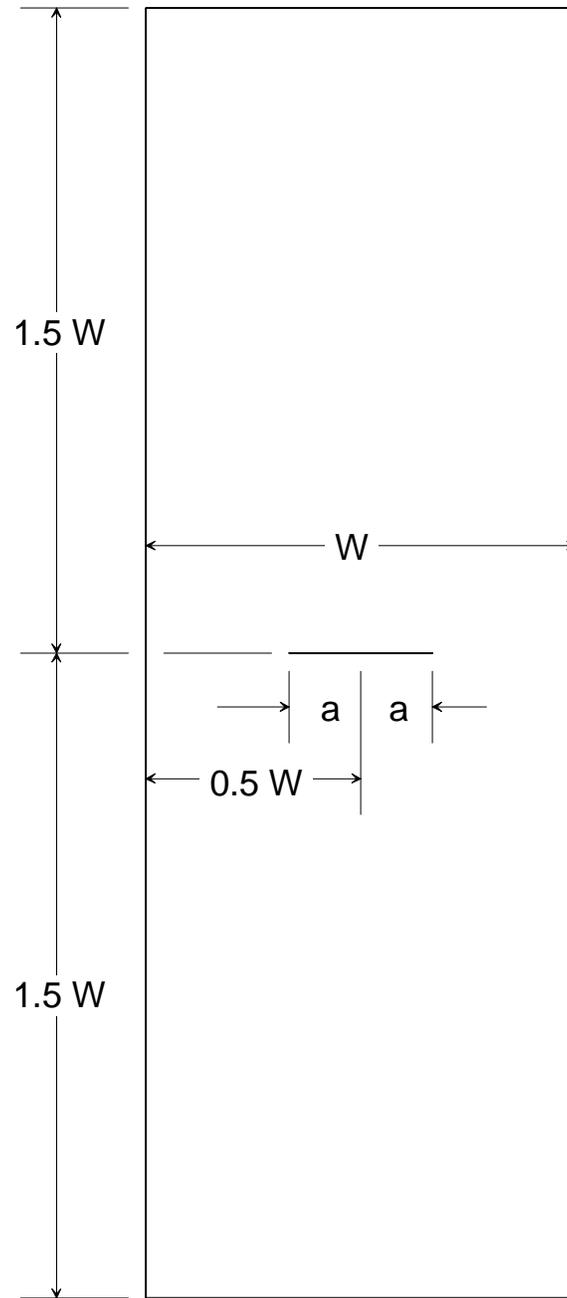


Figure 2. Schematic of a middle crack tension specimen ( $W$  = specimen width).

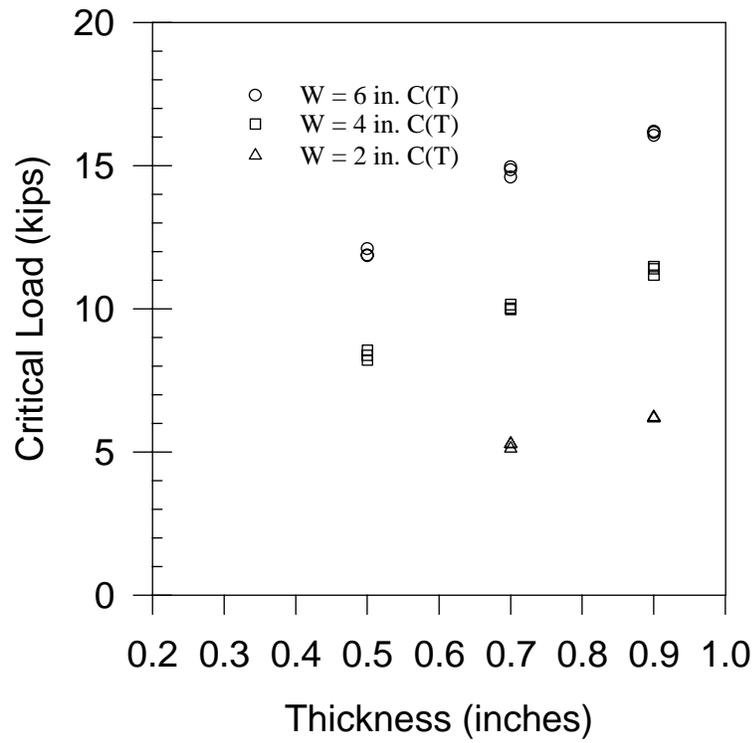


Figure 3. Failure loads for C(T) fracture test specimens with different widths. (Initial  $a/W = 0.4$ )

