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Flaw Growth in Complex Structure Volume II – Test Data

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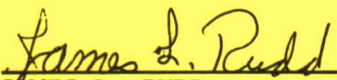
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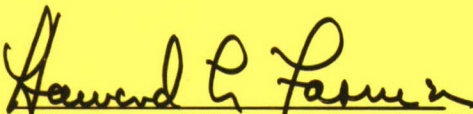


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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The test data from Contract F33615-75-C-3093 "Flaw Growth in Complex Structure" are summarized in this volume of this report. Sixty-eight structural speci- mens (26 joints and 42 stringer-reinforced panels) were machined, precracked, assembled and fatigue tested. (Volume I is a detailed technical discussion of the program.) Data are tabulated for each specimen. Data plots are also pre- sented in which the test results are compared to analytical predictions.		

FOREWORD

The experimental and analytical research program reported herein was the responsibility of the Structural Methods Group of the Lockheed-California Company from 12 May 1975 to 12 September 1977. The work was performed for the Air Force Flight Dynamics Laboratory to fulfill the objectives of Contract F33615-75-C-3093.

J. L. Rudd was the AFFDL technical monitor, and his continuous interest in every detail was of great technical benefit to the program.

The care that was taken in specimen preparation and testing led to a reliable set of test results. Specimen fabrication and precracking were coordinated by W. P. Renslen with assistance from W. F. Kerwin, both of Del West Engineering. Testing, under the direction of D. E. Pettit, was carried out by the Lockheed Rye Canyon Fatigue Laboratory personnel including F. M. Pickel, D. Black, C. J. Looper, L. Reed, L. Silvas and C. L. Spratt.

Special thanks are in order for W. G. Browne, who provided continuous guidance in budget management and program administration throughout the course of the program. E. K. Walker, J. C. Wordsworth, and J. C. Ekvall are thanked for their valuable contributions in the area of program management as well as their technical consultation. Others in the Stress Department who made significant technical contributions were L. Bakow, W. L. Rakness, P. Schall and R. C. Smith. R. J. Van Ness and the Publication Services Department are appreciated for coordinating the layout, typing and artwork for the final report.

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SECTION I
INTRODUCTION

Sixty-eight fatigue tests were conducted of mechanically-fastened structural test specimens containing 0.050-inch fatigue-induced initial corner cracks. This volume contains a specimen-by-specimen summary of these test data. The data are presented on annotated tables giving crack sizes versus loading cycles. The data are plotted and compared to crack growth predictions, which were formulated prior to the testing as summarized in Section V of Volume I.

Because of the number of specimens tested and the complexity of each, an almost unlimited time could be spent reviewing and learning from the data. The purpose of Volume II is to provide an easy-to-read, concise, yet complete summary of each test result in the program, to facilitate future analytical review and use of the data by readers of the report.

SECTION II

BASELINE DATA

Baseline tensile data for the six product forms used in this program are presented in this section. In addition, R-curve data obtained using four center-cracked panels (CCT) are included. The R-curve data are presented in the form of stress intensity factors, K , versus incremental equivalent crack length, ΔC_e . The equivalent crack length, C_e , was calculated using crack opening displacements (COD) and Equation (50) in Volume I.

Other baseline data are tabulated or plotted in Section IV of Volume I.

TENSILE TEST RESULTS

PRODUCT FORM	SPECIMEN NUMBER	GRAIN DIRECTION	THICKNESS (INCH)	WIDTH (INCH)	TENSILE ULTIMATE (KSI)	TENSILE YIELD (KSI)	PERCENT ELONGATION
0.188 SHEET	N-1T	Trans.	0.1830	0.5030	87.5	76.7	13.0
	N-2T	Trans.	0.1827	0.5035	87.0	76.3	13.5
	N-3T	Trans.	0.1833	0.5030	87.2	76.6	13.0
	N-4L	Long.	0.1823	0.5020	85.2	78.6	14.0
	N-5L	Long.	0.1820	0.5017	85.4	78.6	14.5
	N-6L	Long.	0.1825	0.5023	85.1	78.5	14.0
0.094 SHEET	A-1L	Long.	0.0949	0.4973	83.5	77.3	12.5
	A-2L	Long.	0.0946	0.4977	83.9	77.9	13.0
	A-3L	Long.	0.0947	0.4985	83.5	77.1	13.0
	A-1T	Trans.	0.0948	0.4983	85.2	74.9	13.0
	A-2T	Trans.	0.0948	0.4985	85.2	73.7	13.0
	A-3T	Trans.	0.0948	0.4983	85.4	74.4	12.5
0.25 PLATE	B-1L	Long.	0.2557	0.5025	83.5	78.2	13.0
	B-2L	Long.	0.2554	0.4952	82.8	77.2	13.0
	B-3L	Long.	0.2556	0.4957	83.3	77.7	13.0
	B-1T	Trans.	0.2588	0.5010	84.4	73.6	13.0
	B-2T	Trans.	0.2587	0.5020	83.8	73.0	12.5
	B-3T	Trans.	0.2588	0.5018	84.1	72.0	13.0
0.375 PLATE	C-1L	Long.	0.386	0.5015	84.4	42.4*	14.0
	C-2L	Long.	0.3851	0.4997	84.4	79.6	14.0
	C-3L	Long.	0.3861	0.4995	84.0	78.1	13.5
	C-1T	Trans.	0.3858	0.4993	85.7	61.0*	12.0
	C-2T	Trans.	0.3858	0.5000	85.5	74.6	12.5
	C-3T	Trans.	0.3859	0.4994	85.6	75.2	10.0
0.25 ANGLE EXTRUSION	ANGLE-1L	Long.	0.2492	0.5000	89.3	61.9*	12.0
	ANGLE-2L	Long.	0.2473	0.4900	88.9	80.4	11.5
	ANGLE-3L	Long.	0.2495	0.4983	89.5	81.3	11.5
	ANGLE-1T	Trans.	0.0825	0.1280	83.4	75.3	13.0
	ANGLE-2T	Trans.	0.0823	0.1284	78.3	71.2	12.0
	ANGLE-3T	Trans.	0.0823	0.1288	79.0	70.7	12.0
0.188 TEE EXTRUSION	TEE-1L	Long.	0.1857	0.4993	88.4	80.8	9.5
	TEE-2L	Long.	0.1844	0.4983	87.8	80.3	11.0
	TEE-3L	Long.	0.1860	0.4983	87.9	80.7	11.0
	TEE-1T	Trans.	0.0805	0.1282	82.3	71.8	12.0
	TEE-2T	Trans.	0.0801	0.1287	79.7	71.7	12.0
	TEE-3T	Trans.	0.0795	0.1282	79.8	72.2	14.0

*Values not considered in computing average properties

R-CURVE DATA - SPECIMEN A-3-CCT

7075-T6, B = 0.0901 inch, w = 12.0 inch, A = 1.081 inch,
 E = $10.4 \cdot 10^6$ psi, $2C_1 = 3.993$ inch

LOAD, p (kip)	COD (inch)	C_e (inch)	K (ksi $\sqrt{\text{in.}}$)	ΔC_e (inch)
19.2	0.0160	1.995	47.76	0
24.0	0.0207	2.06	60.97	0.065
26.0	0.0232	2.125	67.44	0.130
28.0	0.0257	2.18	73.89	0.185
28.4	0.0261	2.19	75.18	0.195
28.4	0.0271	2.25	76.60	0.255
29.0	0.0288	2.345	80.54	0.35
29.48	0.0298	2.375	82.62	0.38
29.48	0.0356	2.76	92.72	0.765
30.24	0.0372	2.82	96.82	0.825

$2C/w = 0.333$, $CEB_T = 0.71$, shift $0.781 - 0.71 = 0.071$

R-CURVE DATA - SPECIMEN B-3-CCT

7075-T6, B = 0.1825 inch, w = 12.0 inch, A = 2.190 inch,
 E = $10.4 \cdot 10^6$ psi, $2C_1 = 4.005$ inch

LOAD, p(kip)	COD (inch)	C_e (inch)	K (ksi $\sqrt{\text{in.}}$)	ΔC_e (inch)
21.6	0.0089	2.00	26.57	0
30.0	0.0129	2.075	37.80	0.075
35.0	0.0152	2.105	44.53	0.105
40.0	0.0180	2.16	51.78	0.160
40.9	0.0157	2.195	53.53	0.195
42.0	0.0195	2.225	55.48	0.225
43.0	0.0204	2.27	57.60	0.27
44.0	0.0209	2.28	59.12	0.28
45.4	0.0219	2.30	61.38	0.30

NOTE: Two partial return slopes equal to measured $\frac{\text{COD}}{P}$ VOLUME ABOVE.

Precracked $\frac{2C}{w} = 0.33$, CEB = 0.71, shift = $0.782 - 0.71 = 0.072$

R-CURVE DATA - SPECIMEN B-4-CCT

7075-T6, B = 0.183 inch, w = 12.0 inch, A = 2.196 inch,
 E = $10.4 \cdot 10^6$ psi, $2C_i = 3.995$ inch

LOAD, p(kip)	COD (inch)	C_e (inch)	K (ksi $\sqrt{\text{in.}}$)	ΔC_e (inch)
25.0	0.0102	2.00	30.7	0
30.0	0.0127	2.07	37.6	0.07
35.0	0.0152	2.11	44.5	0.11
40.0	0.0180	2.17	51.8	0.17
41.0	0.0192	2.27	54.8	0.27
42.0	0.0198	2.28	56.3	0.28
42.5	0.0203	2.30	57.3	0.30
42.5	0.0210	2.345	58.2	0.345
43.0	0.0211			
44.0	0.0218	2.35	60.2	0.35

$$\frac{2C_i}{w} = 0.332, \text{ CEB} = 0.71, \text{ shift} = 0.778 - 0.71 = 0.068$$

NOTE: Slight buckling indication on partial unloadings.

R-CURVE DATA = SPECIMEN C-3-CCT

7075-T6, B = 0.3862 inch, w = 12.0 inch, A = 4.634 inch²,
 E = 10.4 · 10⁶ psi, 2C_i = 4.00 inch

LOAD, (kip)	COD (inch)	C _e (inch)	K (ksi √in.)	Δ C _e (inch)
48.0	0.0096	2.00	28.26	0
60.0	0.0126	2.10	36.20	0.10
70.0	0.0150	2.12	42.44	0.12
74.0	0.0165	2.22	46.13	0.22
78.0	0.0179	2.27	49.38	0.27
80.0	0.0189	2.33	51.59	0.33
82	0.0200	2.40	54.02	0.40
84	0.0212	2.52	57.38	0.52
86.3	0.0233	2.64	61.10	0.64

Precracked $\frac{2C_i}{w} = 0.333$, CEB = 0.71, shift 0.803 - 0.71 = 0.093.

SECTION III

DOUBLE LAP JOINTS

The following pages present tabulated crack length versus number of cycles data for the fourteen precracked double lap joint specimens along with a graphic presentation of the crack path shown on face-to-face pages to facilitate cross reference. Specimens 4.6A-1 through 4.6A-10 are thick double lap joint specimens, and 4.6B-1 through 4.6B-4 are thin double lap joint specimens. The initial damage conditions for each specimen* were listed in Table 2 of Volume I. The applied cyclic stress was $S_{\max} = 17 \text{ ksi}$, $R = 0.1$.*

On the following data tables, the notation is as follows. In the double lap joint specimens the fasteners are numbered 1 through 6 in the precracked row (Row 2) and 7 through 12 in Row 3, where some secondary cracking often occurred. Side "A" is the fastener-head side of the specimen and Side "B" is the collar side. Thus a_{34} is the length of a crack on the head side of the specimen originating at Fastener Hole 3 and growing toward Hole 4, while b_{12-11} is the length of a crack on the collar side, originating at Hole 12 and growing toward Hole 11.

In some cases cracking occurred at the outermost fastener hole and grew toward the free edge. In this instance, the notation "E" is used to denote the edge of the specimen. Thus a_{7E} is the length of a crack in the skin originating at Fastener Hole 7 and growing toward the edge of the specimen. Crack lengths are in inches as measured from the edge of the hole on the visible outer surface.

In other cases fretting cracks occur away from the fastener holes. A fretting crack on the head side of a double lap joint specimen, originating between fastener Rows 2 and 3 directly above Fastener 4 is labeled " a_{F4} " and the length is simply the total length as measured on the visible surface.

To further clarify the notation a sequence of sketches is given for Specimen 4.6A-5 showing how the damage developed in this specimen.

*Except for Specimens 4.6A-9 and -10 which were identical to Specimens 4.6A-3 and -4 but were Phase II spectrum tested with a reference maximum spectrum stress of 30 ksi.

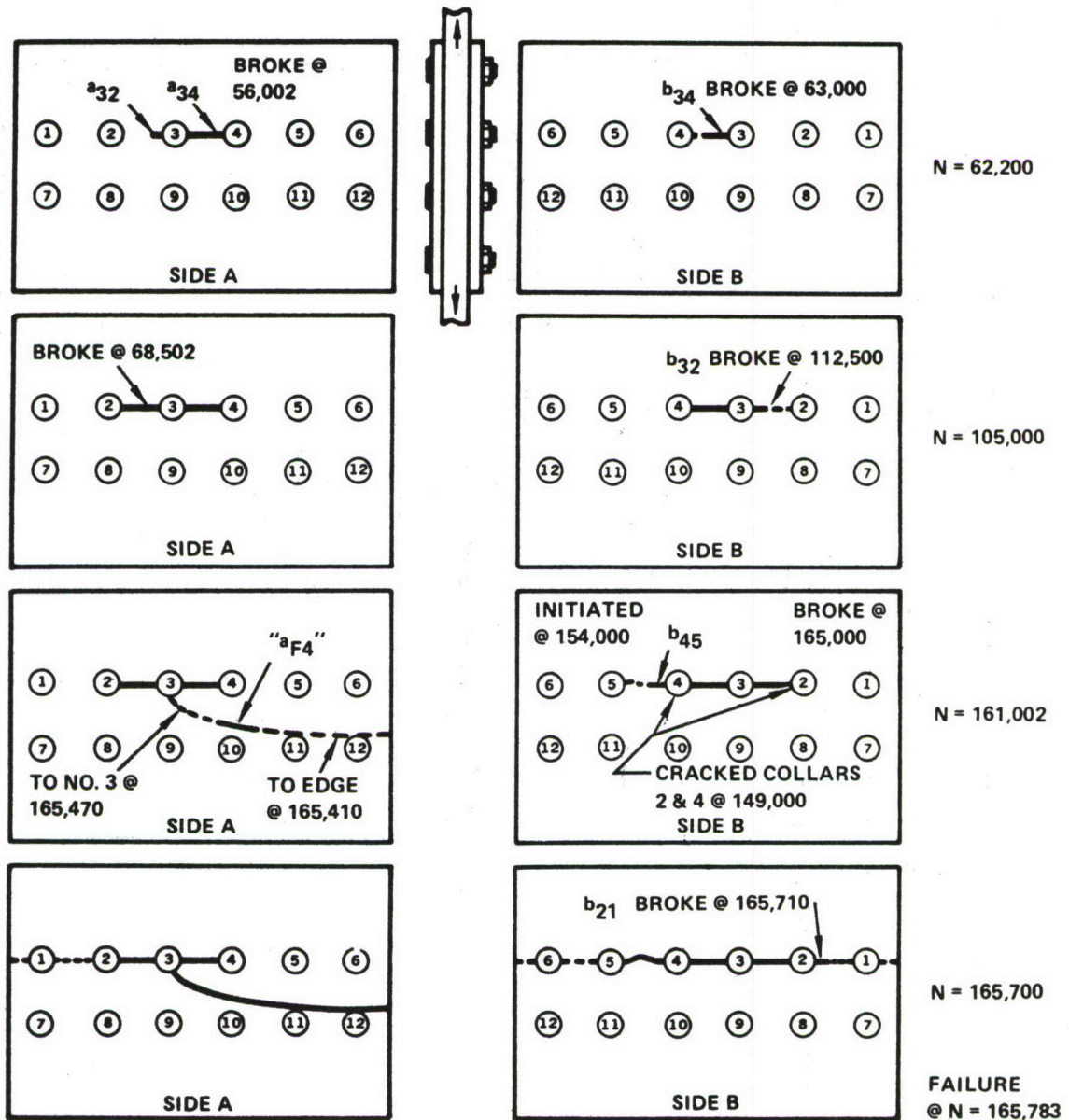
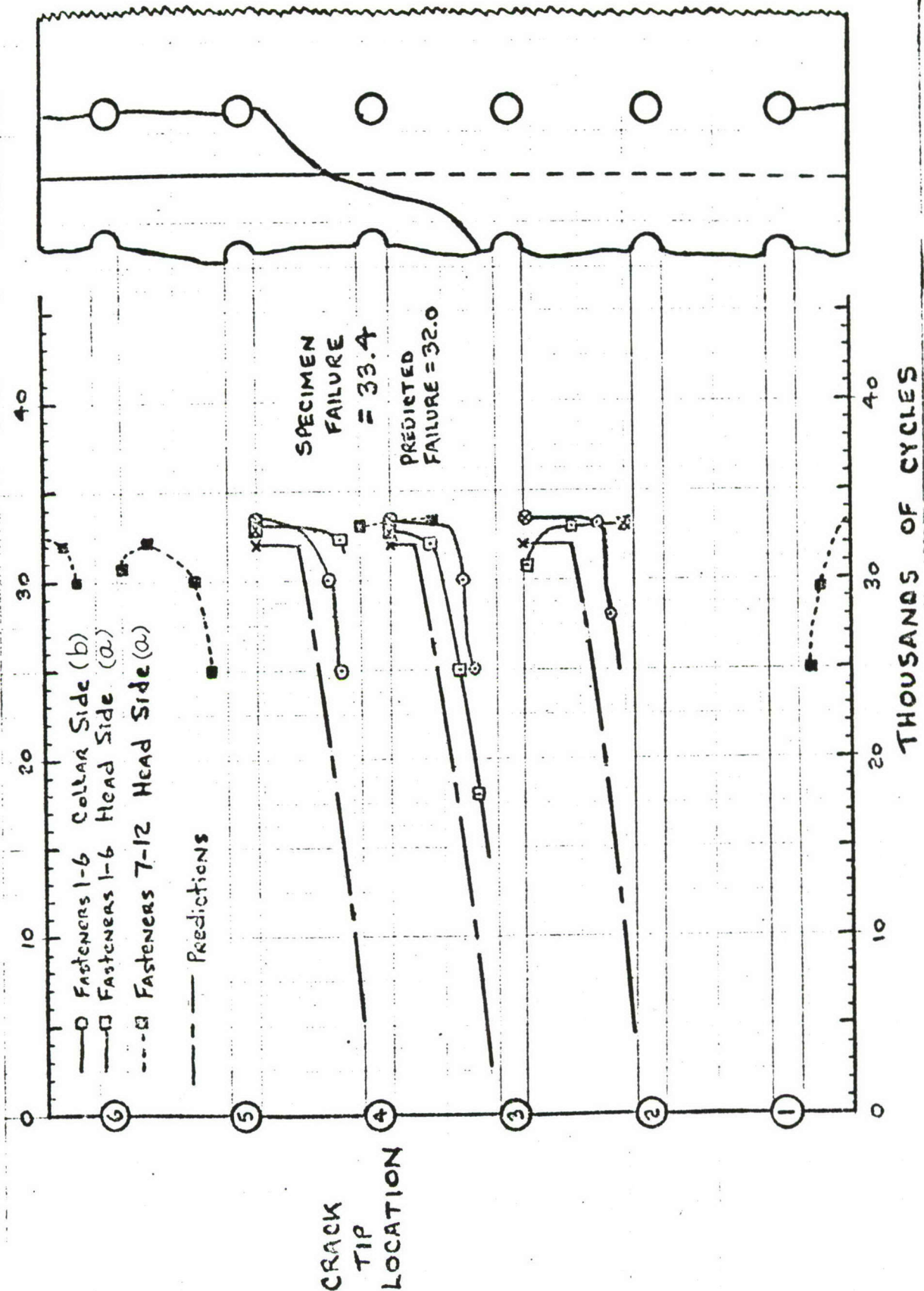


Figure 1. Example of Notation: Cracking Sequence in Specimen 4.6A-5

SPECIMEN 4.6A-1

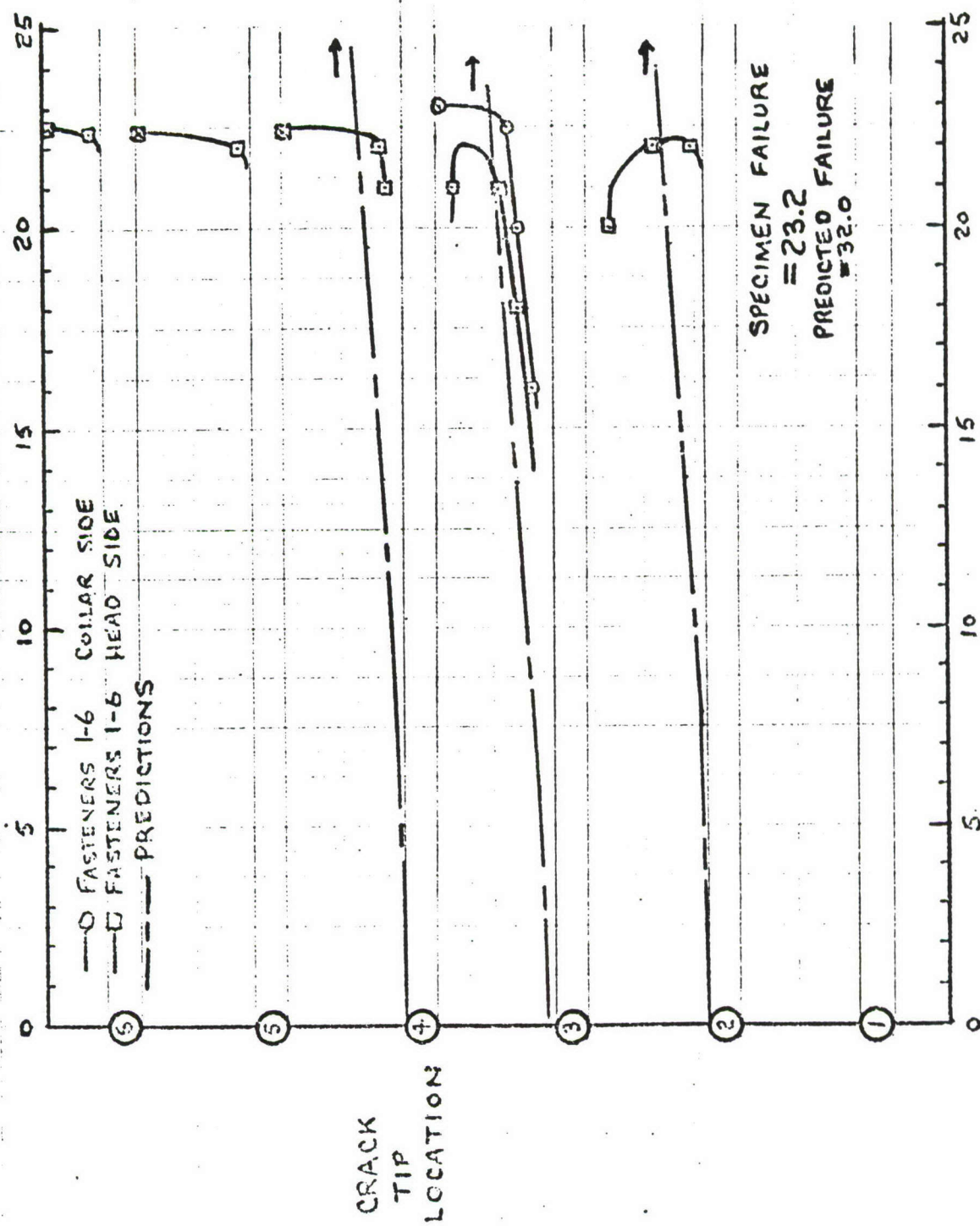


SPECIMEN 4.6A-1

N	a _{7E}	a ₂₃	a ₃₂	a ₃₄	a ₄₅	a ₁₁₋₃	a ₁₁₋₁₂	a ₁₂₋₁₁	a _{12-E}	b ₂₃	b ₃₄	b ₄₅
I.C.		".005"		(.046)	".005"					.005"	(.047)	".005"
14500				.116								
16000				.157								
18000				.210								
20000				.260								
22000				.313								
25000	.160			.400		.197				.178	.263	.241
28000	.207			.506		.258				.251	.334	.316
30000	.293			.592		.375			.225	.308	.379	.365
32000	—			.740	.205	—	.260	.380				
32,300	.430			.770	.230	1.125 BROKE		.562 BROKE				
32,715	—			.1125 BROKE	.420							
32800	.475			.670						.315	.495	.505
32820	—			1.125 BROKE						—	—	—
33003	.510		.500							.415	.525	.565
33075	.562 BROKE	1.125 BROKE										
33090	—					1.43						
33300	—					2.48				.575	1.125 BROKE	1.125 BROKE
33402	—					↓				1.125 @ 37400	↓	↓ FAILURE

SPECIMEN 4.6A-2

OF THE CALIFORNIA INSTITUTE OF TECHNOLOGY



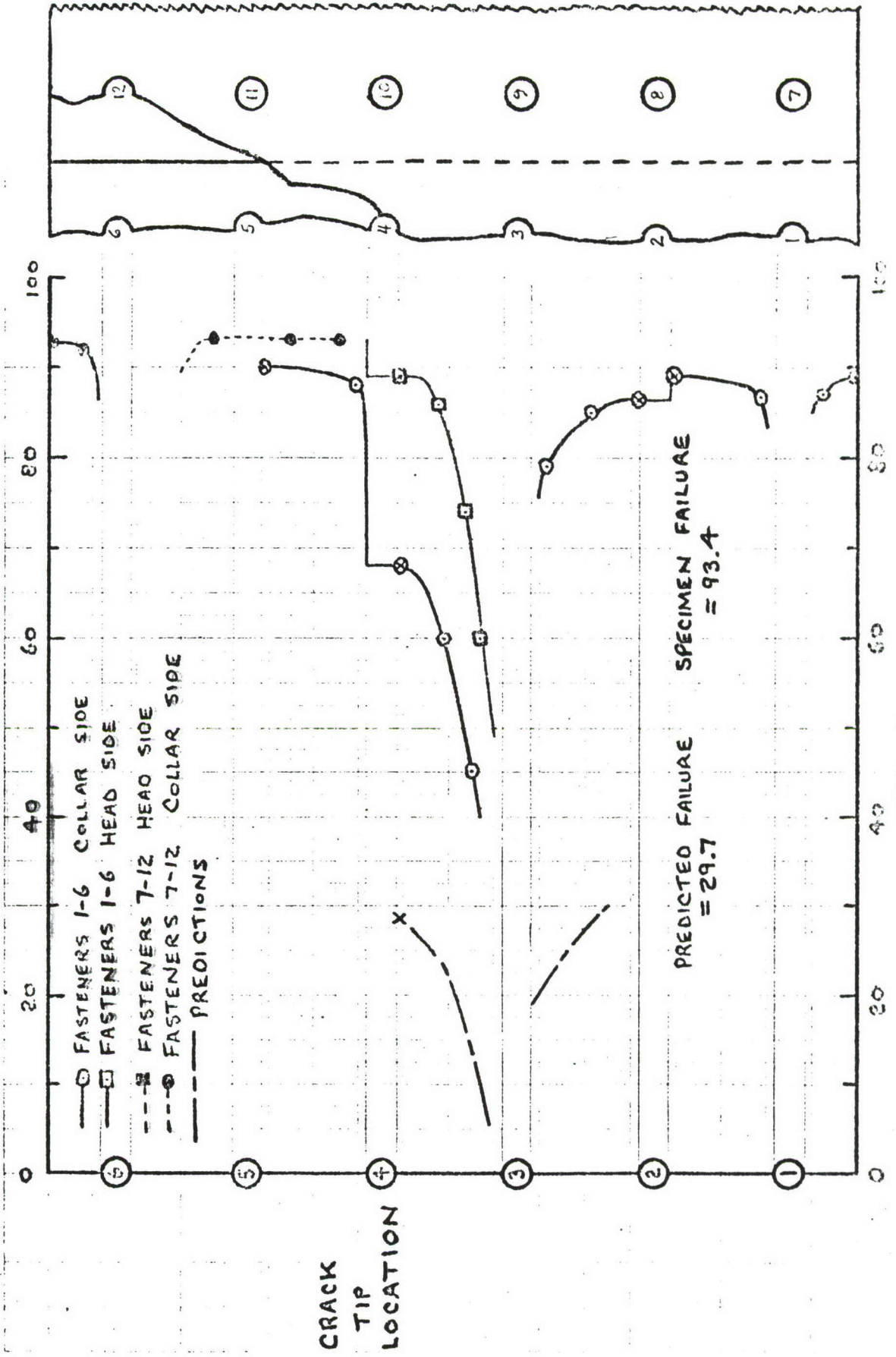
THOUSANDS OF CYCLES

SPECIMEN 4.6A-2

N	a _{1E}	a ₂₁	a ₂₃	a ₃₂	a ₃₄	a ₄₃	a ₄₅	a ₅₆	a _{6E}	b ₂₃	b ₃₄	b ₄₅
IC												
14000					.197							
16000					.275						.215	
18000					.345						.254	
19000					.382						.315	
20000				.210	.453						.354	
21000				.218	.538	.157	.153				.396	
22000			.142	.642	.713	.205	.201				.429	
22042			—	—	1.125 BROKE THRU	—	—	.143			—	
22151			1.125 BROKE THRU	—	—	—	—	—			—	
22320			—	—	—	1.125 BROKE	1.125 BROKE	—	.138		—	
22358			—	—	—	—	—	—	.562 BROKE		.445	
22821		"DIMPLE"	—	—	—	—	—	—	—		.545	
22875		"DIMPLE"	—	—	—	—	—	—	—		.595	
22920	—	—	—	—	—	—	—	—	—		—	
23037	.562 BROKE	—	—	—	—	—	—	—	—		.685	
23111	—	—	—	—	—	—	—	—	—		1.125 BROKE	1.125 BROKE
23243	—	—	—	—	—	—	—	—	—		—	—
23247	—	—	F	A	I	L	U	R	E		—	—

SPECIMEN 4.6A-3

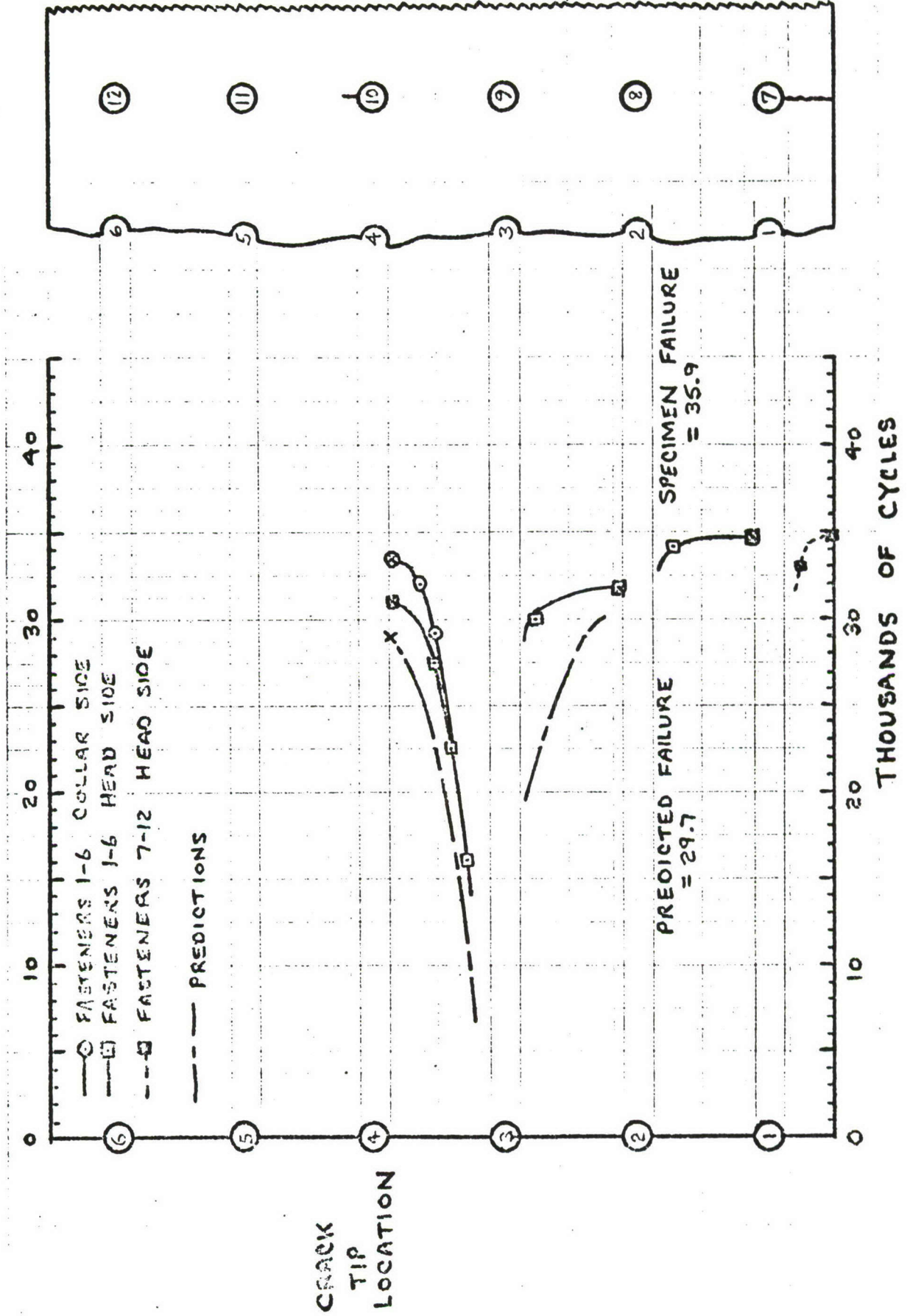
LOCKED COLLAR POSITION



SPECIMEN 4.6A-4

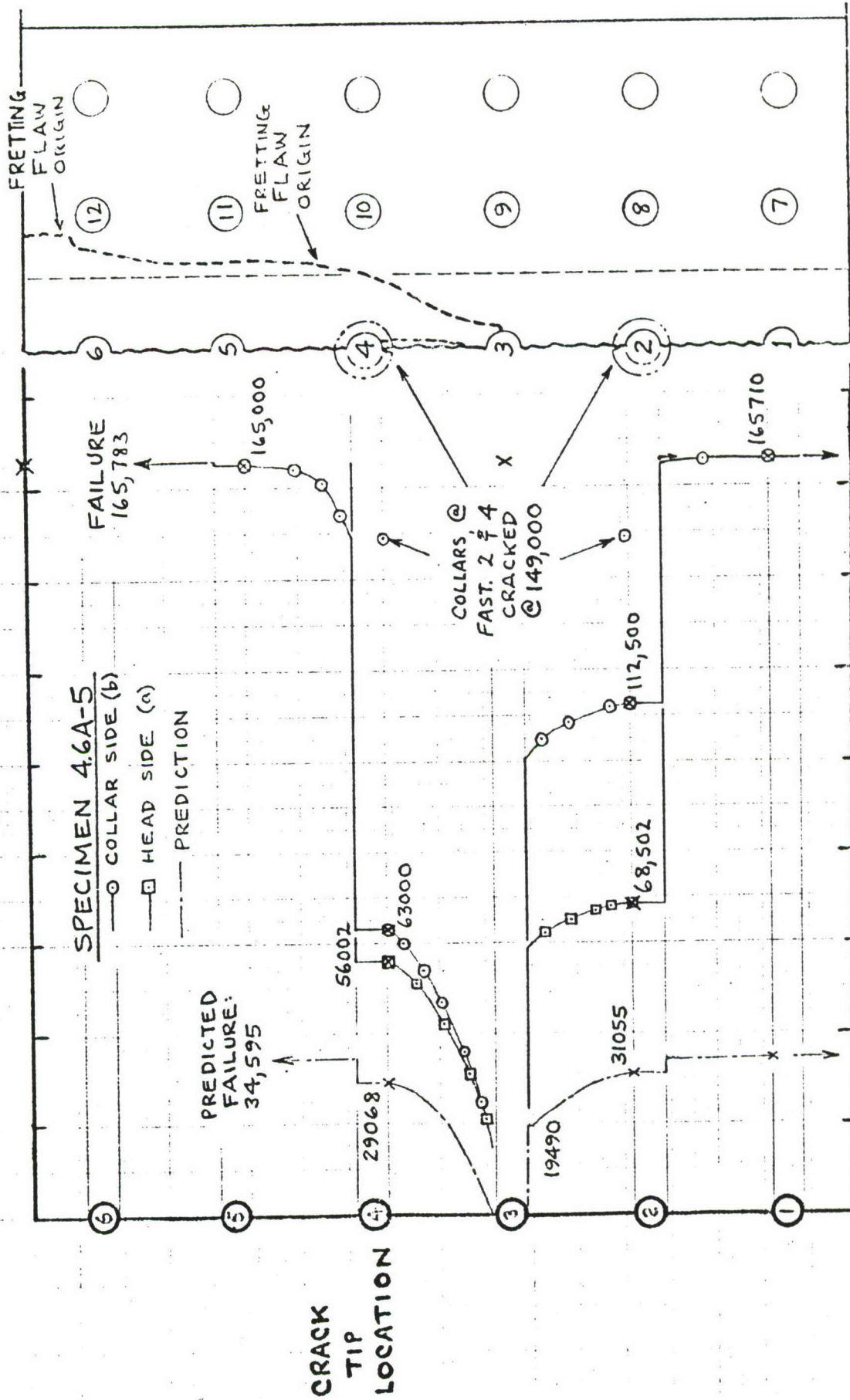
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TESTED AT: GEORGETOWN



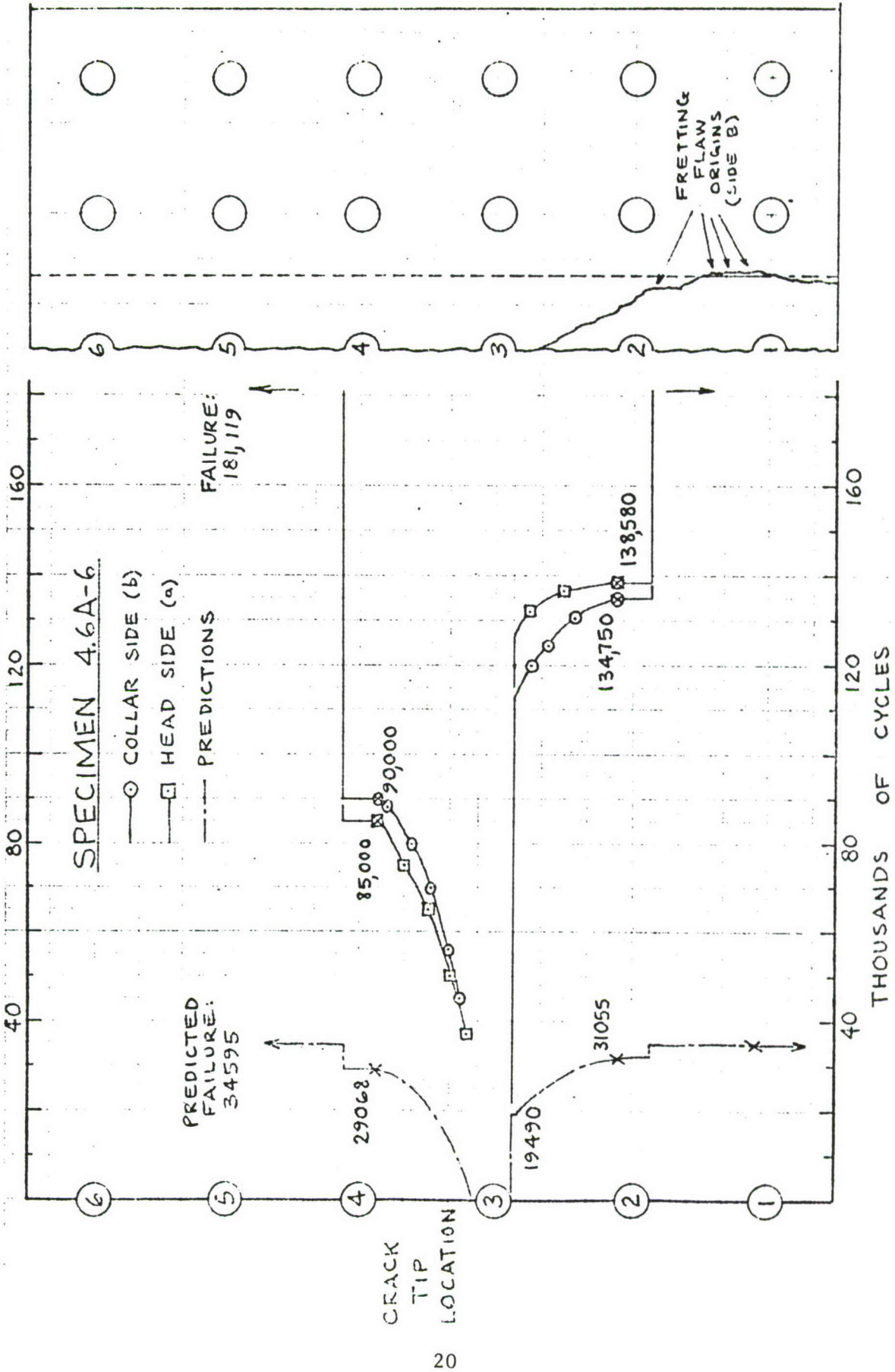
SPECIMEN 4.6A-5

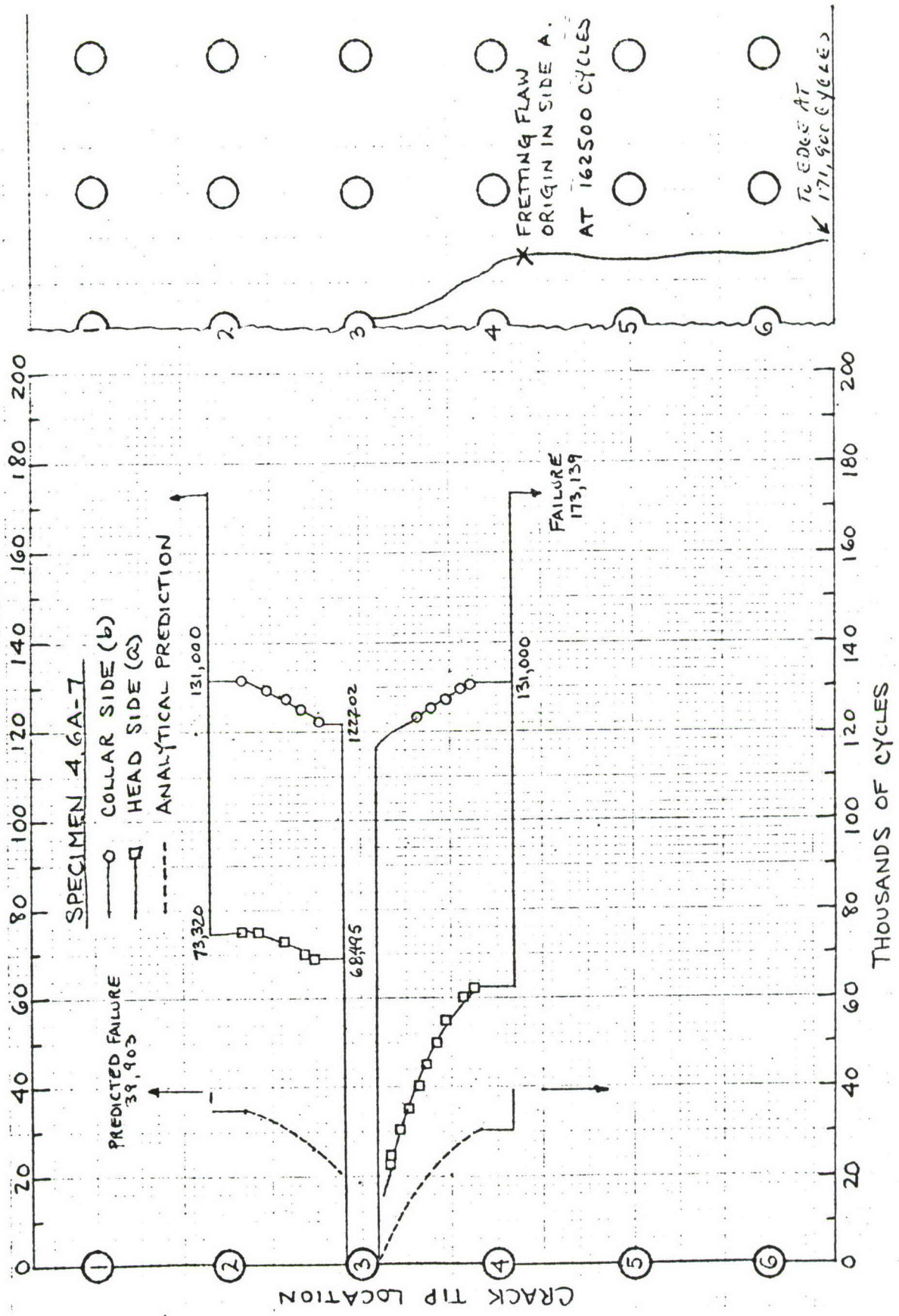
LOGGED CATEGORY 1



SPECIMEN 4.6A-5

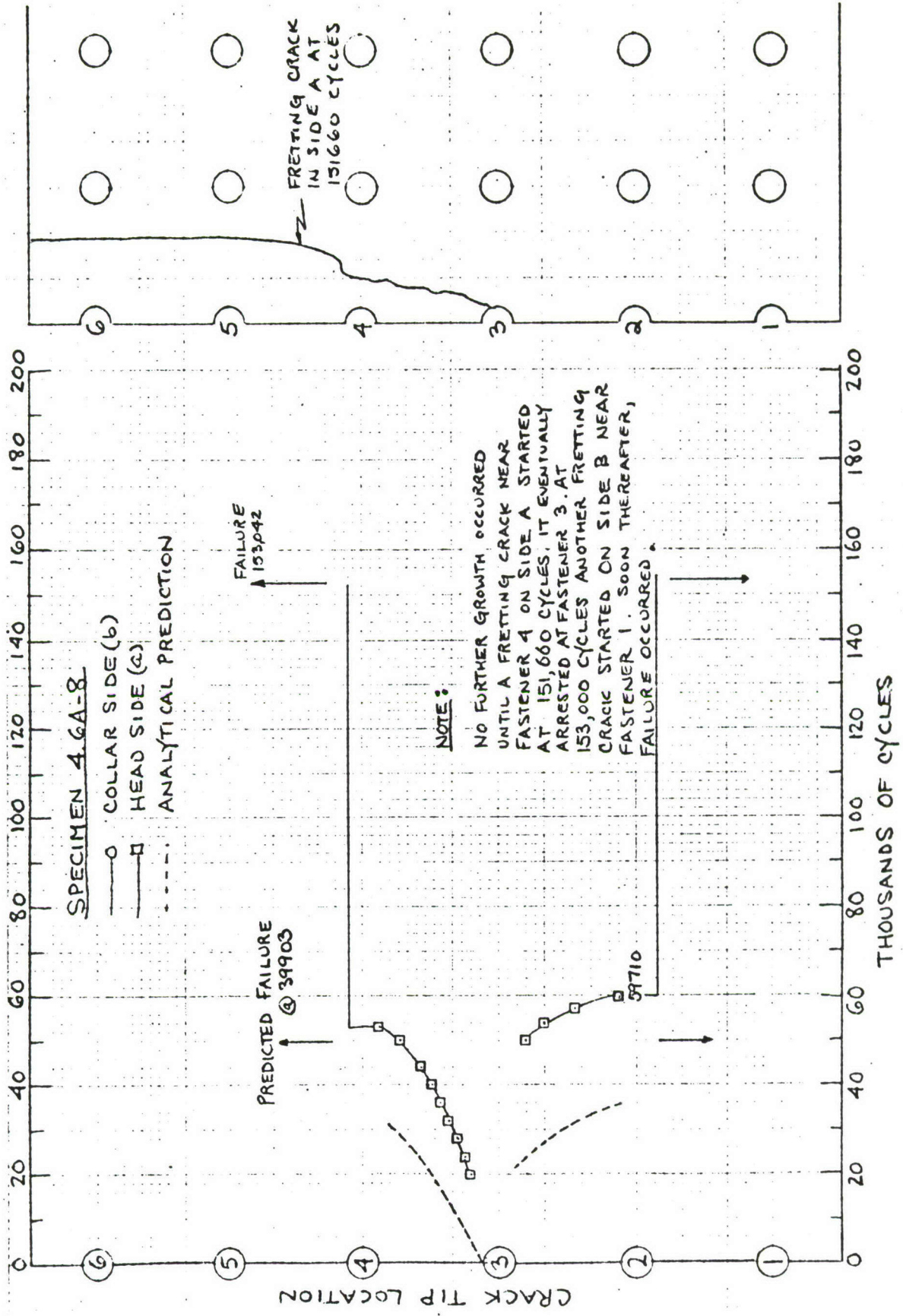
N	a ₃₂	a ₃₄	"a _{F4} "	b ₄₅	COLLAR B4	b ₃₄	b ₃₂	COLLAR B2	b ₂₁
21000		.113							
25000		.190				.162			
30000		.281				.233			
36000		.392				.337			
42000		.547				.467			
47000		.690				.575			
51000		.845				.678			
54000		1.000				.769			
56002		BRUKE 1.125				—			
60000						.990			
62200	.198					—			
63000	.250					1.125 BRUKE			
64002	.357								
65002	.485								
67002	.755								
68002	.919								
68502	1.125 BRUKE								
105000							.174		
106600							.300		
108600							.470		
110600							.694		
112000							.917		
112500							1.125 BRUKE		
149000					CRACKED			CRACKED	
154000				.145					
157000				.211					
161000			.134	.332					
162000			.329	.378					
163100			.68	.515					
164000			.92	.635					
164500			1.20	.745					
165000			1.72	1.125 BRUKE					
165410			TO EDGE						
165470			TO FASTN. A3						
165700									.445
165710									1.125 BRUKE
165783	F	A	I	L	U	R	E	—	—