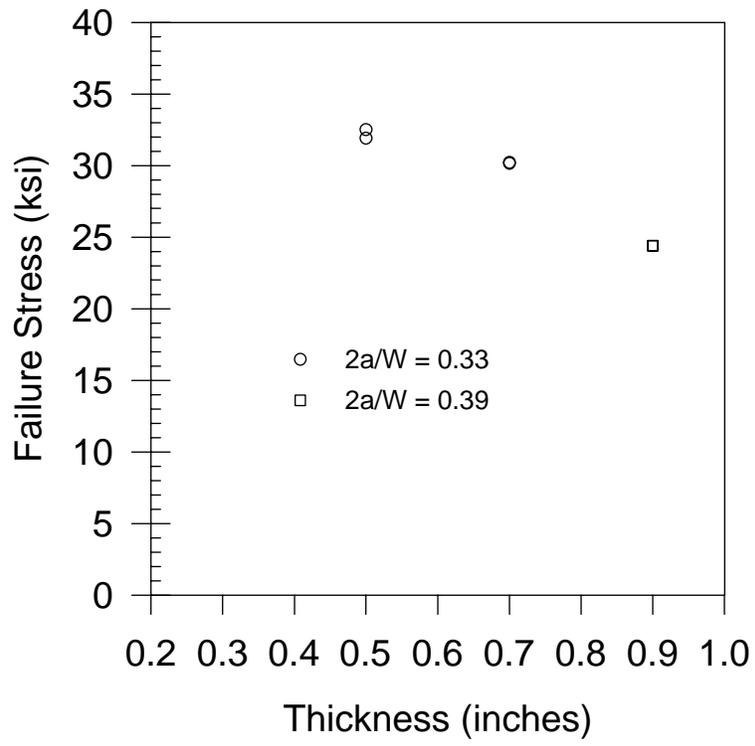


Figure 4. Failure stress results for the 12-inch-wide M(T) fracture test specimens.