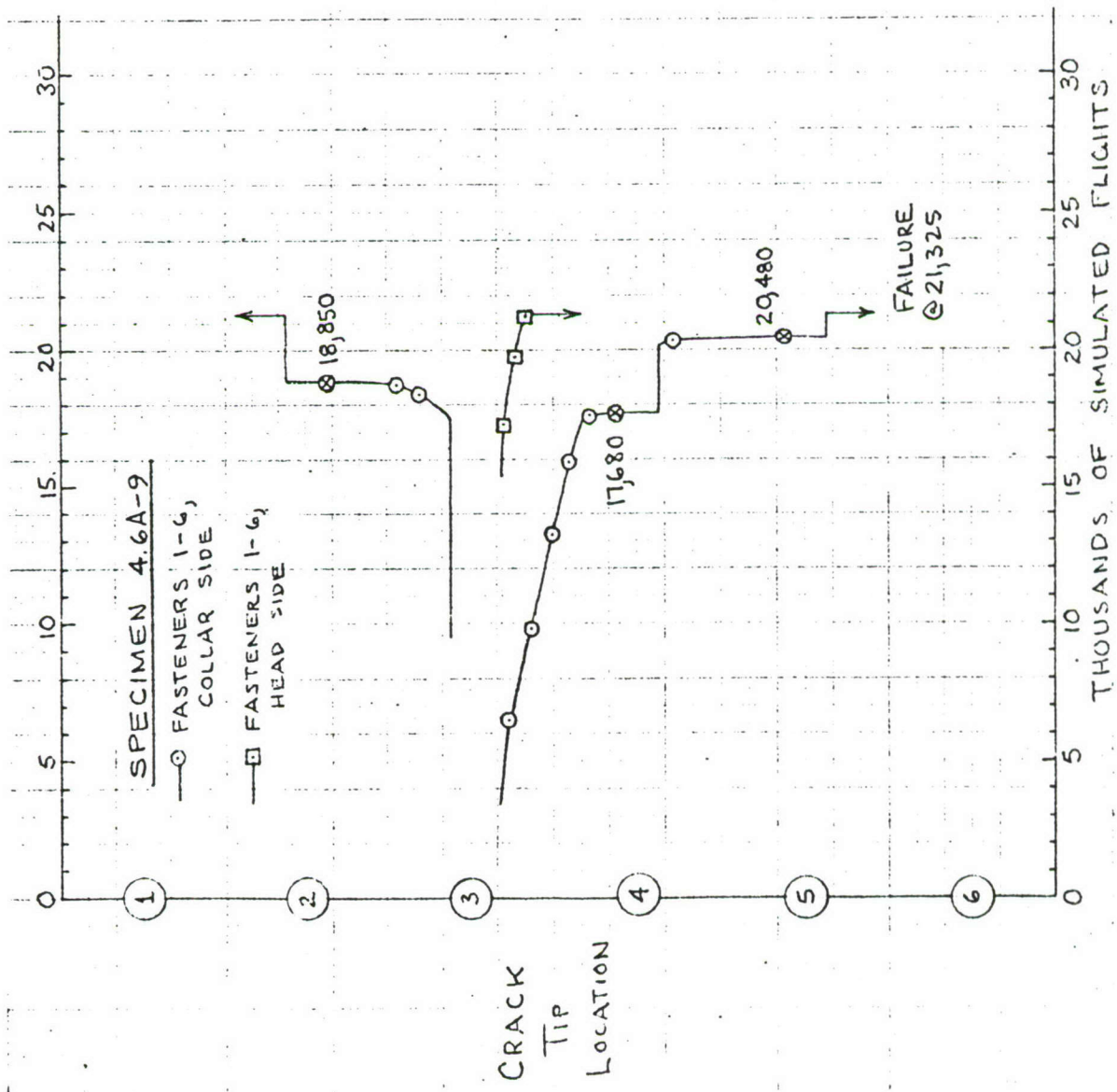




SPECIMEN 4.6A-7

N	a_{F3}	a_{43}	a_{45}	b_{45}	b_{43}
22500		.131			
25000		.169			
30000		.248			
35000		.336			
40000		.434			
45000		.540			
50000		.655			
55000		.795			
60000		.958			
62000		1.042			
68495		BROKEN THRU	.320		
70000			.435		
71000			.515		
73000			.671		
75000			.957		
75320			1.125 BROKE		
122202				.276	.441
125002				.485	.593
127504				.645	.752
129504				.835	.928
130000				.888	.988
131000				1.125 BROKE	1.125 BROKE
162500	.15				
165000	.36				
167000	.60				
168000	.74				
169000	.92				
170000	1.24				
170700	1.66				
171200	2.14				
171700	2.78				
171850	3.62				
171900	5.00 TO EDGE				
173139	———— FAILURE ————				





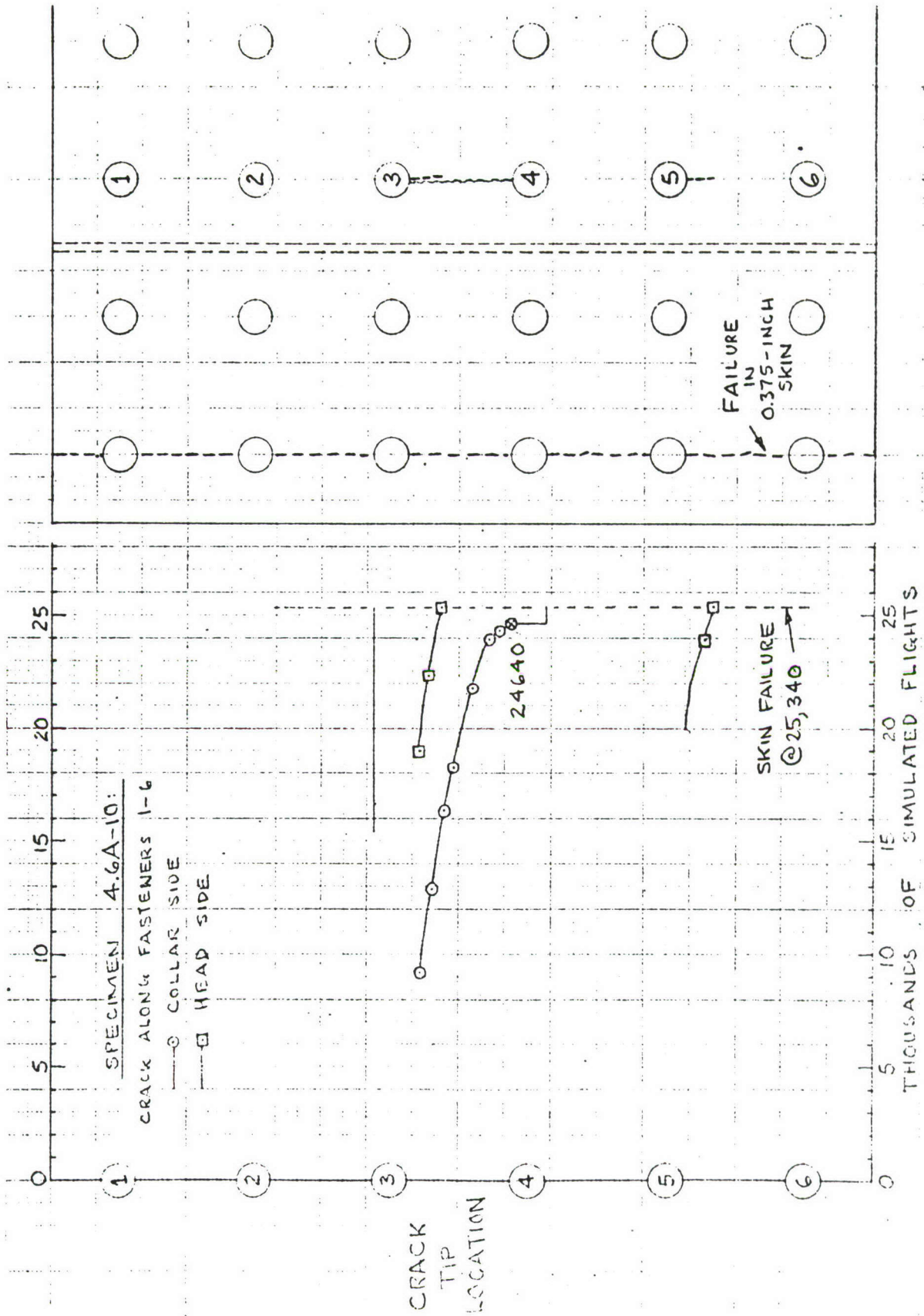
SPECIMEN 4:6A-9

DATA SHEET(S) : 573605-08

TEST DATE(S) = 10-1-76 TO
10-6-76

FLTS	a ₃₄	b ₃₄	b ₃₂	b ₄₅	b ₅₆				
6480		0.158							
6800		0.177							
7200		0.215							
7920		0.253							
8720		0.294							
9840		0.359							
11680		0.441							
12640		0.498							
13280		0.533							
14400		0.587							
15200		0.646							
15920		0.690							
16160	DIMPLE	0.703							
16720	—	0.748							
17280	0.119	0.803							
17600	0.130	0.881							
17680	—	CRACK TO FASTENER							
18240	0.149								
18400	0.161		0.281						
18750	0.167		0.477						
18850	0.179		CRACK TO FASTENER						
18960	0.202								
19760	0.218								
20320	0.264			0.135					
20480	0.278			CRACK TO FASTENER					
21280	0.310								
21325		FAILURE			(.030)*				

*Seen on fracture surface;
present just before failure.

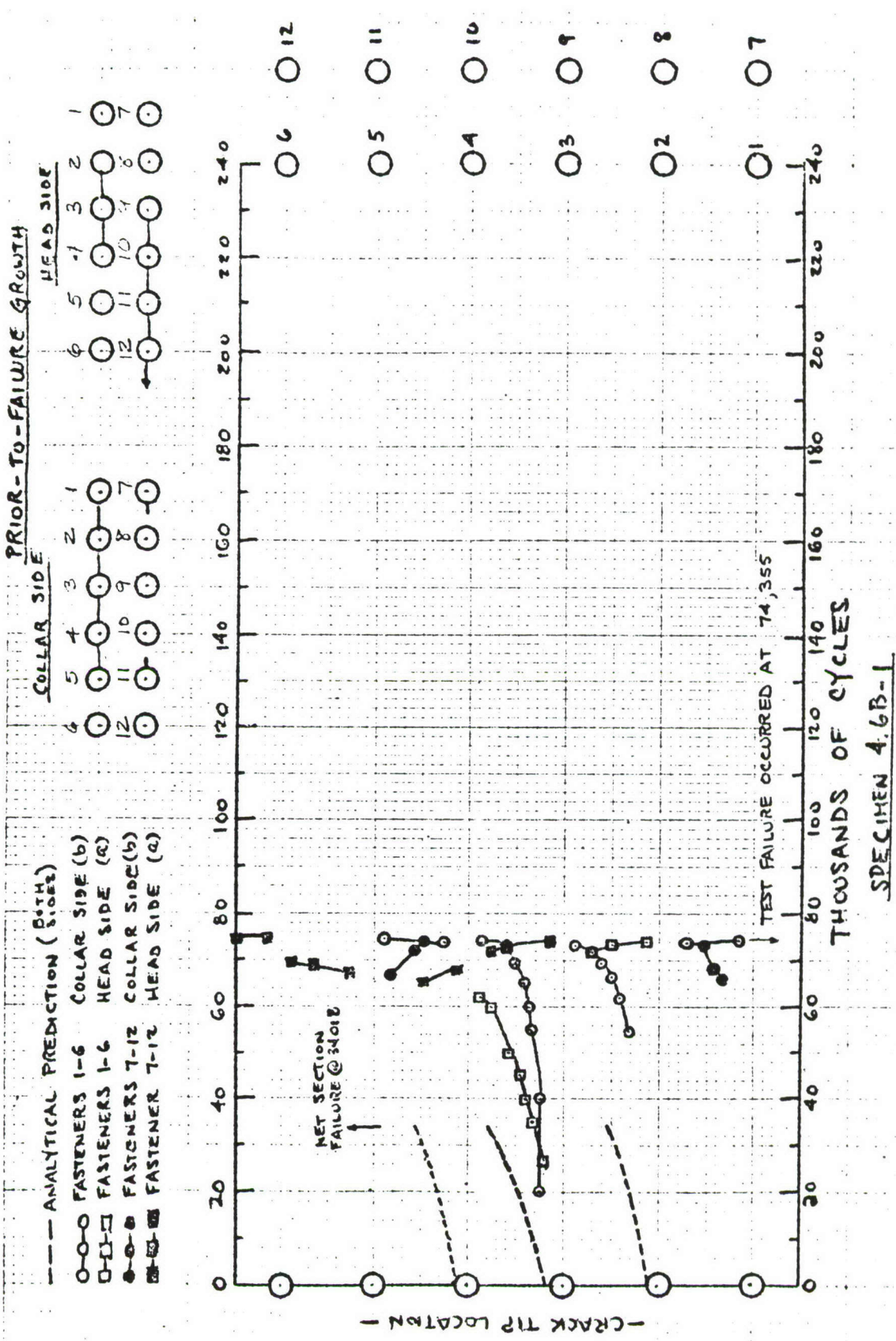


SPECIMEN 4.6A-10

DATA SHEETS : 573609-11

TEST DATES : 10-7-76 To
10-18-76

FLTS	a ₅₆	a ₃₄	b ₃₄	b ₂₁
7960			DIMPLE	
9200			0.139	
9440			0.170	
10960			0.221	
11760			0.236	
12880			0.272	
13680			0.296	
14000			0.320	
14800			0.344	
15520			0.374	
16320			0.409	
16720		DIMPLE	0.423	
17040			0.453	
18240			0.502	
18960		0.130	0.531	
19760		0.154	0.581	
20640		0.171	0.633	
21280		0.197	0.666	
21760		0.212	0.713	
22400		0.225	0.738	
23440		0.273	0.826	
23920	0.215	0.294	0.879	
24320	0.231	0.308	0.997	
24640	0.251	0.326	CRACK TO FASTENER	
25040	0.290	0.353		
25340	0.311	0.367	DIMPLE	
25340	FAILURE IN MAIN SHEET ACROSS THE OUTSIDE FASTENER ROW. NO VISIBLE CRACKS APPEARED ON THE DOUBLER PRIOR TO FAILURE			

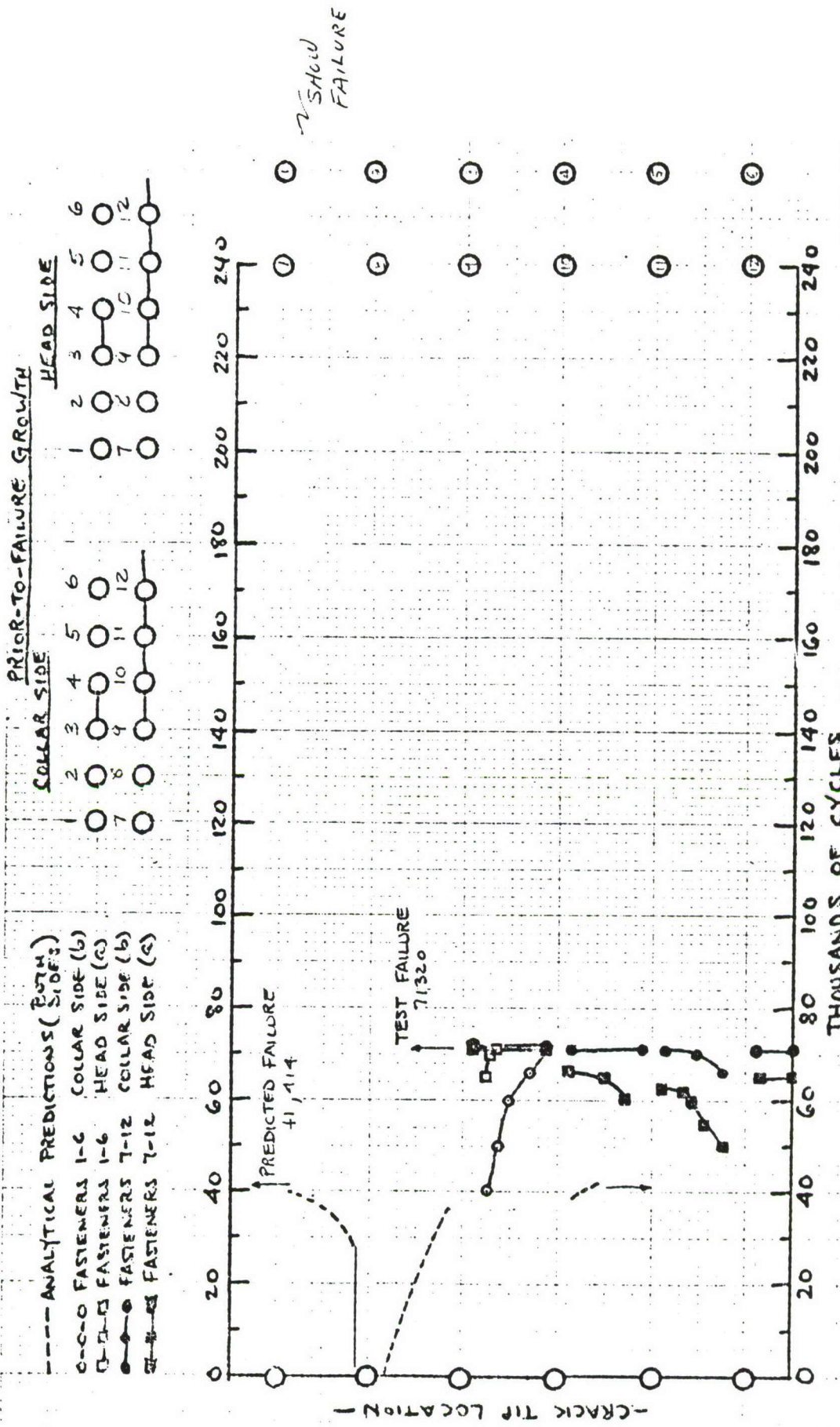


MD = R1.075
COLLAR = R4.080

4, 6 B-1

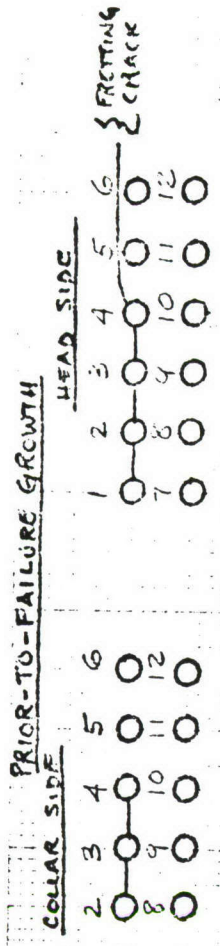
SPECIMEN

N	a7E	a87	a89	a98	a99	a99u	a34	a45	b12-11	b56	b54	b43	b32	b89
20000												.102		
25000						.097						.118		
30000						.150						↑		
35000						.204						.118		
40000						.263						.135		
45000						.325						.166		
50000						.458					.186	.201		
55000						.505					.256	.242		
60000						.635					.288	.250		
61750						.750 BRIDGE					.345	.282		
65000			.405						.182		.365	.292		
65900			.415	.181					.196		.378	.302		
66590			.750 BRIDGE	.750 BRIDGE					.196		.382	.317		.160
67000		.165							.280		.432	.362		.180
68200		.355							.280		.460	.364		.230
69000		.525							.290		.482	.370		.230
69450		.750 BRIDGE							.330		.550	.410		.280
71800						.095		.155	.340		.560	.420		.290
72100						.275		.175	.360		.58	.44		.320
72400						.395		.245	.360		.62	.44		.320
73000						.495		.375	.380		.750 BRIDGE	.48		.35
73500						.655		.750 BRIDGE	.40		.54	.54		.35
73790						.750 BRIDGE			.41		.63	.63		.38
74000		.750 BRIDGE							.41		.750 BRIDGE	.750 BRIDGE	.160	.40
74097									.41	.33			.750 BRIDGE	.40
74245									.41	.750 BRIDGE				.40
74281									.41					
74355			F	A	I	L	U	R	E					

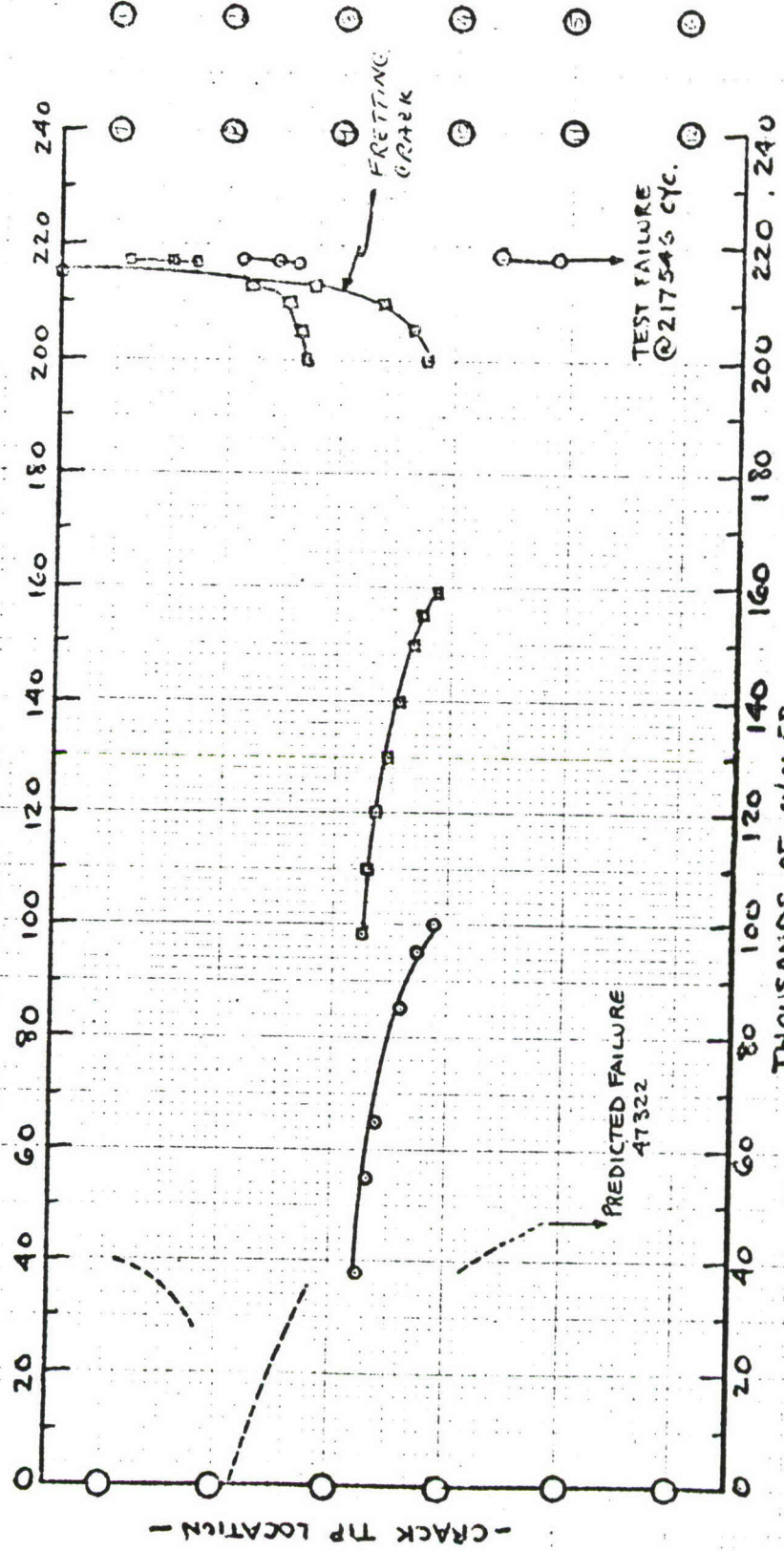


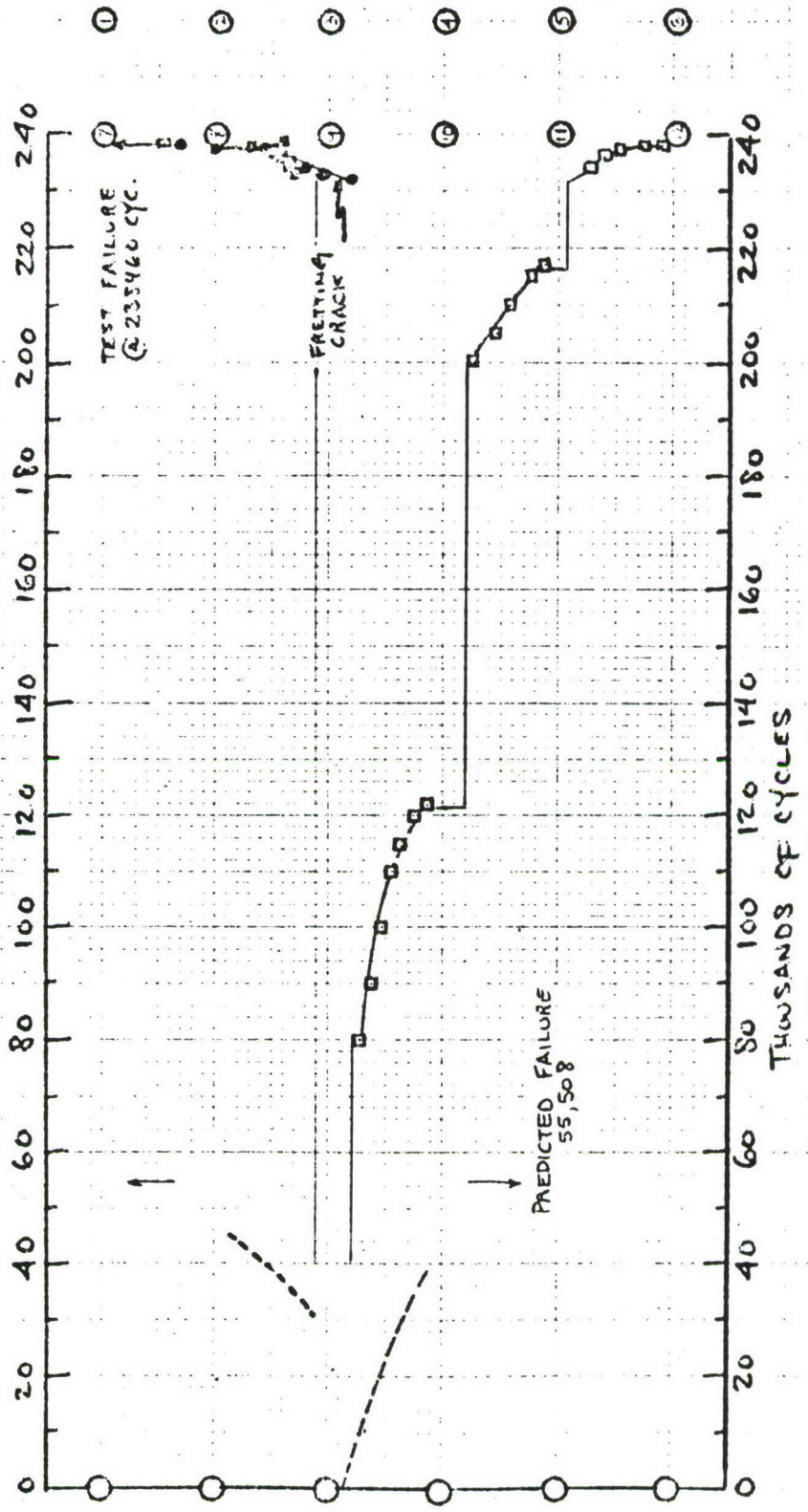
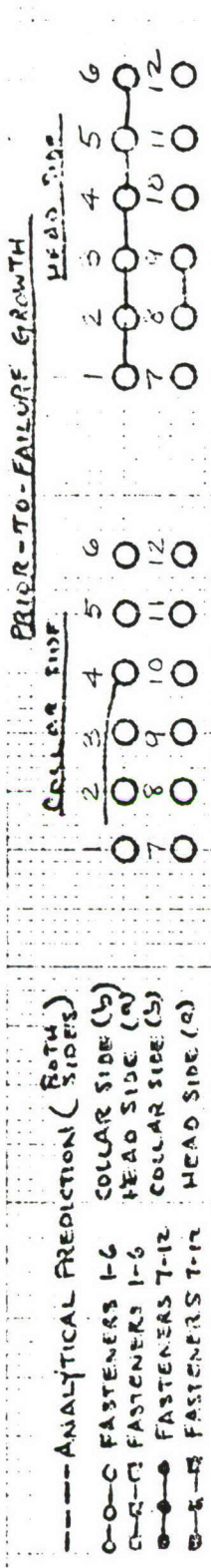
SPECIMEN 4.6B-2

N	a ₃₄	a ₁₀₋₉	a ₁₁₋₁₀	a ₁₂₋₁₁	a _{12E}	b _{12E}	b ₁₁₋₁₀	b ₁₀₋₉	b ₃₄
35000									.122
40000									.155
45000									.198
50000				.103					.245
55000				.315					.300
58000				.395					.356
60000			.175	.455					.365
62000			.215	.555					.404
62580			.255	.75 BRUKE					
65000	.115		.375						.490
65800	.125		.655						.580
66200	.127		.75 BRUKE						.580
70000	.170						.120		.580
70500	.185						.400		.750 BRUKE
70930	.185						.720		
70980	.185						.750 BRUKE		
71227	.189								
71310		BRUKE IN 10 CYCLES							
71320		F	A	I	L	U	R	E	.750 BRUKE



- ANALYTICAL PREDICTIONS (BOTH SIDE)**
- FASTENERS 1-6 COLLAR SIDE (b)
 - FASTENERS 1-6 HEAD SIDE (R)
 - FASTENERS 7-12 COLLAR SIDE (b)
 - FASTENERS 7-12 HEAD SIDE (S)





SECTION IV

SINGLE LAP JOINTS

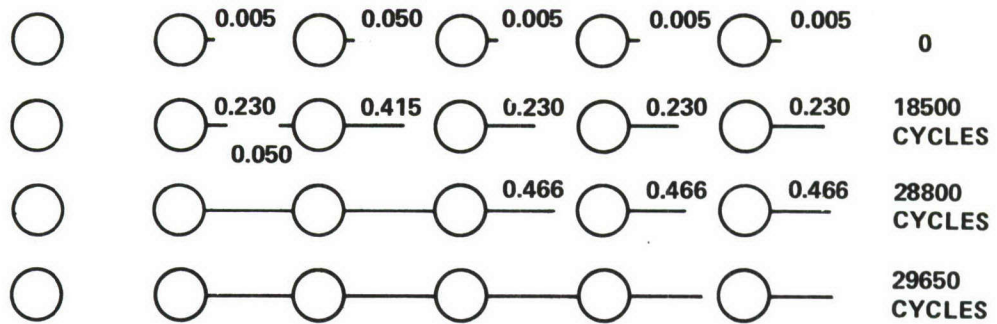
Crack growth predictions and test data are summarized in this section for the single lap joint specimens. Predictions are available only for Specimens 4.7-1 through -8, which were constant amplitude tested. Specimens 4.7-10 through -13 were 80-flight spectrum tested. Simplified crack growth life predictions were made for these specimens based upon the corresponding constant-amplitude results, but no detailed prediction of cracking sequence was done. There are three constant-amplitude predictions corresponding to three combinations of fastener clearance and continuing damage condition. Figure 2 shows the predicted damage sequences as well as the estimated crack lengths versus applied load cycles for these three predictions.

Crack growth data are presented in the following tables in terms of crack length versus number of cycles along with a graphic presentation of the crack path for the twelve single lap joint specimens tested. They are presented face-to-face to facilitate cross reference. Specimen configurations and initial damage conditions for each specimen are identified in Figures 4 and 6 and Tables 2 and 4 of Volume I.

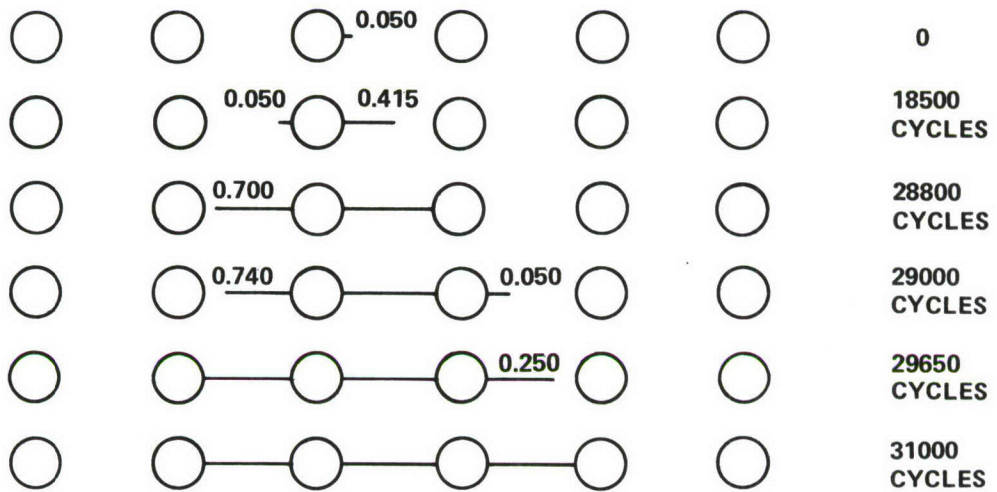
Of the twelve specimens, Specimens 4.7-1 through 4.7-8 were constant amplitude spectrum tested, and Specimens 4.7-10 through 4.7-13 were 80-flight spectrum tested. The applied cyclic stress for the constant amplitude tests was $S_{\max} = 17$ ksi, $R = 0.1$. There are two reference maximum stress levels for the 80-flight spectrum tests; $S_{\text{ref}} = 25$ ksi for Specimen 4.7-10 and $S_{\text{ref}} = 30$ ksi for Specimens 4.7-11 through 4.7-13. The load sequence of the 80-flight spectrum is shown in Figure 7a of Volume I.

The notations used in the following data tables are similar to those used on double lap joint specimens in Section III. The fasteners are numbered 1 through 7 in the precracked row, with the precrack at Fastener 4. Side "A" is the fastener-head side of the specimen (hence, the skin member) and Side "B" is the collar side (hence, the doubler). Thus a_{43} is the length of the main crack in the skin, originating at Fastener Hole 4 and growing toward Fastener Hole 3.

CLEARANCE FIT, CONTINUING DAMAGE, SPECIMENS 4.7-2 AND 4.7-3



CLEARANCE FIT, NO CONTINUING DAMAGE, SPECIMENS 4.7-1 AND 4.7-4



INTERFERENCE FIT, NO CONTINUING DAMAGE, SPECIMENS 4.7-5 TO -8

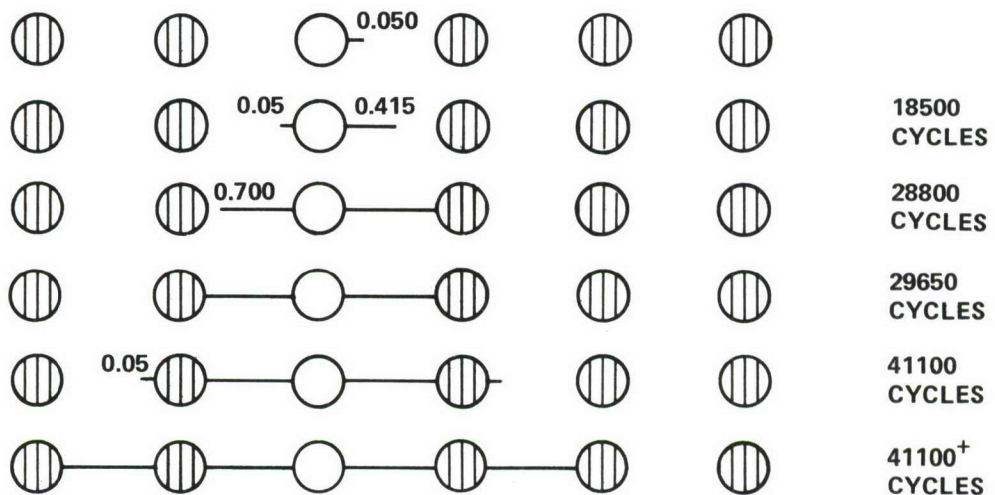
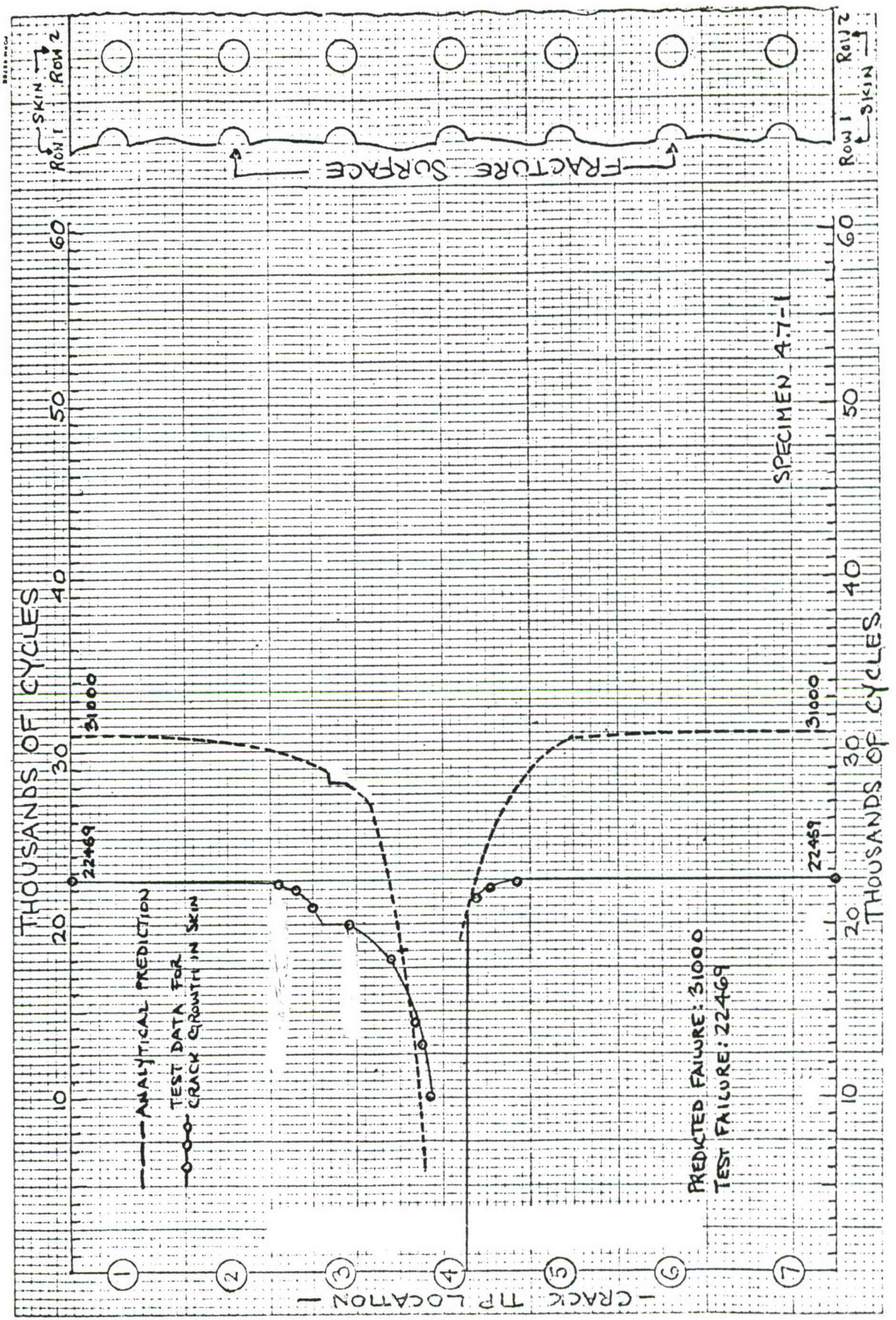


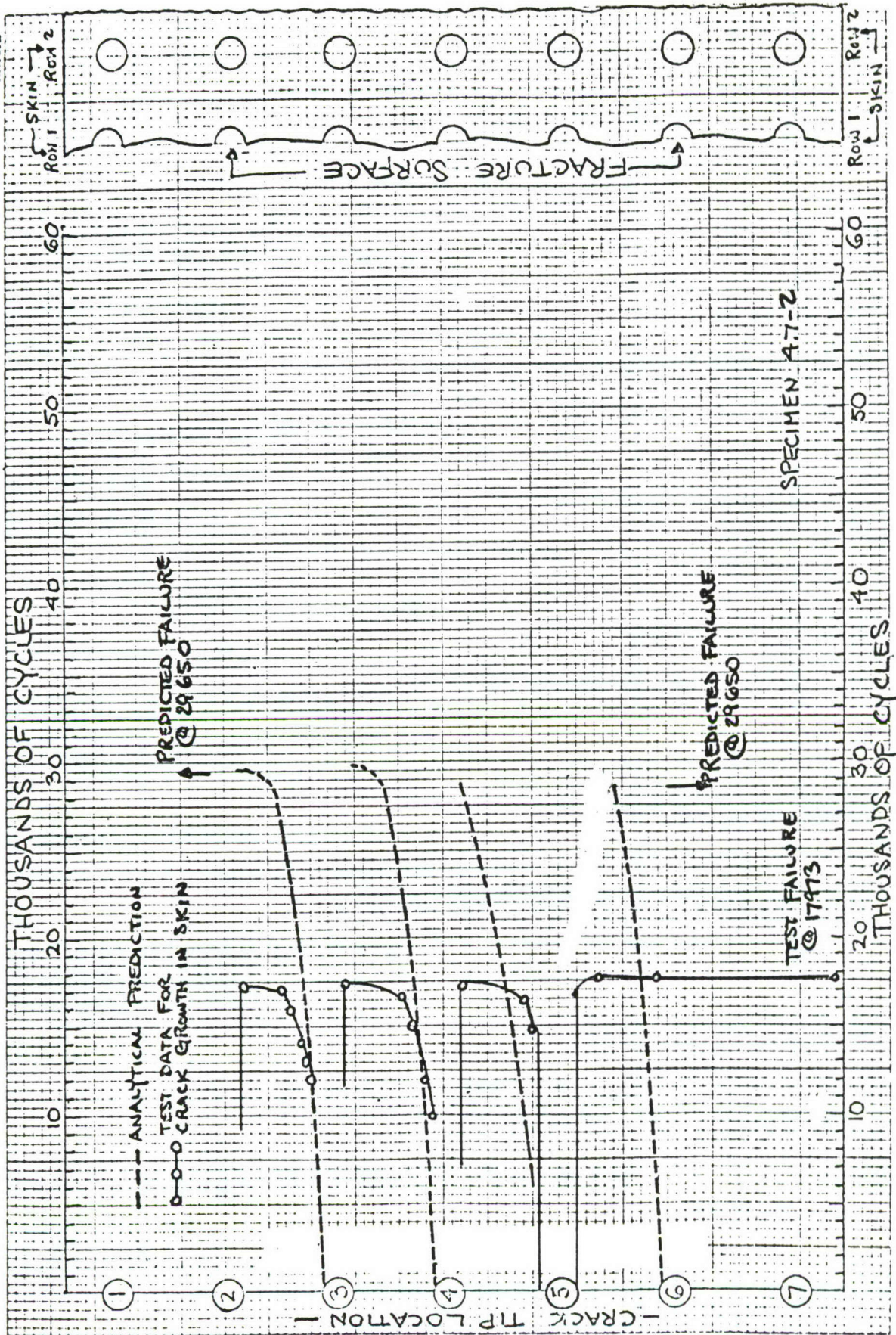
Figure 2. Predicted Crack Growth Sequence, Single Lap Joint Specimens

In some cases cracking occurred at the outermost fastener hole and grew toward the free edge. In this instance, the notation "E" is used to denote the edge of the specimen. Thus a_{7E} is the length of a crack in the skin originating at Fastener Hole 7 and growing toward the edge of the specimen.



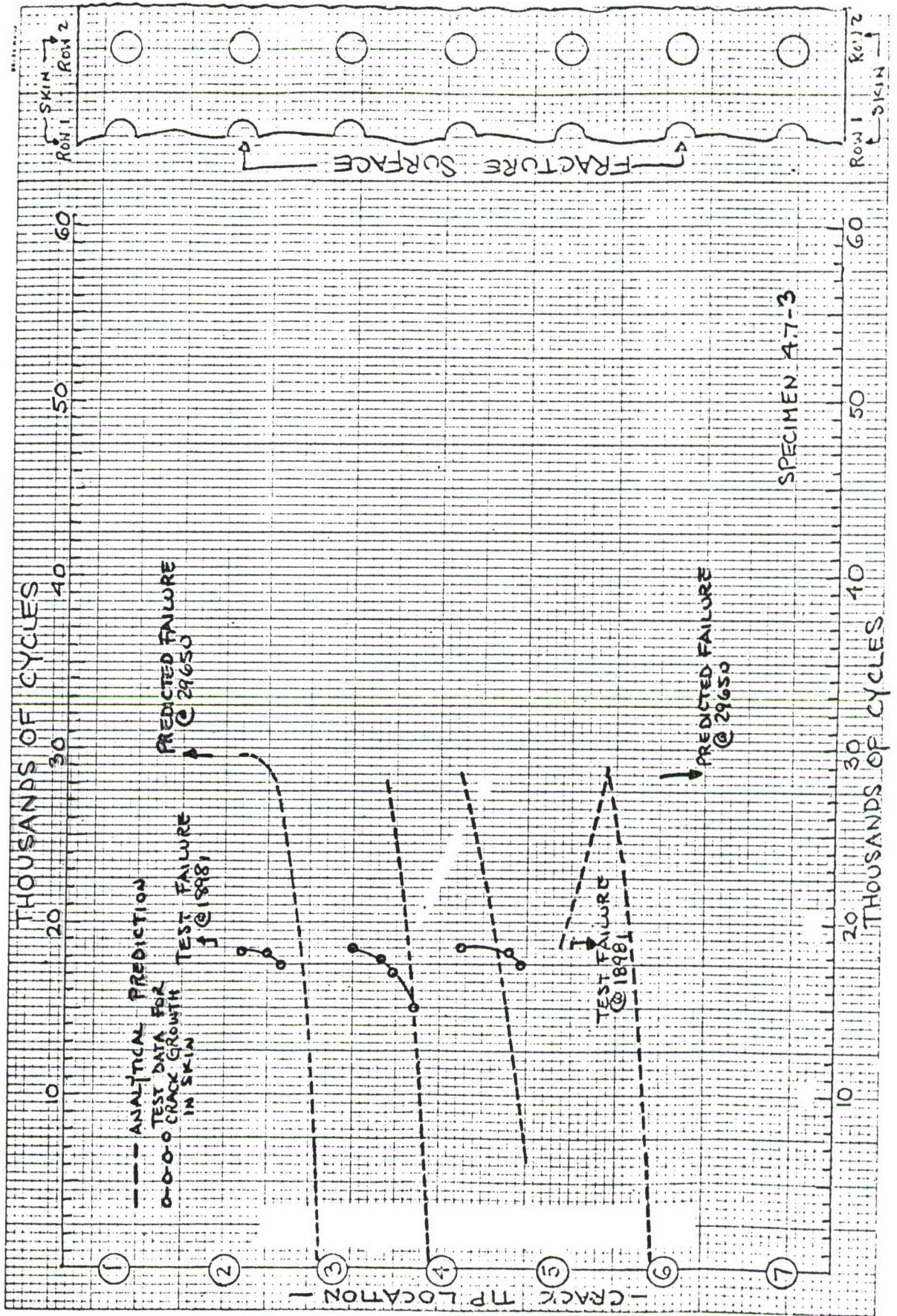
SPECIMEN 4.7-1

N	a ₃₂	a ₄₅	a ₄₅
10,000		.109	
11,000		.140	
12,000		.168	
14,000		.250	
16,000		.373	
18,000		.526	
20,000		458 BROKE	
21,000			.114
22,000	.168		.318
22,400	.359		.511
22,469	F A I L U R E		