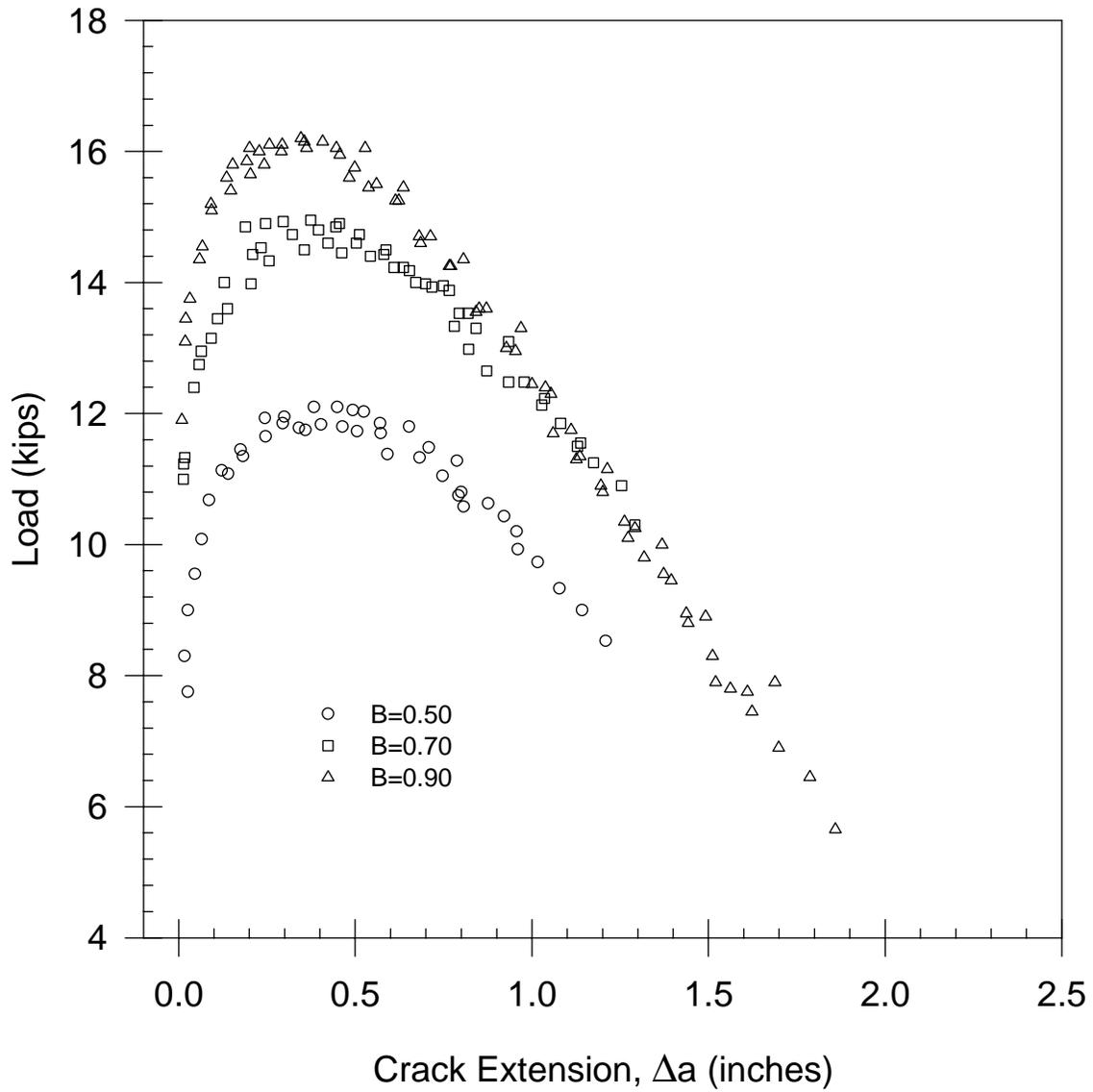


Figure 5. Load versus crack extension results for the 6-inch-wide C(T) specimens of different thicknesses (Initial  $a/W=0.4$ ).

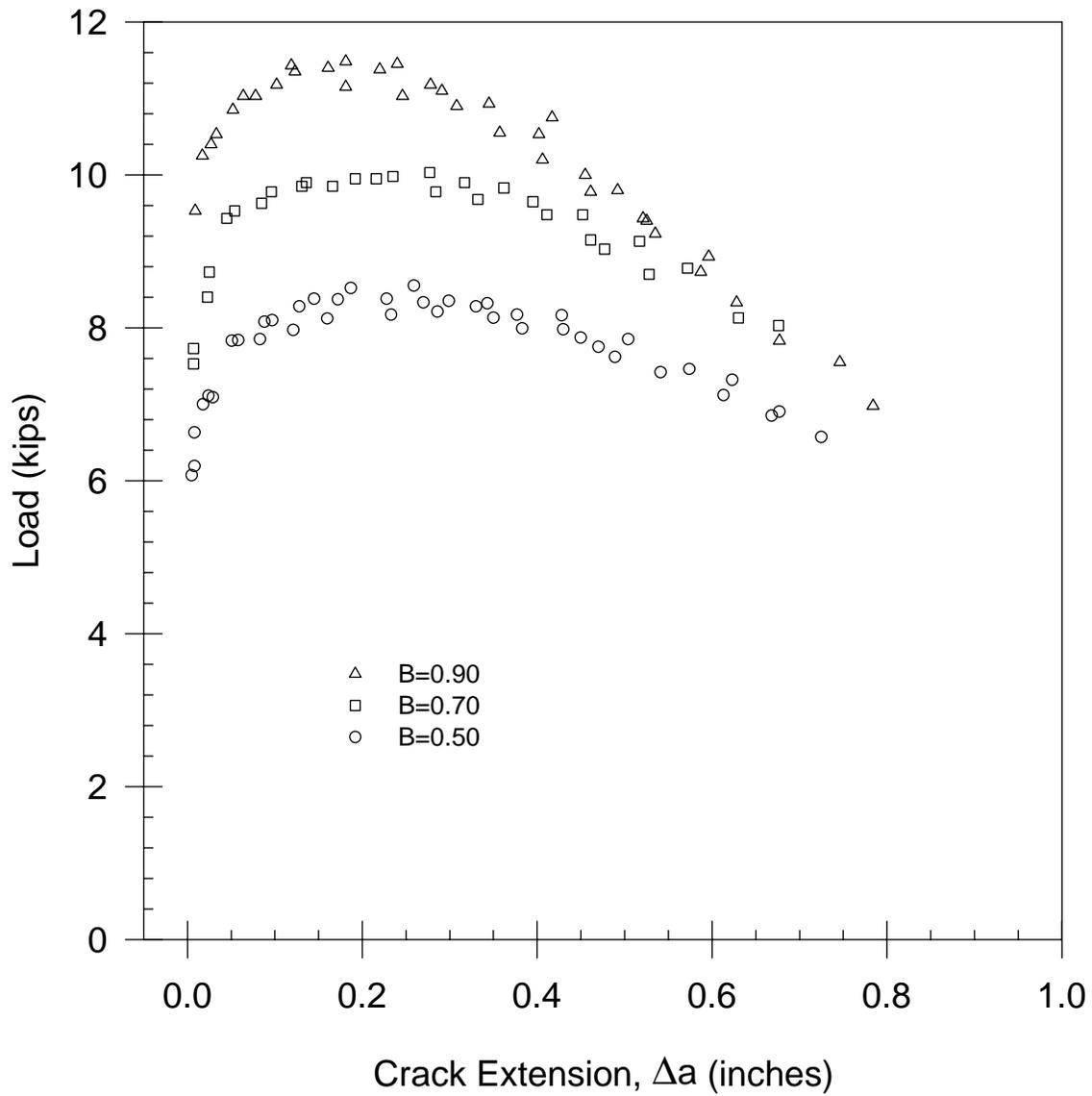


Figure 6. Load versus crack extension results for the 4-inch-wide C(T) specimens of different thicknesses (Initial  $a/W=0.4$ ).