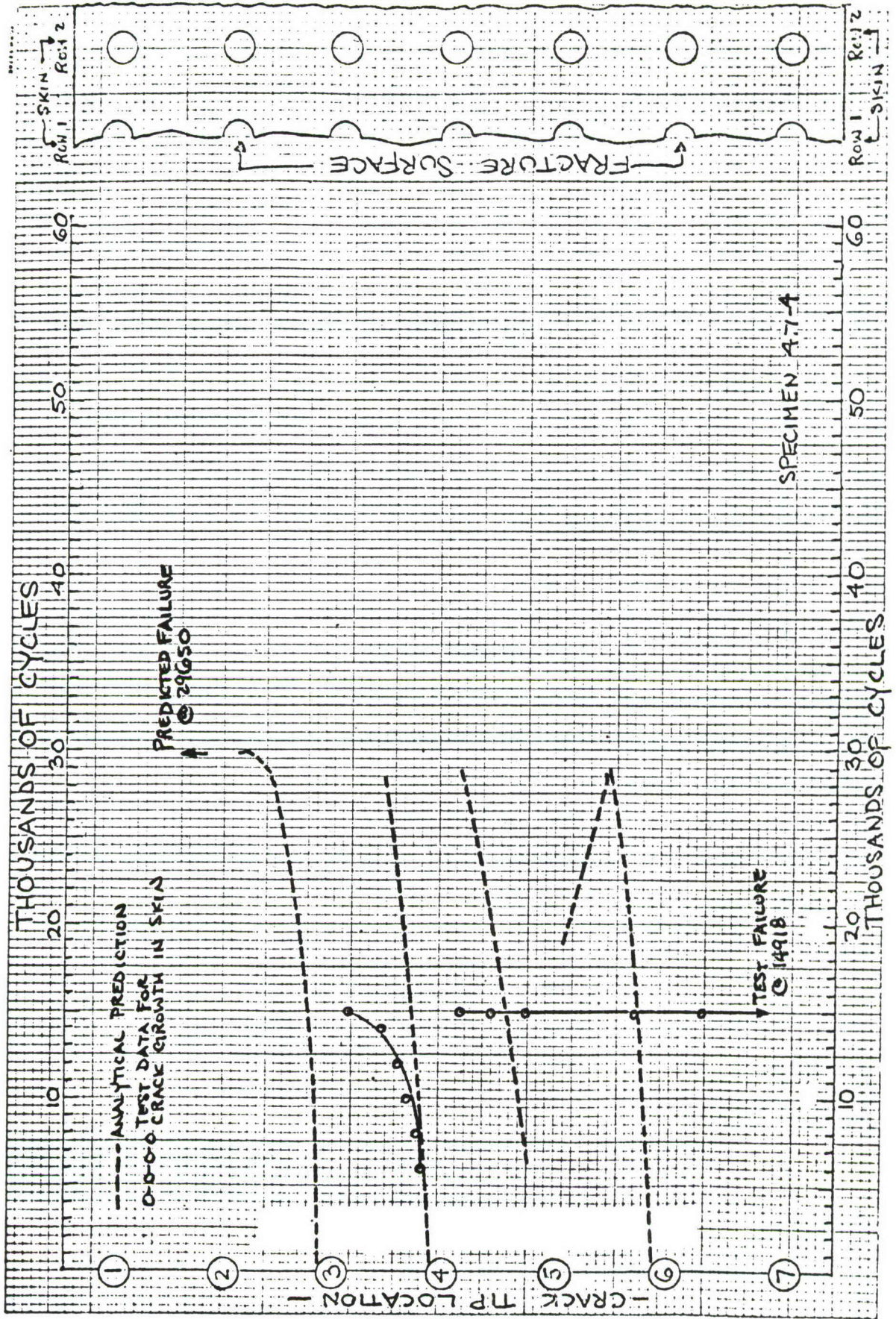
SPECIMEN 4.7-2

N	a ₅₆	a ₅₄	a ₄₃	a ₃₂
10,000			"DIMPLE"	
12,000			.100	.100
13,000			.145	.150
14,000			.178	.206
14,817		.125	.208	.253
16,002		.167	.273	.331
16,502		.192	.302	.375
17,002		.220	.340	.419
17,472		BROKE	BROKE	BROKE
17,778	.243			
17,789	BROKE			
17,973	F A I L U R E			



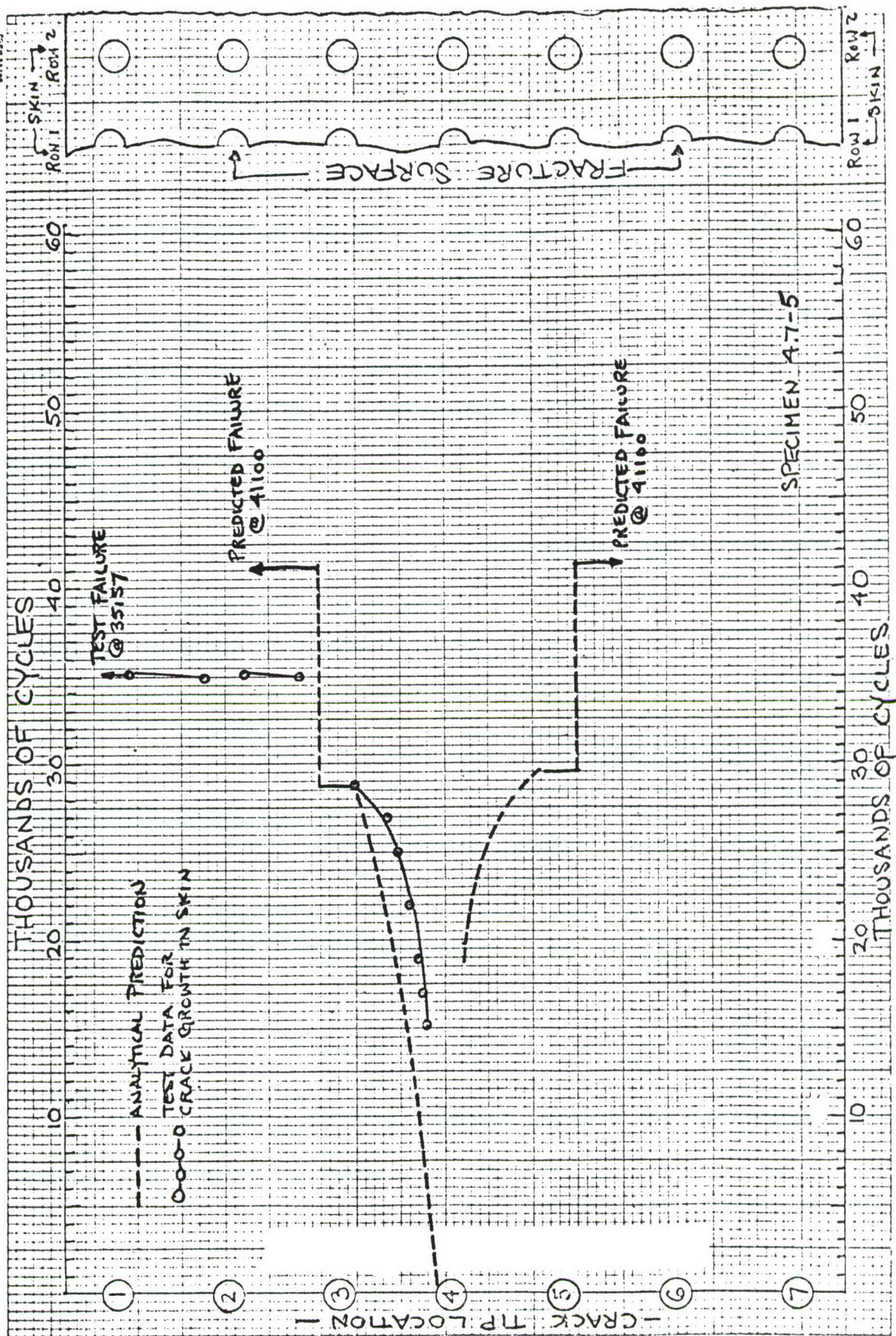
SPECIMEN 4.7-3

N	Q ₃₂	Q ₄₃	Q ₅₄
	(.005)	(.050)	(.005)
15,000		.190	
17,000		.430	
17,530	.440	.506	.284
17,700	.486	.546	.388
18,300	.600	938 BROKE	.388
18,315	938 BROKE		—
18,400			.405
18,507			938 BROKE
18,981	F A I L U R E		



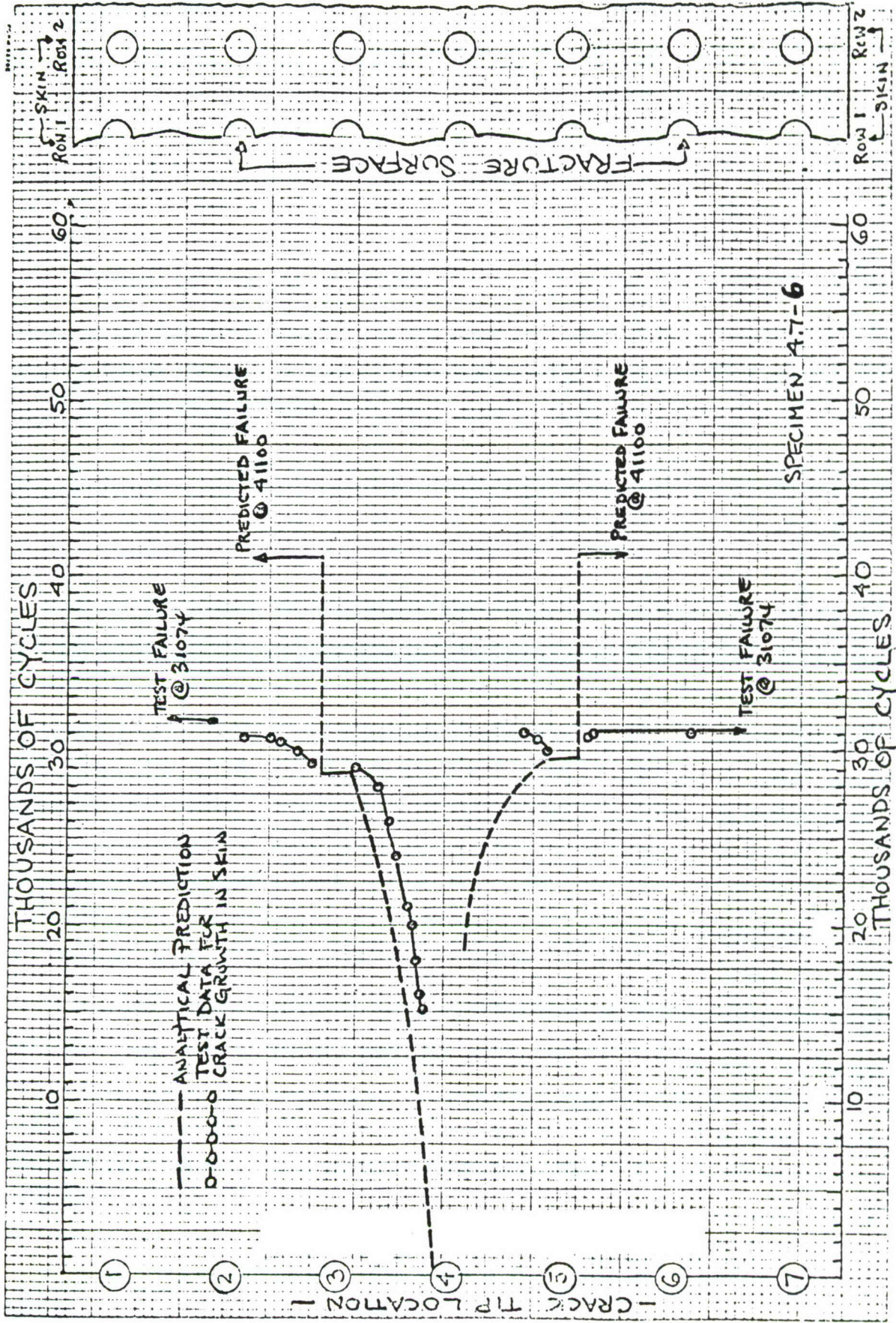
SPECIMEN 4.7-4

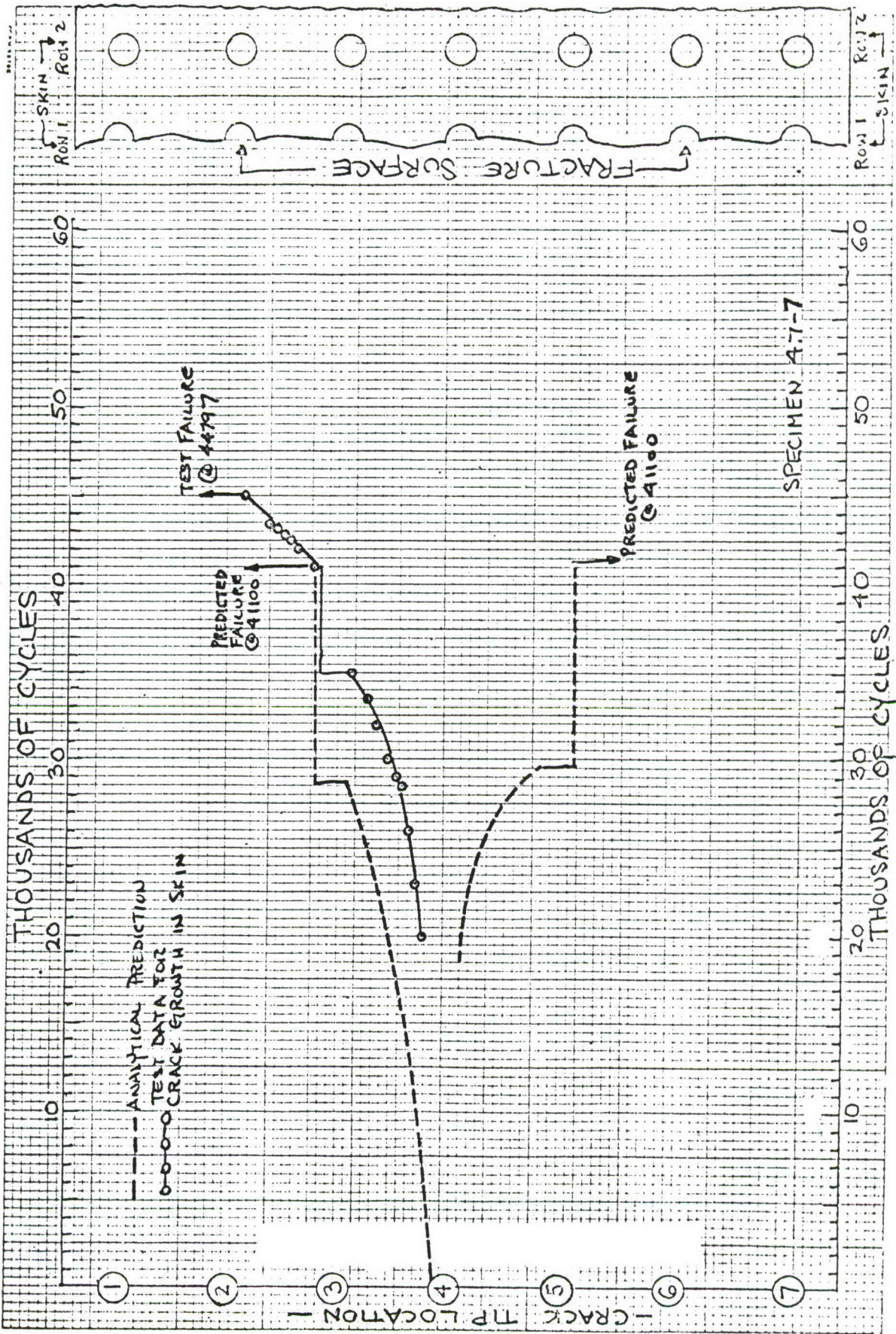
N	a43	a45	a54	a65	a67
6000	.100				
8000	.180				
10000	.283				
12000	.381				
14000	.537				
14917	BROKEN THRU	.35	(~.2)	(~.2)	(~.2)
14918	F A I L U R E				



SPECIMEN 4.7-5

N	a ₄₃	a ₃₂	a ₂₁	a _{1E}					
15 100	.100								
16 000	.124								
17 000	.155								
18 000	.180								
19 000	.211								
20 000	.241								
21 000	.277								
22 000	.306								
23 000	.341								
25 000	.429								
27 000	.535								
28 850	.938 BROKE								
35 000		.263	.132						
35 144		.938 BROKE	.938 BROKE	.469 BROKE					
35 157	—	F	A	I	U	R	E		



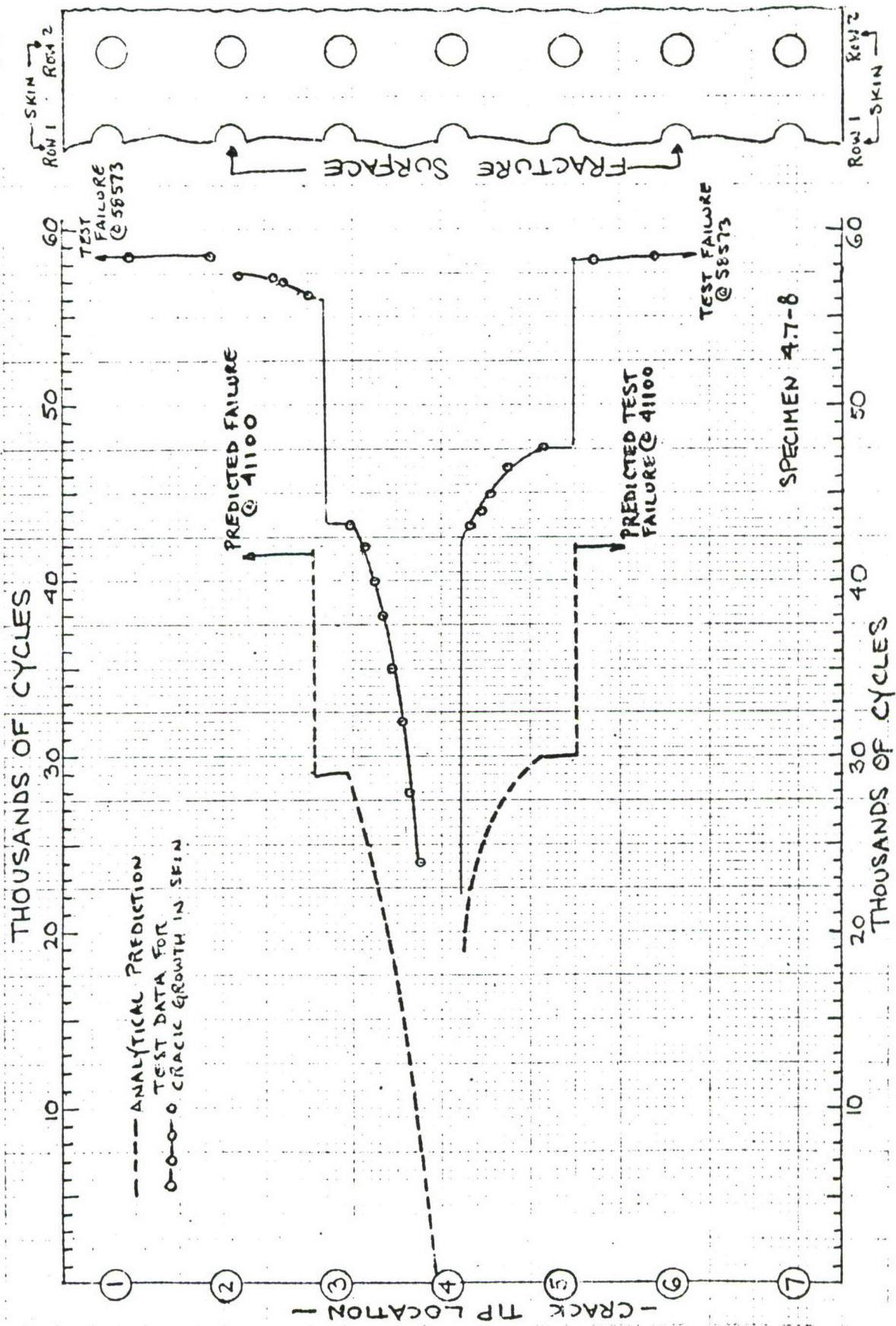


DATA SHEET NO(S) : 357472-74

TEST DATE(S) : 9-21-76 TO
9-22-76

SPECIMEN 4.7-7

N	a ₄₃	a ₃₂	
20000	0.115		
21000	0.149		
22000	0.172		
23000	0.202		
24000	0.240		
25000	0.266		
26000	0.280		
27000	0.325		
28000	0.364		
29000	0.424		
30000	0.504		
31000	0.561		
32000	0.620		
33000	0.716		
34000	0.766		
35000	BROKE		
36000	THRU		
41000		0.098	
42000		0.257	
42500		0.343	
42800		0.414	
43100		0.497	
43400		0.578	
43700		0.696	
43800		0.726	
43900		0.853	
44797	FAILURE		* POPPING SOUNDS AT 44360 CYCLES, NO NEW CRACKS SEEN



SPECIMEN 4.7-8

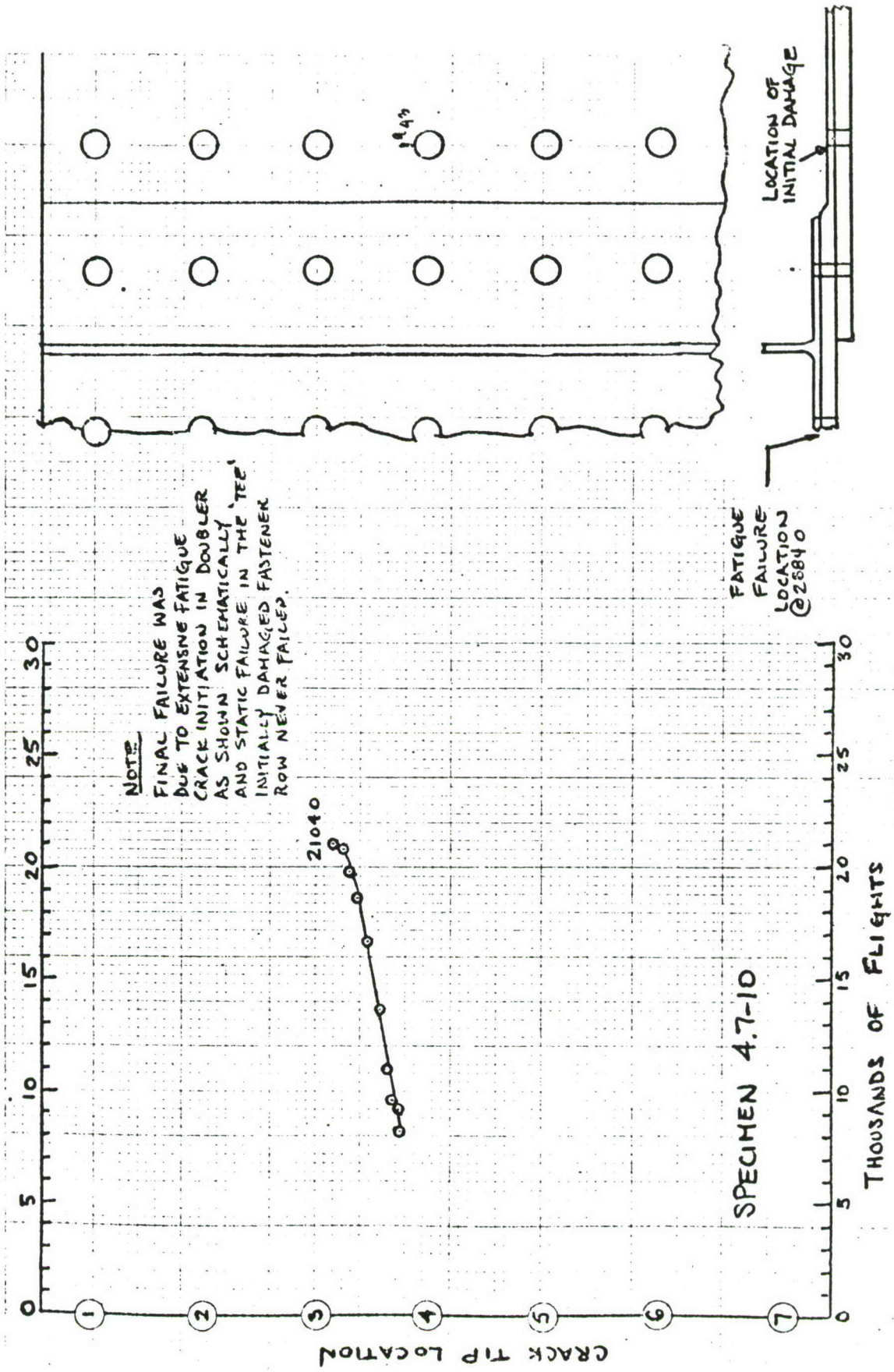
DATA SHEET(S) : 357475-78

TEST DATE(S) : 9-23-76 T.
9-24-76

N	a ₄₃	a ₄₅	a ₃₂	a ₅₆	a ₂₁ (OR a ₁₂)
24x10 ³	0.132				
26	0.182				
28	0.233				
32	0.340				
35	0.441				
38	0.558				
40	0.650				
42	0.776				
42.4	0.814				
42.7	0.846				
43.2	CRACK TO FASTENER	0.114			
44.1		0.214			
45.1		0.329			
45.8		0.415			
46.6		0.526			
47.2		0.650			
47.6		0.779			
47.7		CRACK TO FASTENER			
56.3			0.130		
56.4			0.183		
56.8			0.285		
57.05			0.398		
57.25			0.498		
57.35			0.572		
57.45			CRACK TO FASTENER	(1)	
58.4			0.210		
58.45			0.470		
58.475			CRACK TO FASTENER	(2)	
58.509				CRACK TO FASTENER	
58.573		FAILURE			

NOTES : (1) CRACK ORIGINATED AWAY FROM NET SECTION
BETWEEN HOLE 5 AND HOLE 6

(2) CRACK WAS FIRST OBSERVED FROM FASTENER
TO FASTENER

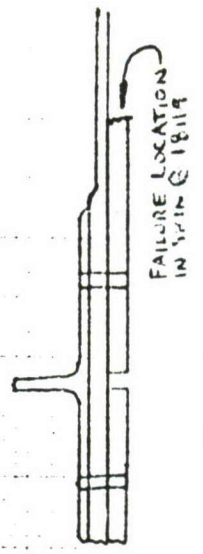
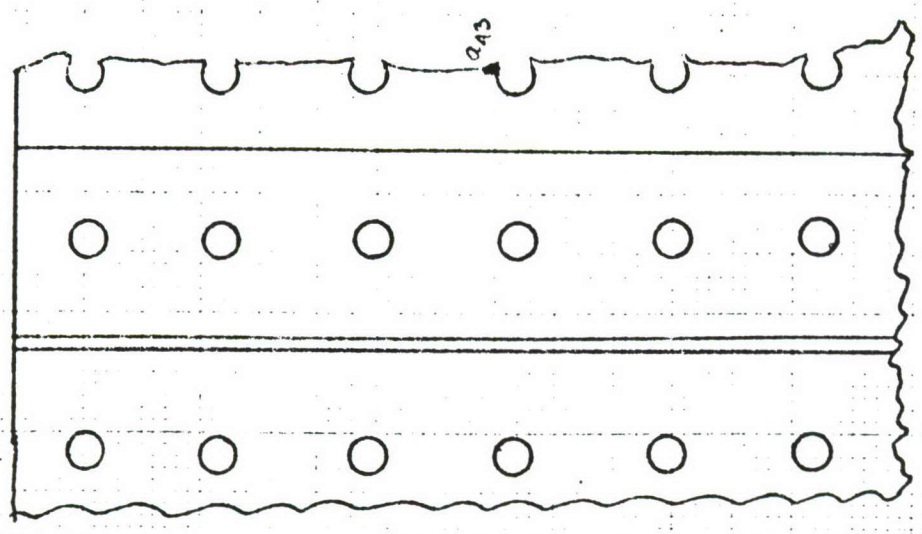
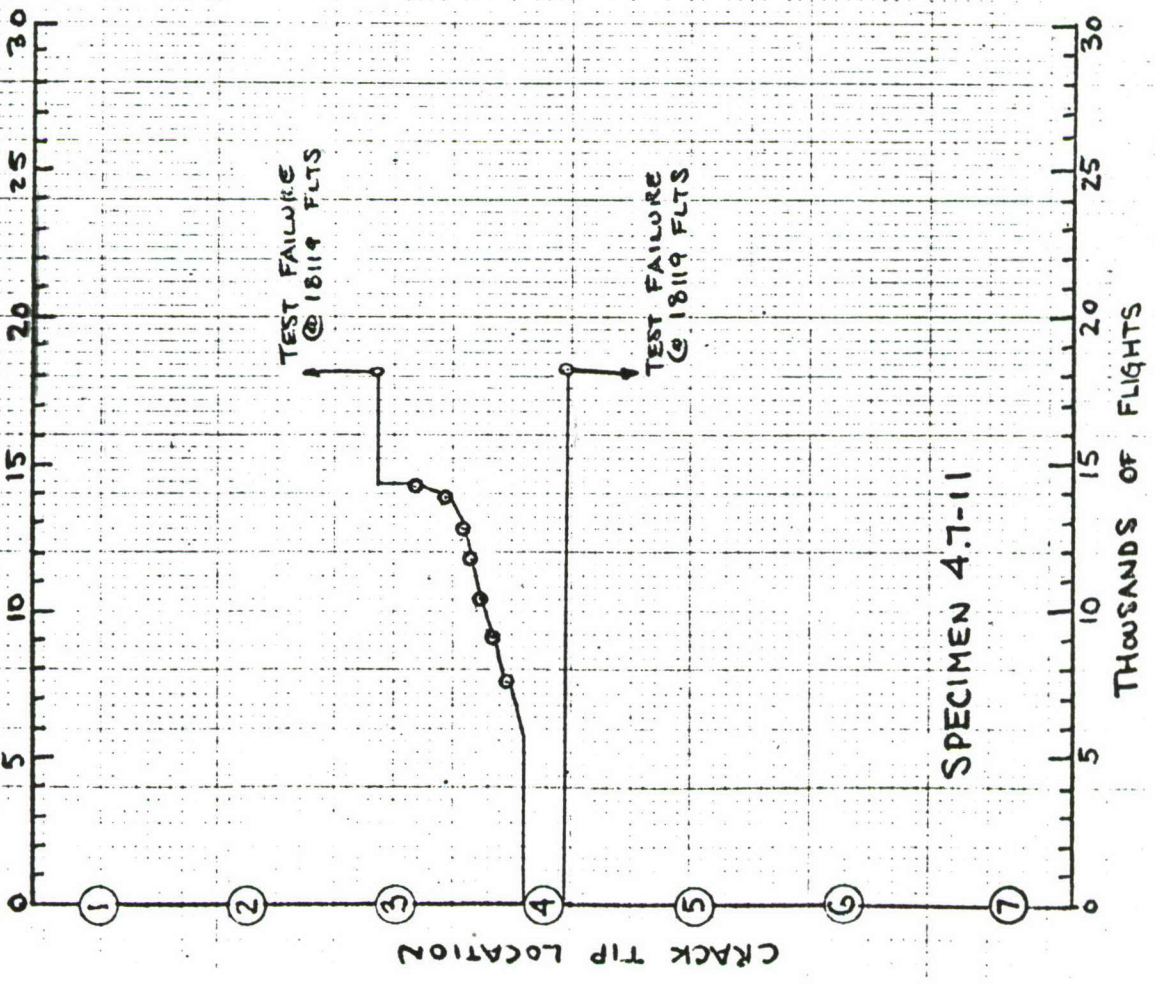


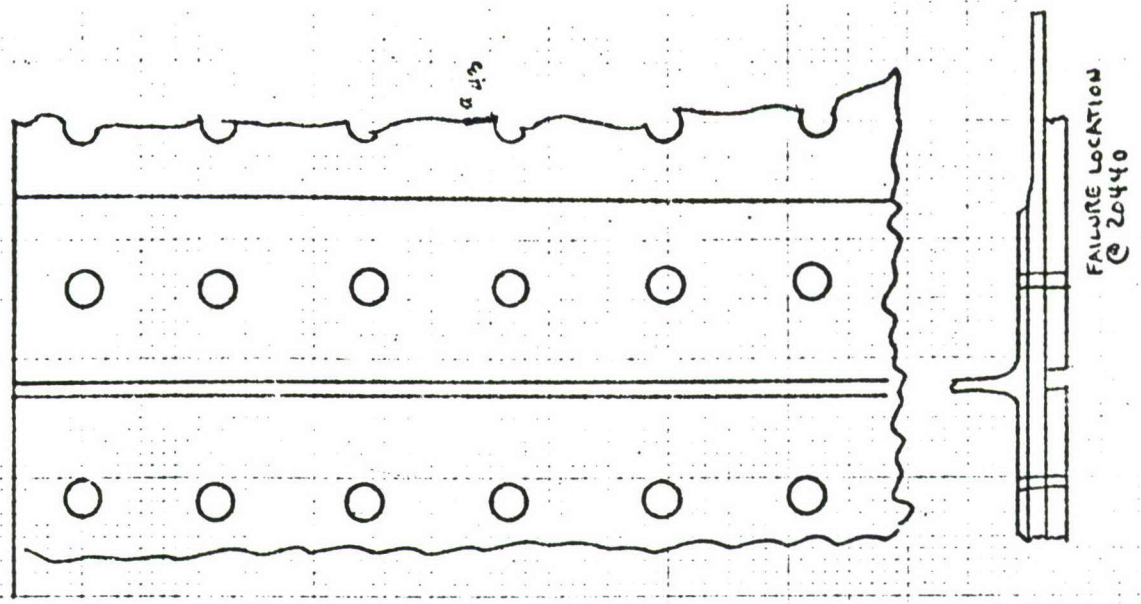
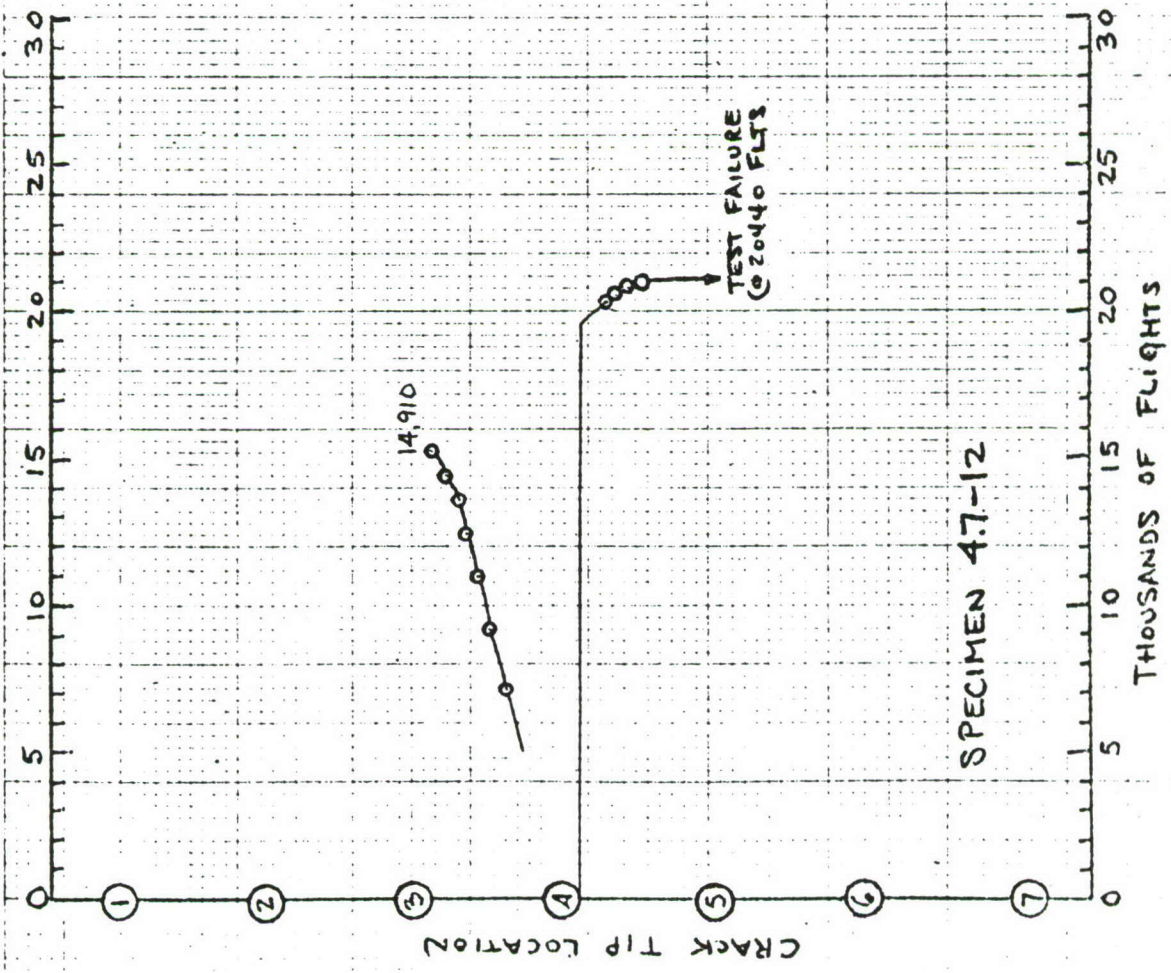
DATA SHEET(S) : 57331S-19

TEST DATE(S) : 3-23-77 TO
3-25-77

SPECIMEN 4.7-10

FLTS	a_{43}	
7.8×10^3	0.160	* SURFACE DIMPLE
9.12	0.160	
9.24	0.187	
9.36	0.195	
9.48	0.230	
9.84	0.232	
10.24	0.265	
10.64	0.278	
10.72	0.285	
10.88	0.295	
10.96	0.300	
11.36	0.308	
12.16	0.337	
13.68	0.390	
15.2	0.428	
16.72	0.505	
17.04	0.525	
17.44	0.546	
17.84	0.572	
18.24	0.592	
18.56	0.607	
18.96	0.656	
19.36	0.680	
19.76	0.718	
20.72	0.780	
21.04	CRACK TO FASTENER	
2884	FAILURE	



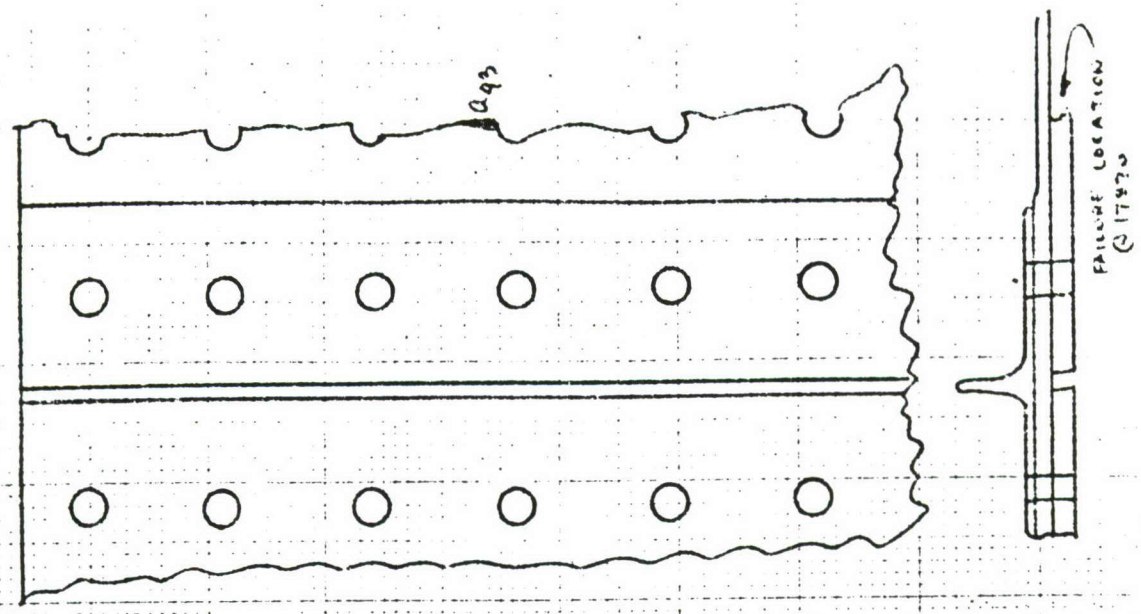
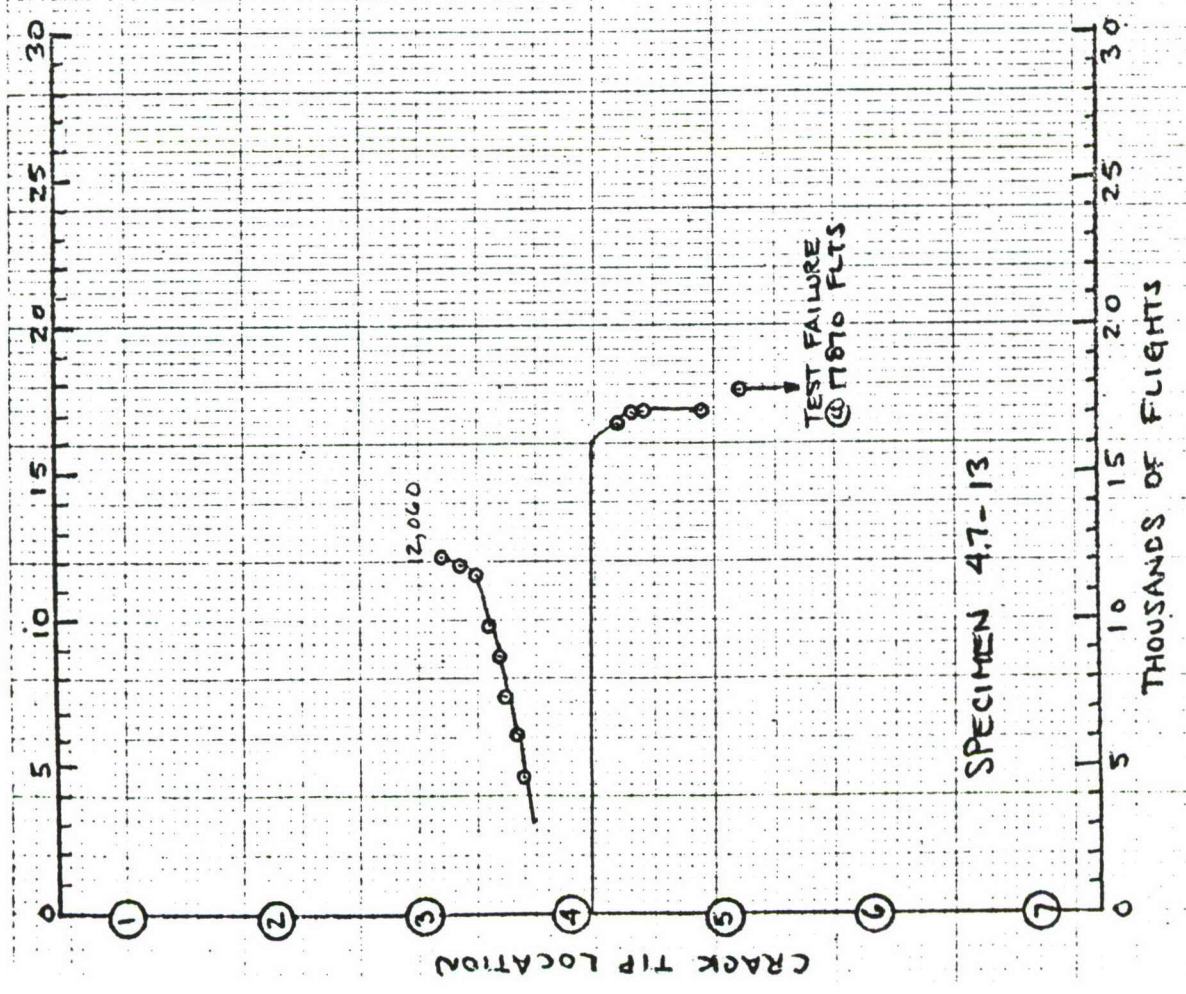


SPECIMEN 4.7-12

DATA SHEET(S): 573325-27

TEST DATE(S): 4-14-77-4-25-7

FLTS	a ₄₃	a ₄₅
7120	0.305	
7600	0.339	
7920	0.354	
8320	0.373	
8720	0.383	
9120	0.411	
9440	0.428	
9840	0.447	
10240	0.470	
10640	0.491	
10960	0.510	
11360	0.565	
12160	0.619	
12640	0.652	
13200	0.698	
13440	0.707	
13680		
14040	0.723	
14400	0.800	
14640	0.864	
14800	0.930	
14910	CRACK TO FASTENER	
15200		
16720		
18240		
19760		
20160		0.261
20280		0.324
20400		0.432
20440	FAILURE	



SPECIMEN 47-13

DATA SHEET(S) : 573320-22

TEST DATE(S) : 3-30-77 TO
4-5-77

FLTS.	A43	A45	A56
4160	DIMPLE		
4560	0.213		
6080	0.280		
7140	0.338		
7600	0.370		
8320	0.414		
8720	0.431		
9120	0.455		
9440	0.489		
9840	0.508		
10240	0.527		
10640	0.544		
11120	0.604		
11360	0.662		
11760	0.743		
11800	0.815		
11880	0.860		
12020	0.920		
12060	CRACK TO FASTENER		
16720		0.238	
16800		0.262	
16880		0.299	
17040		0.328	
17120		0.379	
17159		CRACK TO FASTENER	
17860			0.008
17870	FAILURE		

SECTION V

TEE-REINFORCED CONTINUOUS SKIN SPECIMENS

Crack growth data and predictions for the tee-reinforced specimens with continuous skin are presented in this section. A total of twelve specimens were tested, all under constant amplitude fatigue loading at $S_{\max} = 17$ ksi, $R = 0.1$. The configurations and the initial damage are shown in Figure B-1 (Appendix B) and Table 3 of Volume I.

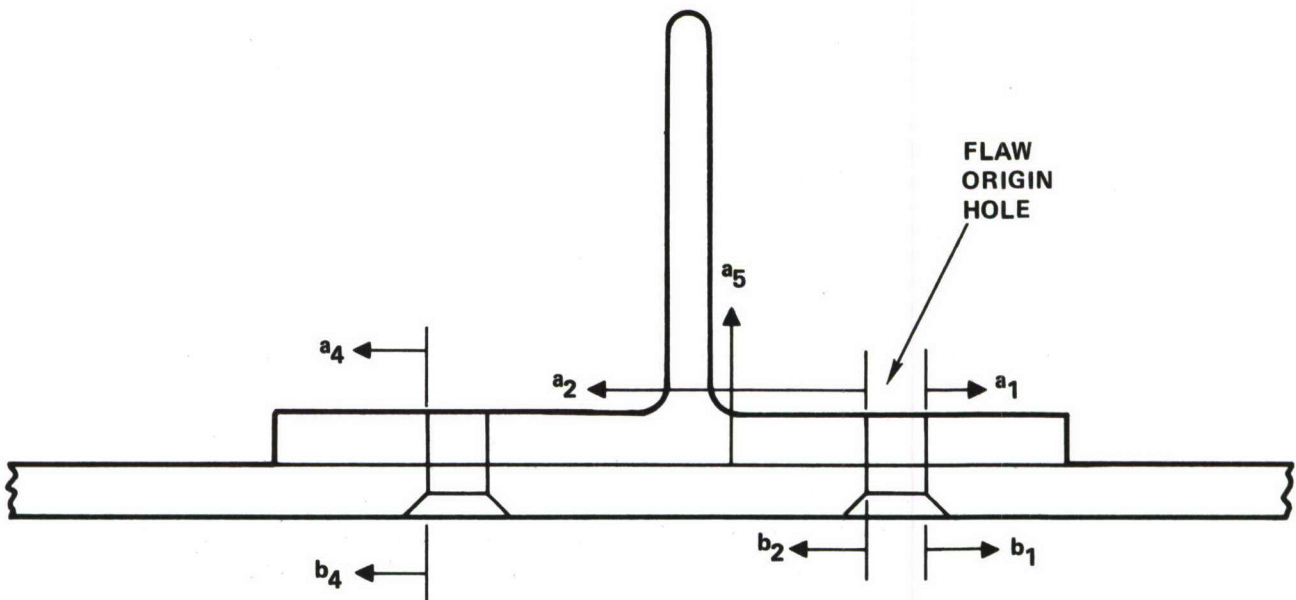
The format of data presentation is similar to the formats of previous sections, in that a graphic presentation of the crack path is added to the tabulated data shown previously. Three schematic views of the central test area of each broken specimen (a sectional view, a top view, and a side view) are shown together with the growth curves to aid in visualizing the actual crack path. The tabulated data and the graphic presentation of crack path are shown on face-to-face pages to facilitate cross reference.

The notation of a_i and b_i are still used to denote crack lengths for cracks on the head side and the collar side, respectively. In addition, the letters A, B, C, etc., are used on the sectional view to indicate locations of thin marks left on the fracture surface by the application of low-amplitude marking cycles.

A stop-drill hole was put in the skin, when necessary, about 1.6 inches from the edge of the fastener hole from which the crack was originated. The stop-drill hole was to prevent the rapid cracking of the skin and enable the accumulation of further crack growth data at the other end of the crack. A nominally 0.375-inch diameter hole was used, and a clearance fit, fully-torqued Hi-Lok fastener was placed in the hole to further retard the crack growth.