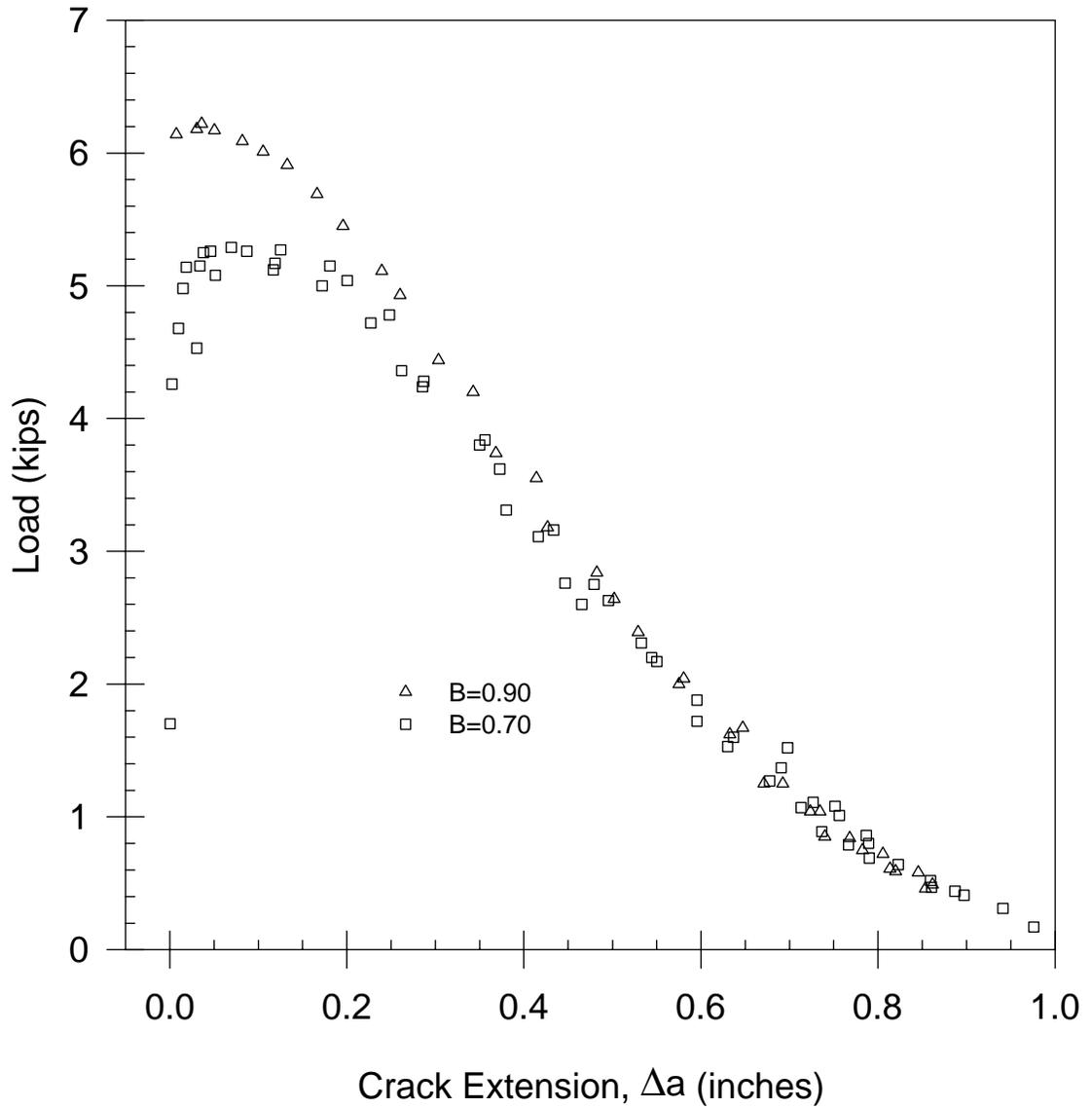


Figure 7. Load versus crack extension results for the 2-inch-wide C(T) specimens of different thicknesses (Initial  $a/W = 0.4$ ).

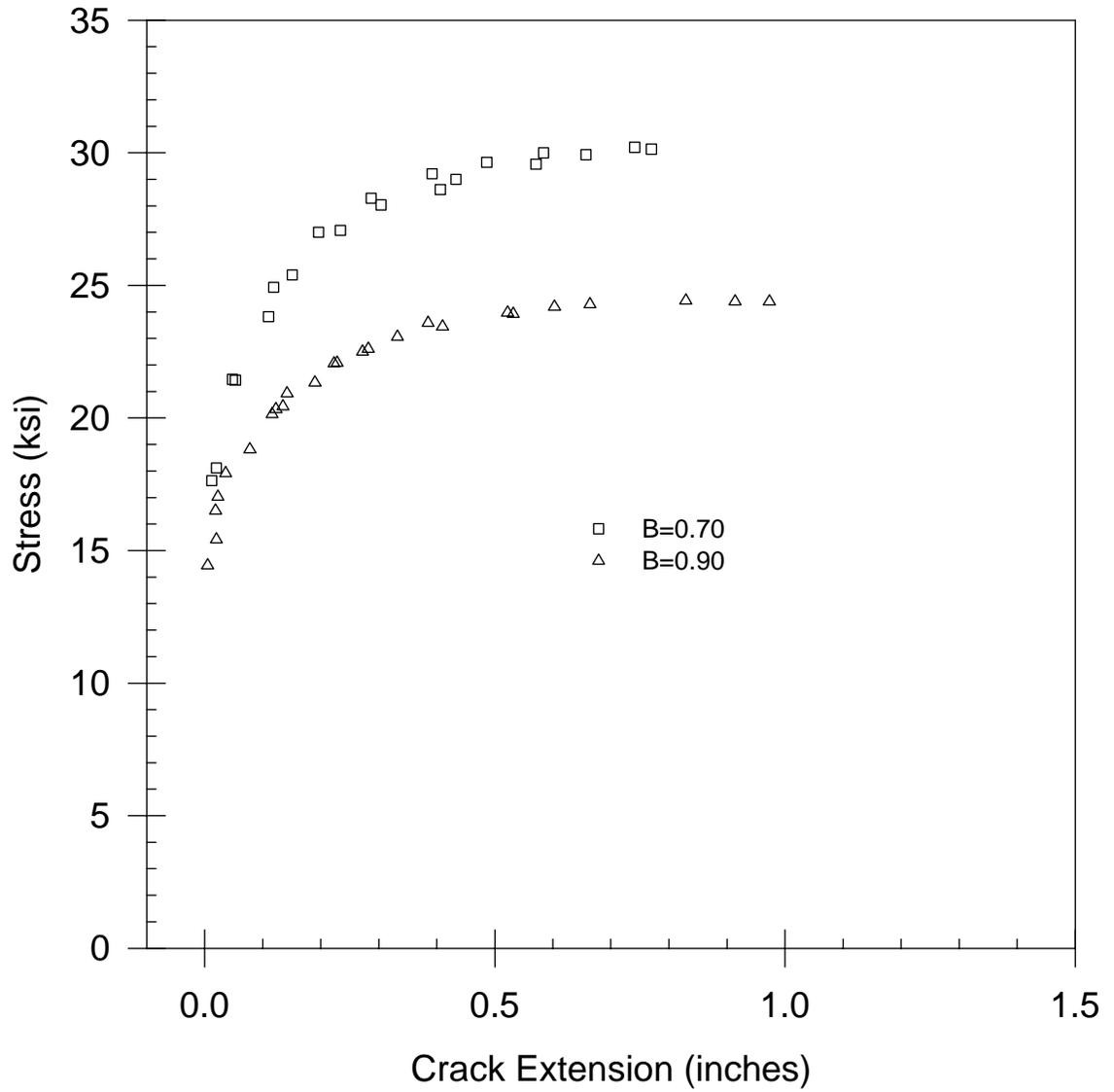


Figure 8. Stress versus crack extension results for the 12-inch-wide M(T) specimens of different thicknesses (Initial  $2a/W = 1/3$ ).

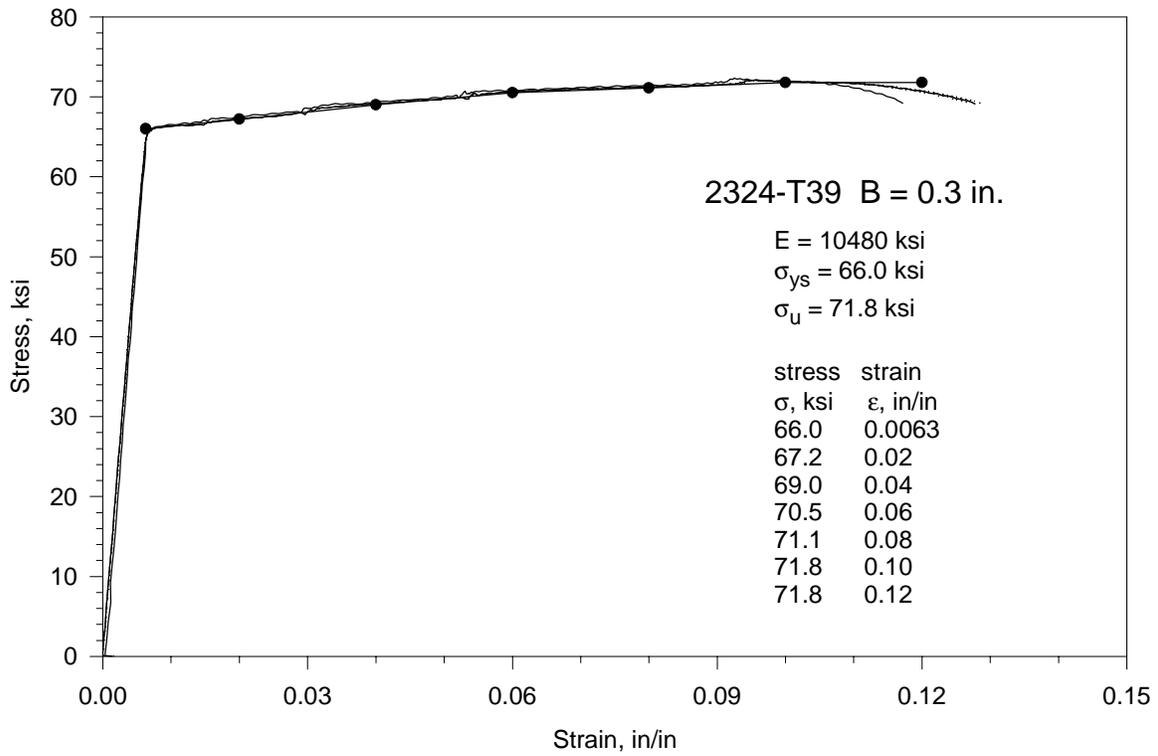


Figure 9. Tensile stress results for 0.3-inch-thick 22324 T-39 aluminum specimens.

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13. ABSTRACT (Maximum 200 words) A summary of experimental data is presented for a series of fracture tests and tensile tests that were conducted on a 2324-T39 aluminum alloy material. Static tensile tests were performed to determine the stress-strain response for the material. For the fracture tests three thicknesses (B= 0.5, 0.7, and 0.9-inches) and two specimen types (middle crack tension and compact tension specimens) were used. The middle crack tension specimens were 12-inches wide, and the compact tension specimens were 2, 4, and 6-inches wide. The fracture tests were conducted in the L-T orientation (crack perpendicular to the rolling direction and load parallel to the rolling direction).				
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