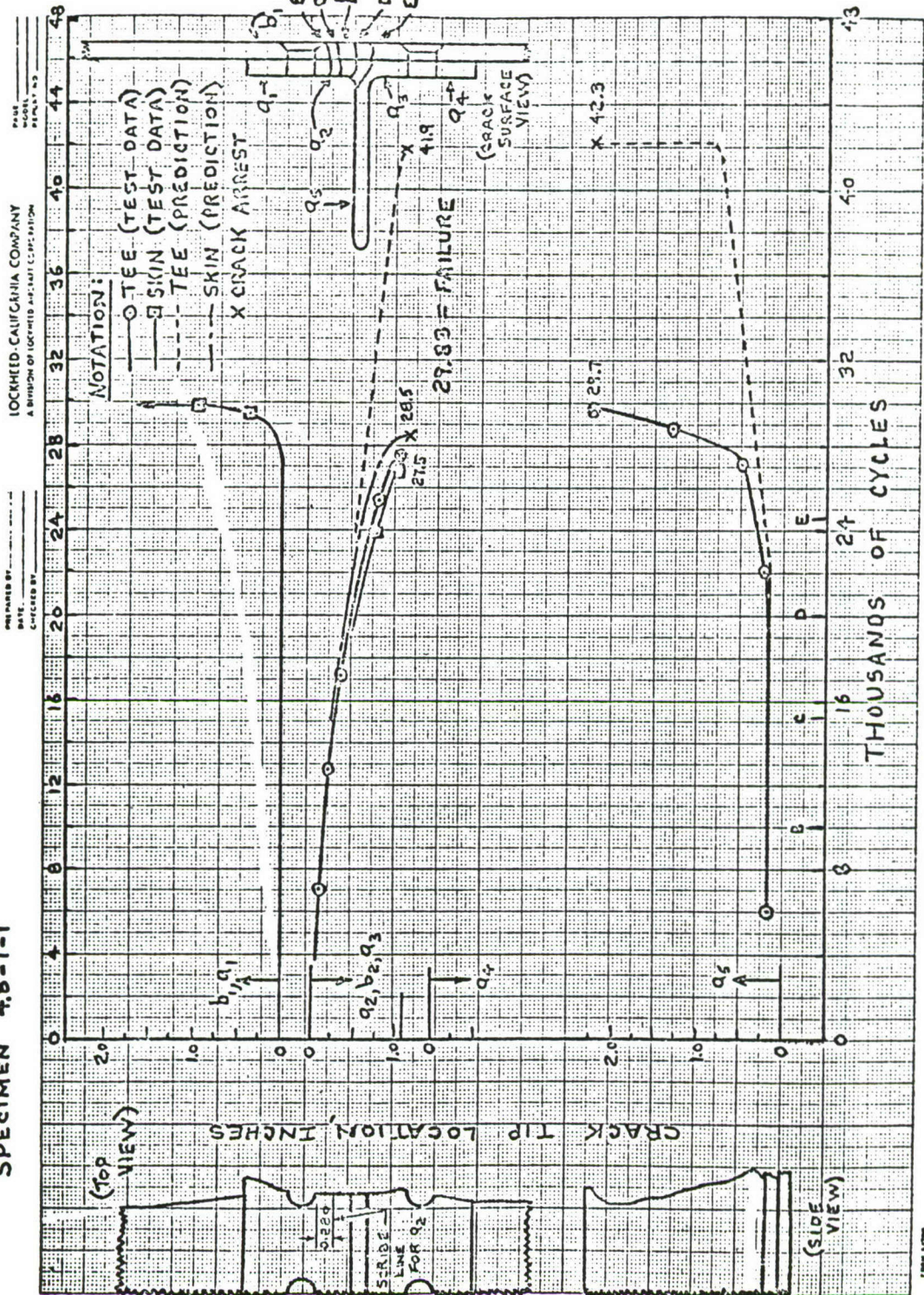
NOTES FOR ALL TEE-REINFORCED CONTINUOUS-SKIN SPECIMENS

- ① Initial crack lengths measured at faying surfaces before assembly. All other length measurements are at externally-visible surfaces.
- ② Marking cycles A, B, C, D, etc. produce thin marks on the fracture surface. (See fracture surface view on drawing.) Numbers in parentheses indicate marking cycles, $S_{\max} = 17.0$ ksi, $R = 0.83$.
- ③ In radius of tee.
- ④ Arrests at hole.
- ⑤ Under head of rivet.
- ⑥ Arrests at edge.
- ⑦ Rapid propagation to edge
- ⑧ Stop drill 0.378 diameter hole; install clearance-fit HL50-12-6 Hi-Lok fastener with steel washers in collar and 190 in.-lb torque.
- ⑨ Initial crack depth measured on fracture surface.
- ⑩ Crack dimension is on faying surface.
- ⑪ Arrests at edge. Tee fails completely.
- ⑫ Complete failure of tee.



NOTATION FOR SPECIMEN TYPE 4.8-1-X

SPECIMEN 4.8-1-1



DATA SHEET No. 3
570286-9

SPECIMEN 4.8-1-1

DATE TESTED
4-19-76

N	a ₁	a ₂	a ₄	a ₅	b ₂	b ₁	b ₄
0		.050 ⁽¹⁾	.017 ⁽¹⁾		.060 ⁽¹⁾		.020 ⁽¹⁾
5		DIMPLE		.182			
A ⁽²⁾ MARK (15)		SAME					
6		.069					
8		.119					
10		.157			.097		
B ⁽²⁾ MARK (10)		.162			.100		
13		.214			.183		
15		.232			.257		
C ⁽²⁾ MARK (10)		.287			.262		
17		.353			.342		
19		.400			.431		
20		(3)			.474		
D ⁽²⁾ MARK (10)		(3)		.182	.480		
22		(3)		.229	.594		
23		(3)		.258	.633		
24.5		(3)		.329	.716		
E ⁽²⁾ MARK (10)		(3)		.329	.728		
27		.910		.479	1.00		
27.45		1.047 ⁽⁴⁾		.519	(5)		
28.25				1.019			
29				1.439		.178	
29.5				1.769		.375	
29.723				(6)		—	
29.750	(7)					.610	
29.798			(7)			.940	
29.833							FAILURE

DATA SHEET NO. 3
570293-5, 7-9

SPECIMEN 4.8-1-2

DATE TESTED
4-27-76

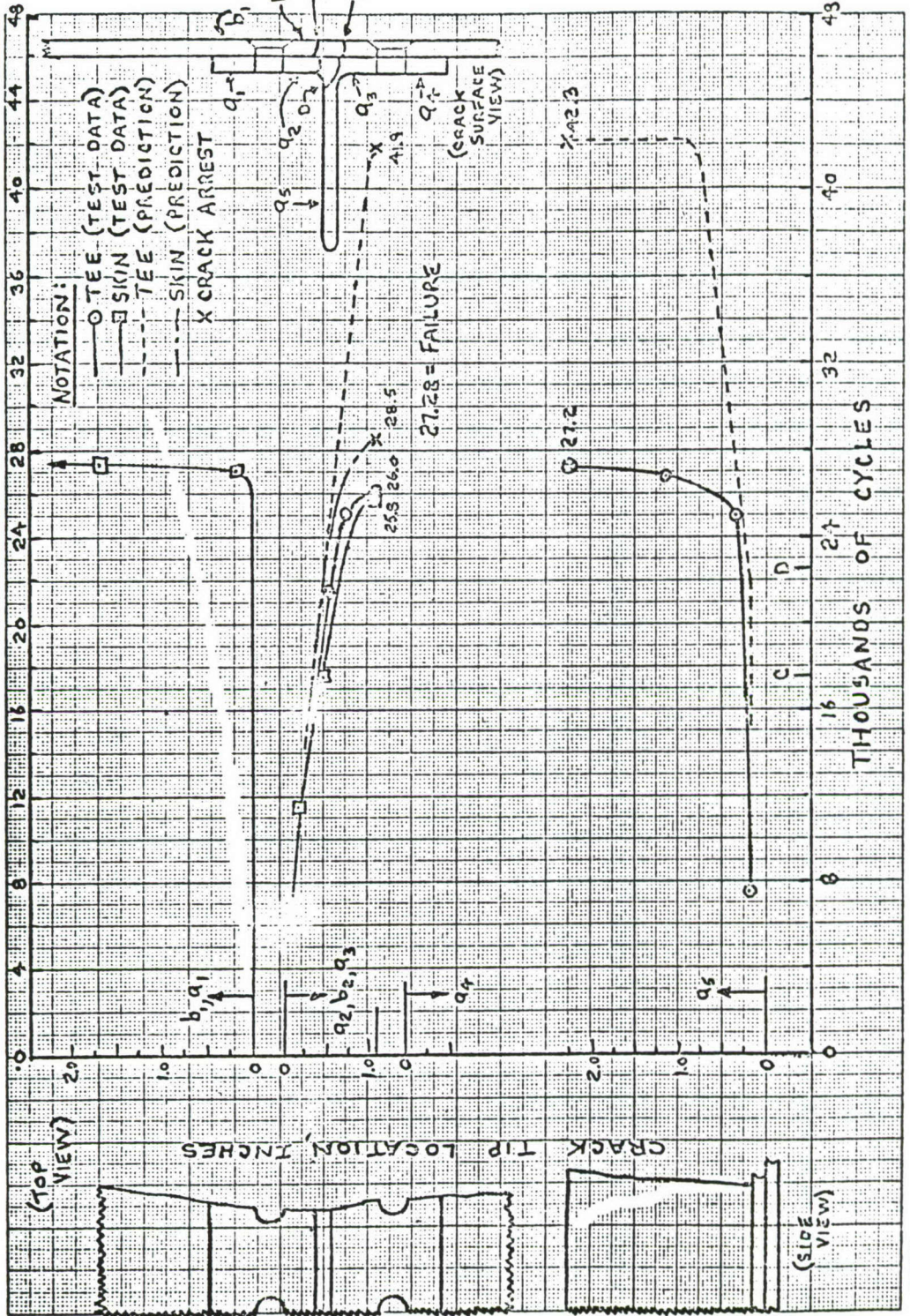
N	a ₂	a ₄	a ₅	b ₂	b ₄	a ₁	Strain Gage Surveys
0	.054 ^①	.022 ^①		.055 ^①	.016 ^①		1 & 2 & 3
4	DIMPLE		.190				
5	DIMPLE						
A ^② MARK (10)	DIMPLE						
5.5	.050						← 4
7.5	.130						
10	.228			.100			5
B ^② MARK (15)	-			-			
11	.265			.136			
13	.326			.176			
15	.351			.223			
C ^② MARK (10)	.351			.224			
15.5	③			.250			
17	③			.335			
19	③		.290	.395			
D ^② MARK (10)	③		-	-			← 6
22.5	.684		.460	.630			7
23.5	.857		.66	.684			
23.753	④		-	-			
24			.75	.725			8
E ^② MARK (5)	-			-			
24.5			.94	.745			
25.25			1.29	④	.192		9
25.275			1.39		⑥		10
25.565			⑥				11
25.715		⑥	⑫				12
26.125	b ₁ + b ₄ = 1.4						13
26.132	FAILURE						

SPECIMEN 4.8-1-3

PREPARED BY: _____
 DATE: _____
 CHECKED BY: _____

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 A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

PAGE: _____
 MODEL: _____
 SHEET NO: _____



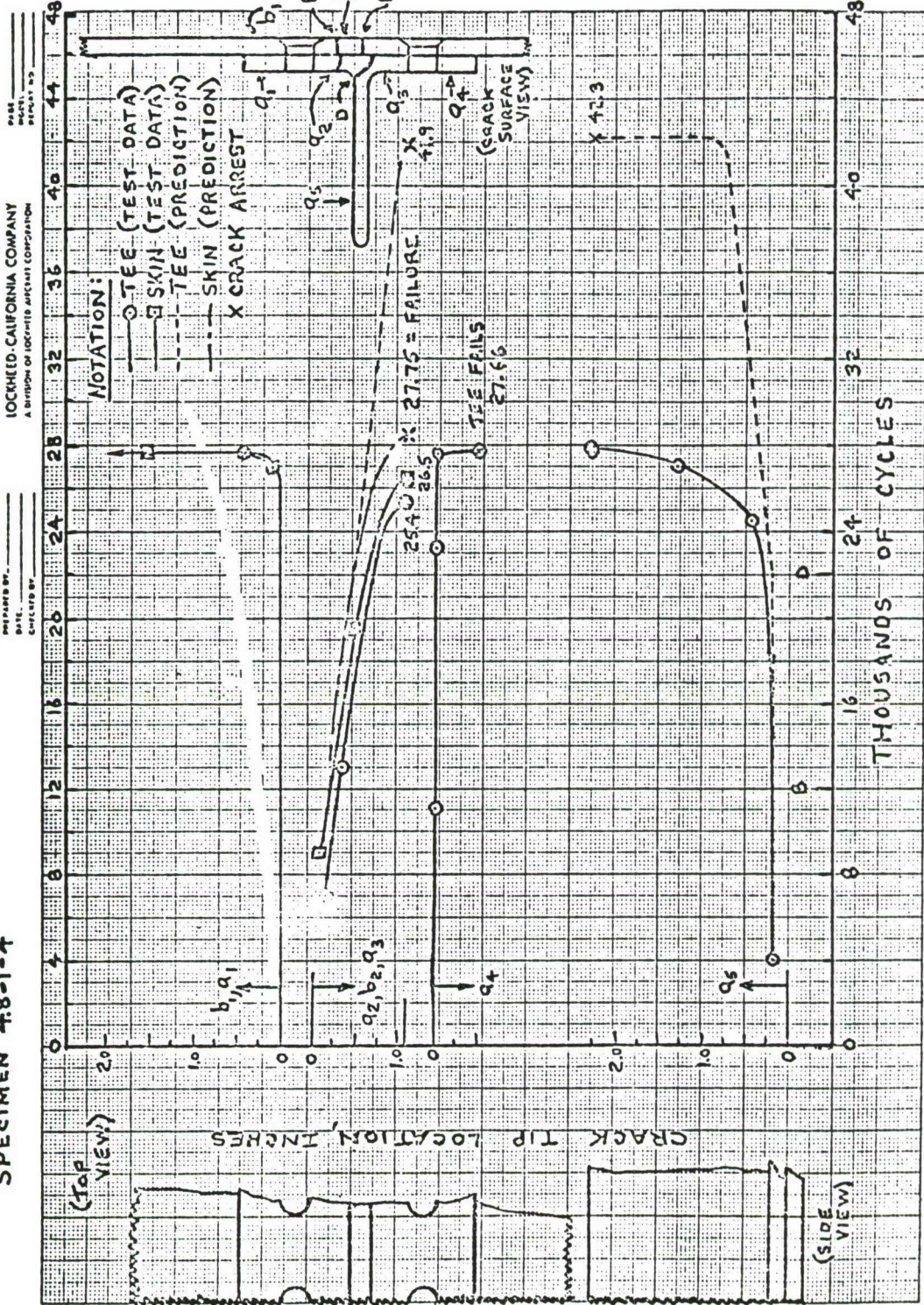
DATA SHEET NO.'s
569971-4

SPECIMEN 4.8-1-3

DATE TESTED
5-1-76

N	a ₁	a ₂	a ₄	a ₅	b ₁	b ₂	
0		.050 ^①				.054 ^①	
5.743		DIMPLE		.194			
7.5		.106					
A ^② MARK (10)							
8.5		.138					
11.5		.234				.188	
12.5		.270				.223	
B ^② MARK (10)		.272				.223	
14.5		.337				.304	
15.5		.370				.347	
15.979		③				-	
17.50		③				.447	
C ^② MARK (10)		③				.449	
22.5		③				.669	
D ^② MARK (10)		③				.676	
23.5		③		.280		.746	
25.0		.698		.350		.868	
25.7		.859		.470		1.048	
25.8		.985		.510		④	
26.0		④		.640			
26.8				1.140	.111		
27.0	1.48			1.310	.182		
27.052	⑥			-	-		
27.2			DIMPLE	1.770	.485		
27.238		.201		⑥	.608		
27.242		⑥			.719		
27.277					1.701		
27.282		FAILURE					

SPECIMEN 48-1-4



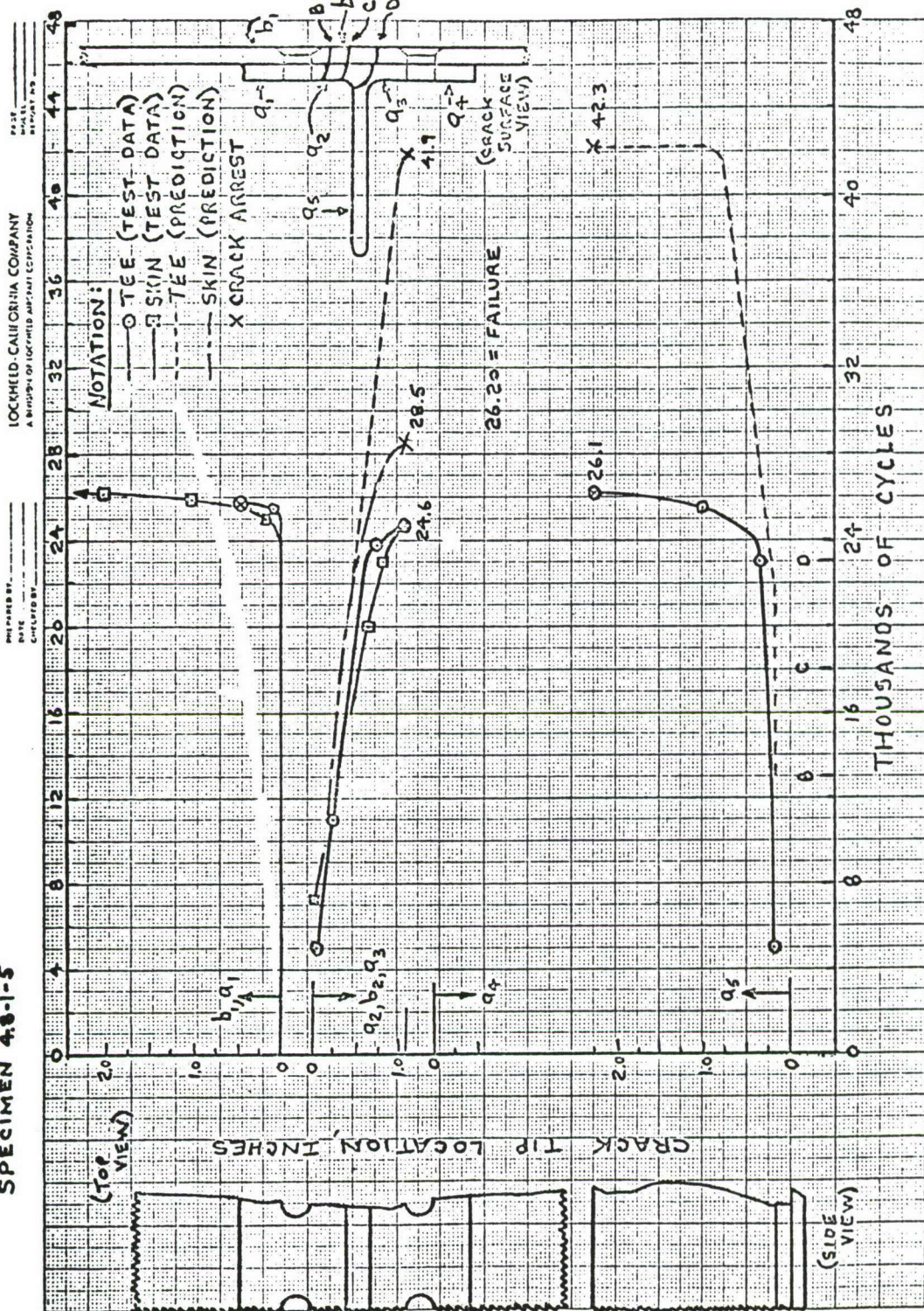
DATA SHEET NO. 5
569979-82

SPECIMEN 4.8-1-4

DATE TESTED
5-20-76

N	a ₁	a ₂	a ₄	a ₅	b ₁	b ₂
0		.084 ⁽¹⁾				.075 ⁽¹⁾
4		.040		.188		
7		.153				
A ⁽²⁾ MARK (10)		.155				
9		.212				.087
12		.303				.128
B ⁽²⁾ MARK (10)		.308				.199
13		.345				.236
15		(3)				.304
17		(3)				.382
C ⁽²⁾ MARK (10)		(3)				.383
19.5		(3)				.479
22		(3)		.310		.576
D ⁽²⁾ MARK (10)		(3)		.310		.577
24.5		.841		.430		.741
25		.955		.490		.780
25.382		1.142		.570		.830
25.392		(4)		—		—
26.401				1.01		1.120
26.5				—		(4)
27				1.29	.090	
27.4	DIMPLE			1.49	.185	
27.5	.156			1.59	.228	
27.55	.284			—	—	
27.566	(6)			—	—	
27.6				1.72	.263	
27.65			.014	(6)	.444	
27.658			(6) (12)		—	
27.723					1.522	
27.745					2.738	
27.749	FAILURE					

SPECIMEN 48-1-5



DATA SHEET NO.'S
569983-6

SPECIMEN 4.8-1-5

DATE TESTED
5-25-76

N	a ₁	a ₂	a ₄	a ₅	b ₁	b ₂	
0		.058 ⁽¹⁾				.046 ⁽¹⁾	
5		.040		.187			
7		.111					
8		.148				.070	
A ⁽²⁾ MARK (10)		.150				.071	
11		.247				.201	
13		.325				.280	
B ⁽²⁾ MARK (10)		.326				.283	
14		.348				.333	
16		(3)				.413	
18		(3)				.498	
C ⁽²⁾ MARK (10)		(3)				.507	
20		(3)				.612	
23		DIMPLE		.350		.794	
D ⁽²⁾ MARK (10)		DIMPLE		—		.813	
23.804		.730		.390		.896	
24.352		.847		.460		.978	
24.5		.898		.500		(5)	
24.6		.969		.530			
24.7		(5)		.600	.101		
25			DIMPLE	.760	.169		
25.3	DIMPLE			.890	.264		
25.5	.107			.990	.357		
25.6	(6)			1.090	.466		
25.9				1.490	1.025		
26.1				1.900	1.78		
26.13				(6)	2.12		
26.186					2.90		
26.197		FAILURE					

DATA SHEET NO'S.:
570281 TO 285

SPECIMEN 4.8-1-6

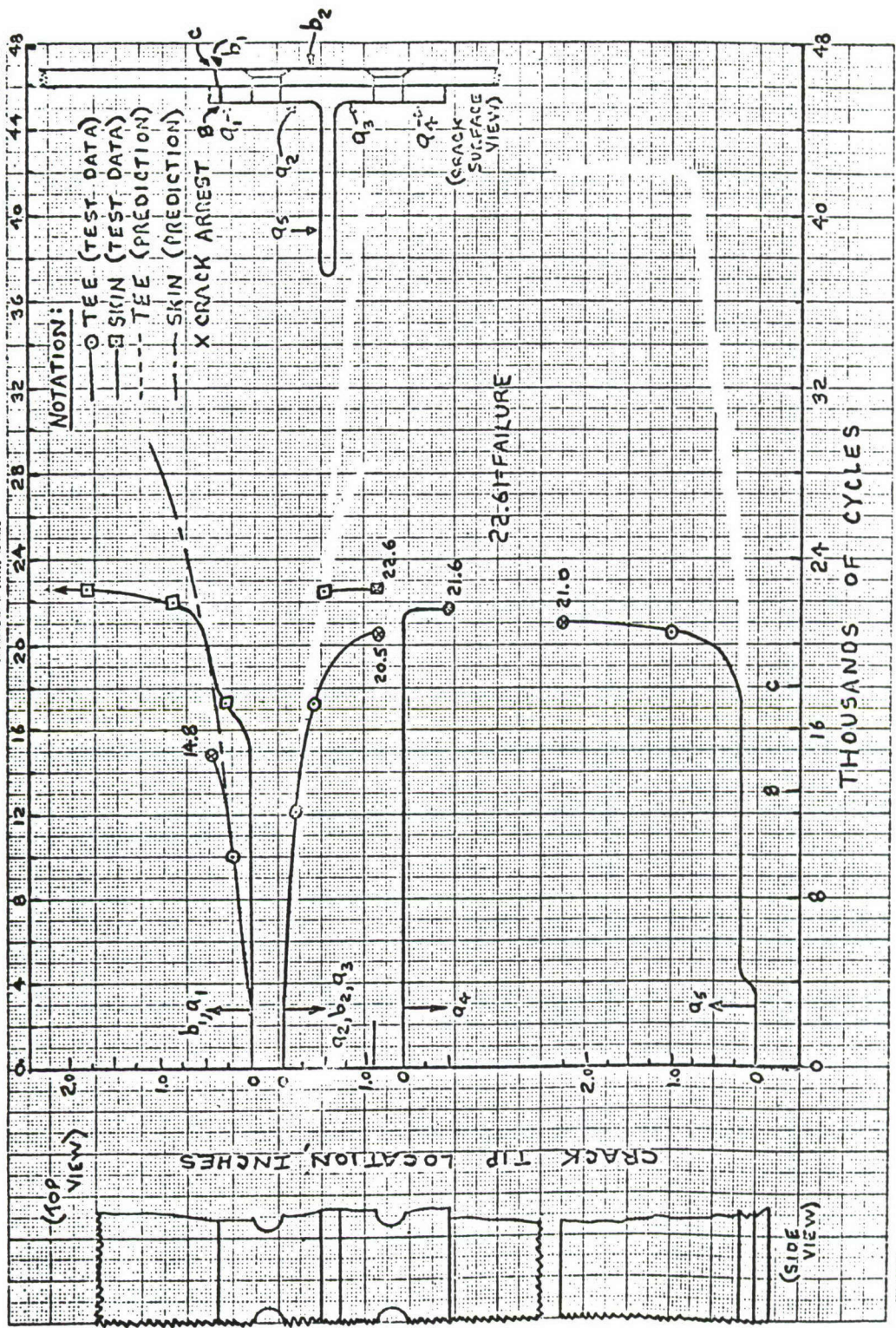
DATES TESTED
4-13 TO 4-16-1976

N	a ₁	a ₂	a ₄	a ₅	b ₁	b ₂	b ₄
0		0.064 ⁽⁷⁾		0.13 ⁽⁹⁾			
4.0		0.033		0.188			
5.0		0.076					
(3) A. MARK (15)		0.094					
6.5		0.131					
9.0		0.187					
12.0		0.278					
15.0		0.373					
17.0		0.42 ⁽³⁾		0.20			
(2) B. MARK (10)							
22.0		0.57		0.24			
(3) C. MARK (10)							
27.0		0.76		0.418			
(2) D. MARK (10)		0.80		0.43			
28.4							
29.0		1.14 ⁽⁴⁾		0.554			
30.0				0.812			
31.0				1.123			
32.0				1.449			
(2) E. MARK (10)	0.08 ⁽¹⁰⁾			1.474			
32.5	0.46 ⁽⁶⁾			1.619			
33.0				1.970			
33.128				2.25 ⁽⁶⁾			
36.959			0.50 ⁽¹¹⁾				
37.0							
(2) F. MARK (10)							
52.0							
(2) G. MARK (10)					0.05 ⁽¹⁰⁾	0.12 ⁽¹⁰⁾	
55.381					0.925	1.14 ⁽⁴⁾	0.08 ⁽¹⁰⁾
55.399	F	A	I	L	U	R	E

SPECIMEN 4.8-1-7

LOGHELD, CALIFORNIA COMPANY
 A DIVISION OF THE UNITED AIRCRAFT CORPORATION

DATE: 11-2-58
 REPORT NO. 48



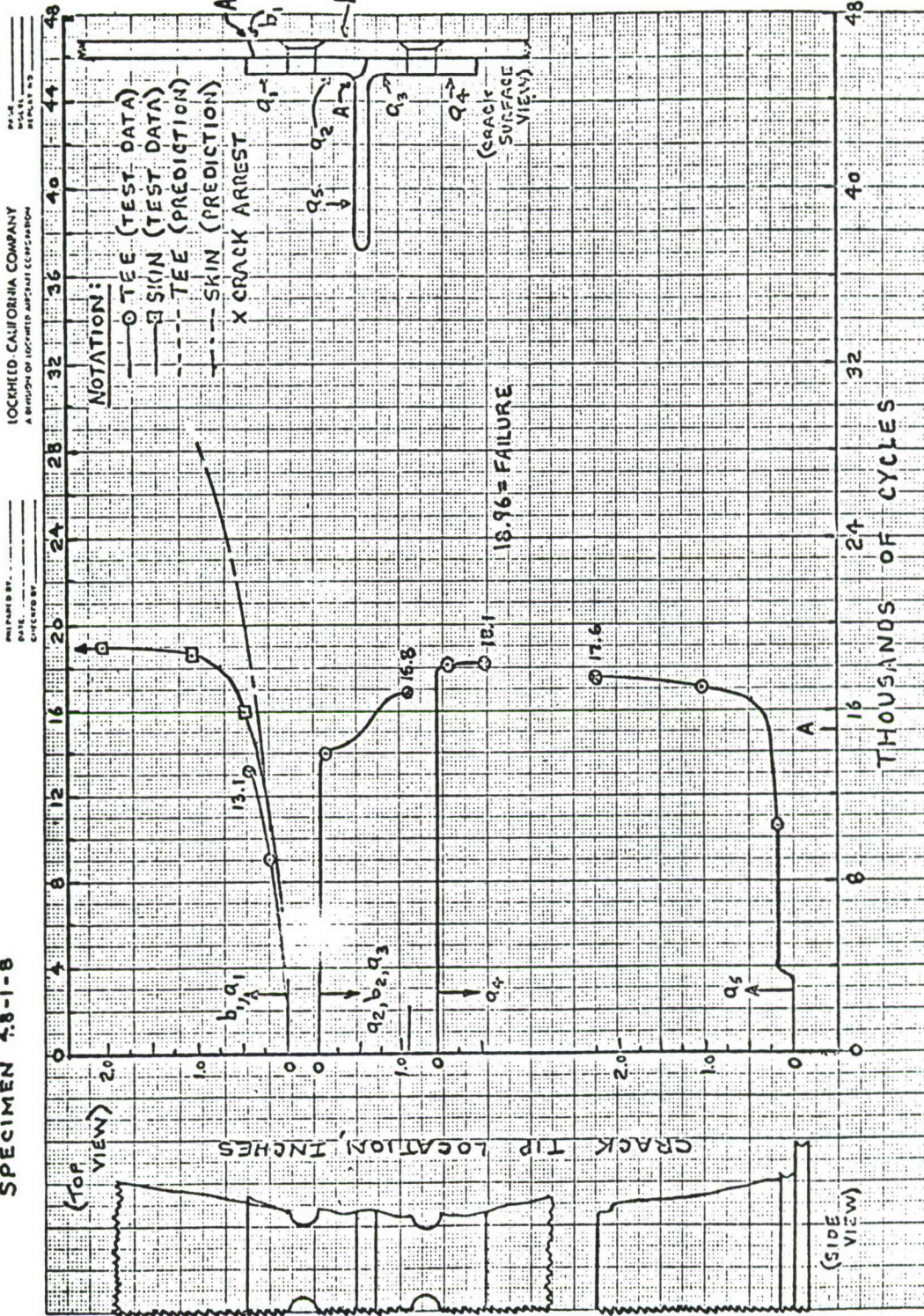
DATA SHEET No. 1
569975 - 8

SPECIMEN 4.8-1-7

DATE TESTED
5-18-76

N	a ₁	a ₂	a ₄	a ₅	b ₁	b ₂
0	.062 ^①	.016 ^①			.049 ^①	
4.5	.027			.187		
5	.066					
6	.110					
8	.151					
A ^② MARK (10)	.153					
10	.206					
12.103	.260	.140				
13	.292	.165				
B ^③ MARK (10)	.320	.167				
14	.365	.205				
14.8	.448	.231				
14.83	⑥	-				
16.5		.288			.005	
16.8		.306			.181	
17.3		.374			.272	
18		③			.360	
C ^④ MARK (10)		③			.368	
19.25		③		.370	.437	
19.8		DIMPLE		.440	.464	
20.5		④		1.01	.512	
20.9				1.49	.562	
21.				1.66	.582	
21.089				⑥	.596	
21.202			DIMPLE		-	
21.628			.15		.685	
21.640			⑥		.694	
22.1					.994	
22.4					1.35	
22.591					1.78	.50
22.6					2.22	④
22.606						FAILURE

SPECIMEN 4.3-1-B



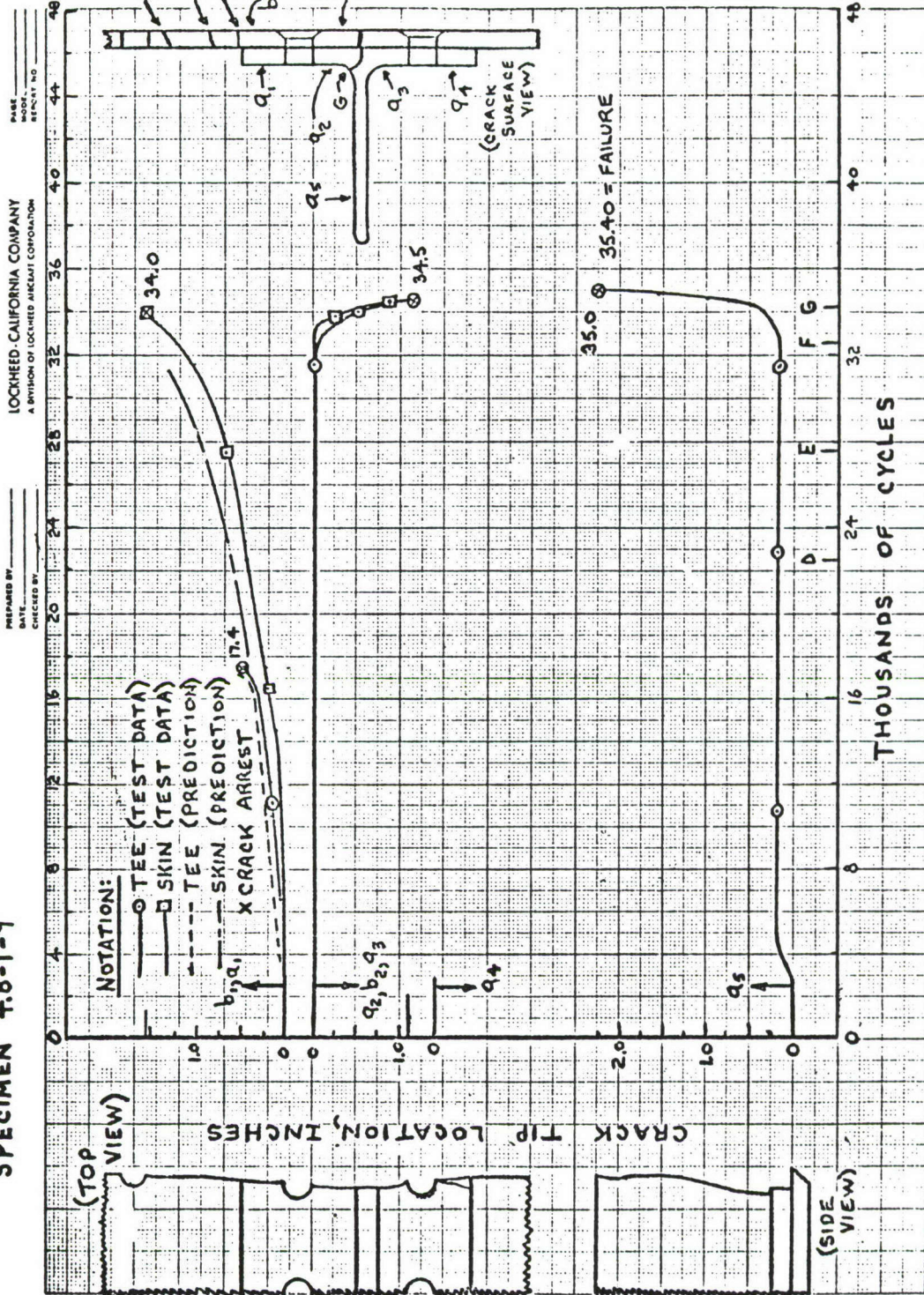
DATA SHEET NO. 5
569957-60

SPECIMEN 4.8-1-8

DATE TESTED
5-10-76

N	a ₁	a ₂	a ₄	a ₅	b ₁
0	.056 ^①	.021 ^①			.050 ^①
4	.028			.187	
5	.071				
6.5	.128				
7.5	.156				.002
8	.174				.062
9	.217				.108
10	.235				.147
12	.322				.230
13	.373				.273
13.085	⑥				—
14		.100			.320
14.5		.365			.345
15.		③			.375
A ^② MARK (10)		③			.385
16		③		.360	.464
16.5		.846		.490	.508
16.741		1.136		.670	.525
17.		④		1.07	.554
17.5				1.83	.624
17.587			DIMPLE	⑥	.651
18.133			.112		.749
18.149			⑥		.768
18.6					1.078
18.8					1.319
18.95					2.050
18.957					FAILURE

SPECIMEN 4.8-1-9



DATA SHEET NO.'S
569966-70

SPECIMEN 4.8-1-9

DATE TESTED
5-12-76

N	a ₁	a ₂	a ₄	a ₅	b ₁	b ₂
0	.055 ⁽¹⁾				.052 ⁽¹⁾	
5	DIMPLE			.188		
7.5	.086					
A ⁽²⁾ MARK (10)	.091					
10.5	.156					
12.5	.200					
B ⁽²⁾ MARK (10)	.207					
14.5	.265				.127	
16.5	.330				.199	
17.408	.428				.228	
17.448	(6)				-	
17.5					.229	
C ⁽²⁾ MARK (10)					-	
18.5					.270	
22.5					.426	
D ⁽²⁾ MARK (10)					.434	
27.5					.694	
E ⁽²⁾ MARK (10)					.698	
31.6		.024			1.083	
32.5		.047			1.197	
F ⁽²⁾ MARK (10)		.060			1.230	
33.8		.338			1.502	.282
34		(3)			1.618(8)	.390
34.2		(3)				.560
G ⁽²⁾ MARK (5)		(3)				.605
34.25		(3)		.510		.668
34.4		(3)		.590		.886
34.45		DIMPLE		.610		(4)
34.55		.964		.750		
34.561		1.145		-		
34.571		(4)		-		
34.6				.980		
34.8				1.570		
34.978			DIMPLE	2.070		
35.			DIMPLE	2.150		
35.014			DIMPLE	(6)		
35.048			(6)			
35.4			FAILURE			

DATA SHEET NO.:
570290-2

SPECIMEN 4.8-1-10

DATE TESTED
4-21-76

N	a_1	a_2	a_s	b_1	b_2
0	.028 ⁽¹⁾			.042 ⁽¹⁾	
10	.072		.197	.102	
A ⁽²⁾ MARK (10)	.072			.104	
13.44	.182	.132		.230	
14	.248	.163		.250	
15	.312	.219		.296	
B ⁽²⁾ MARK (10)	.320	.230		.298	
16	.427	.288		.323	
16.092	(6)	.309		.324	
17		(3)	.260	.372	
19		(3)	.400	.471	
19.5		.710	.460	.439	
19.8		(4)	.680	.534	
20			.880	.549	
C ⁽²⁾ MARK (4)			.940	.555	
20.5			1.380	.676	
20.8			1.720	.722	
20.945			(6)	.749	
21.1				.764	
21.464			(12)	.871	
21.7				1.038	
22.1				1.406	
22.119				1.461	.091
22.181				1.834	(4)
22.2				2.580	
22.204					FAILURE

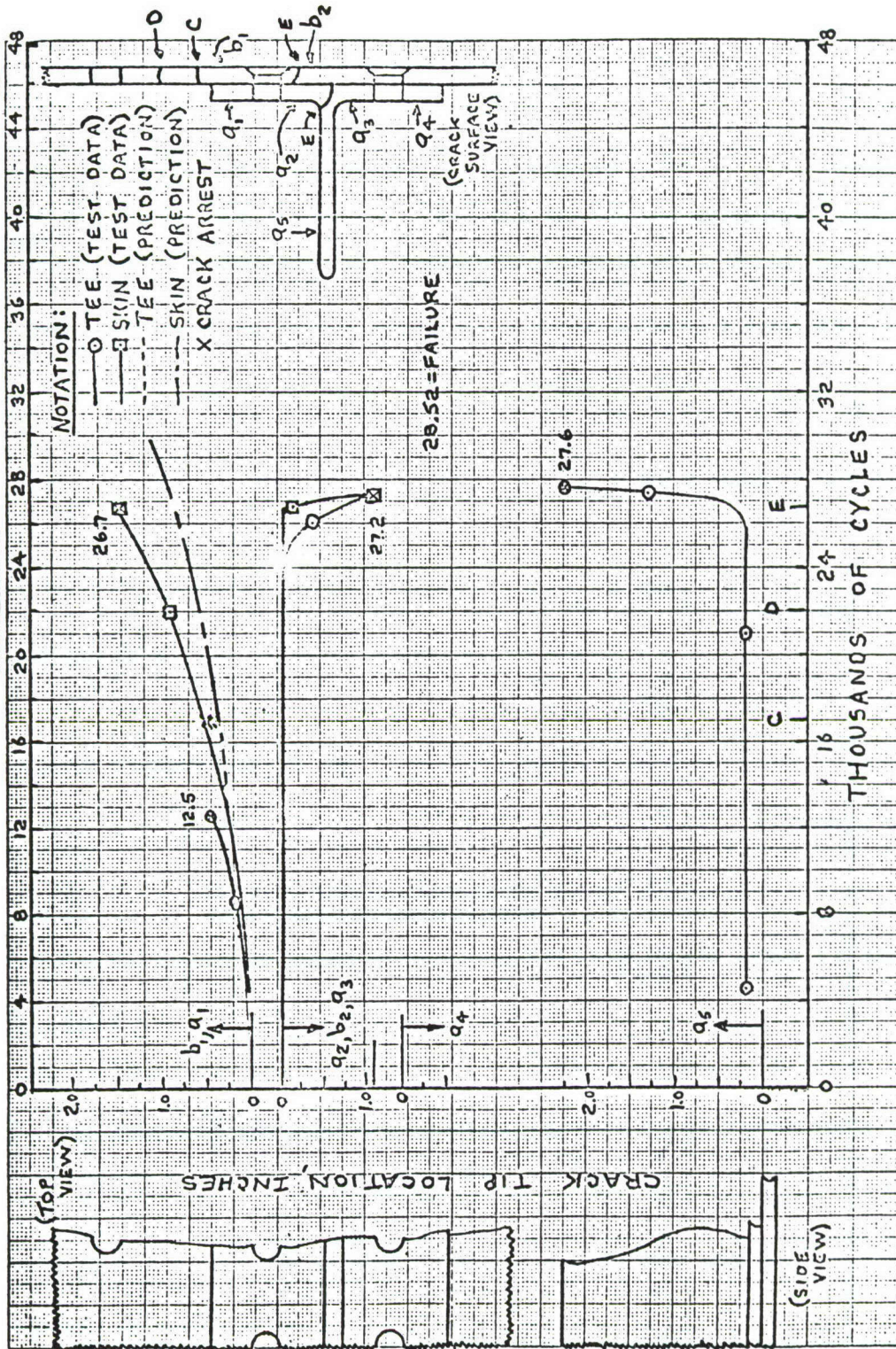
*A tunneled dark area, usually the evidence of a tensile overload, is present at Mark B on a_1 and a_2 . A much thinner, non-tunneled dark line is present on b_1 , also at Mark B. However, no record of overload or other abnormal test condition existed at that time.

SPECIMEN 48-1-11

PREPARED BY: _____
 DATE: _____
 CHECKED BY: _____

LOCKHEED-CALIFORNIA COMPANY
 A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

PAGE _____
 MODEL _____
 REPORT NO. _____

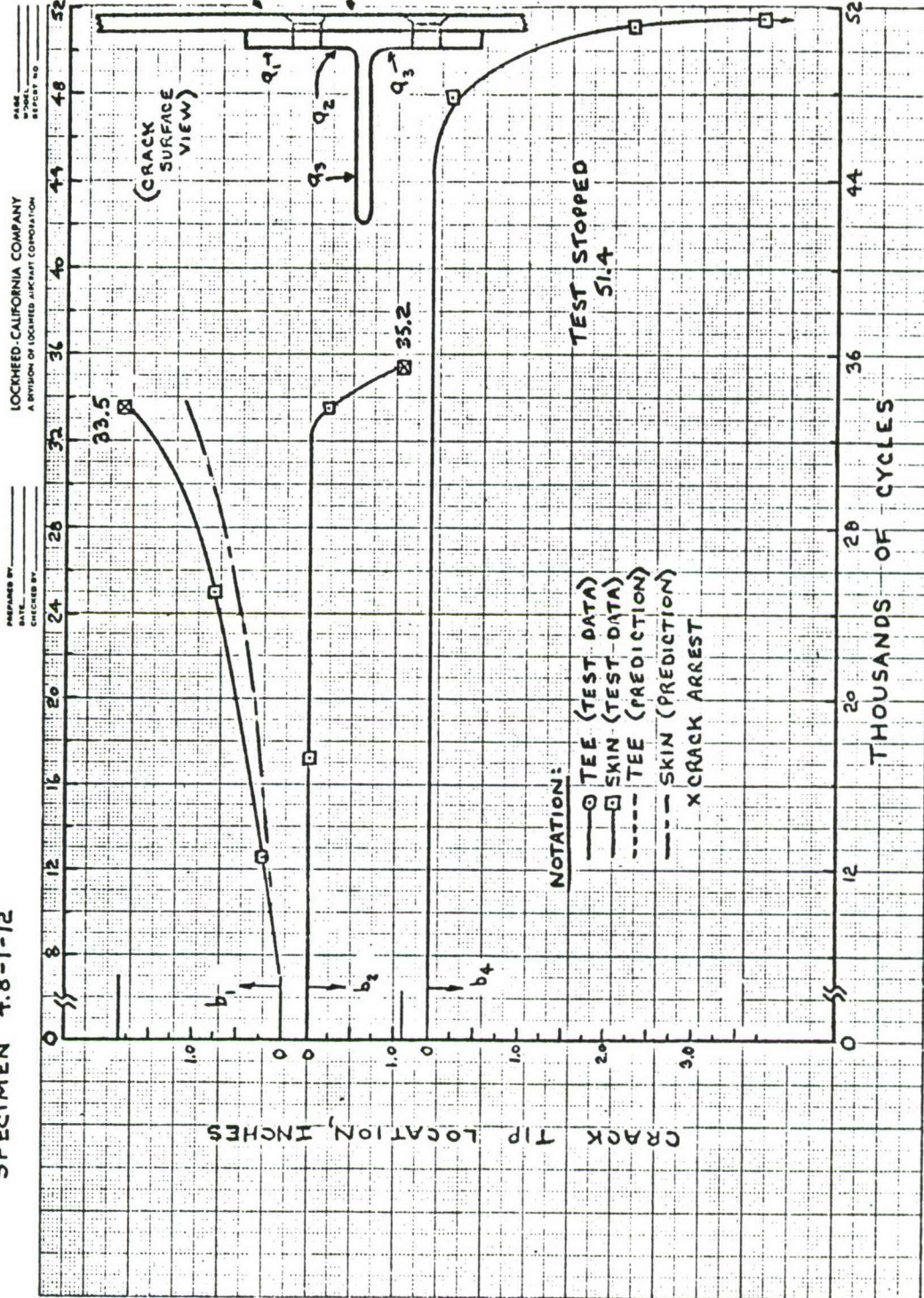


DATA SHEET NO. 15
569961-S

SPECIMEN 4.8-1-11

N	a ₁	a ₂	a ₅	b ₁	b ₂	b ₄
0	.062			.055		
4.5	.036		.187			
5.5	.079					
7	.134					
7.5	.148			.030		
8	.165			.082		
A ⁽²⁾ MARK (10)	—			—		
8.5	.178			.109		
11	.279			.198		
12.458	.417			.251		
12.459	(6)			—		
13				.282		
B ⁽²⁾ MARK (10)				—		
14				.338		
17				.551		
C ⁽²⁾ MARK (10)				.572		
20				.774		
22				.912		
D ⁽²⁾ MARK (5)				.929		
23				1.030		
26		.358		1.400		
26.703		(3)		1.636 (8)	.131	
E ⁽²⁾ MARK (5)		(3)	.287		.180	
27		(3)	.427		.393	
27.05		.848	.437		.459	
27.2		1.063	.637		.749	
27.25		(5)	.837		(5)	
27.4			1.337			
27.55			1.837			
27.6			(6)			
F ⁽²⁾ MARK (2.5)						
28.518					.40	
28.522		FAILURE				

SPECIMEN 4.8-1-12



DATA SHEET No. 3
569951-6

SPECIMEN 4.8-1-12

DATE TESTED
5-6-76

N	b ₁	b ₂	b ₄
0	.062 ⁽¹⁾		
7.5	.039		
9	.101		
10	.131		
A ⁽²⁾ MARK (10)	—		
12.5	.231		
15	.318		
B ⁽²⁾ MARK (10)	—		
20	.527		
C ⁽²⁾ MARK (10)	.532		
25	.782		
D ⁽²⁾ MARK (10)	.790		
30	1.168		
E ⁽²⁾ MARK (7)	1.197		
33	1.652		
33.5	1.806 ⁽³⁾	.210	
34		.390	
34.25		.497	
35		.849	
35.15		(5)	
47.85			.21
48.15			.292
F ⁽²⁾ MARK (5)			.311
48.75			.543
49.25			.769
G ⁽²⁾ MARK (5)			.815
50.25			1.160
50.75			1.658
51.05			2.310
51.25			2.800
51.35			3.750
51.395			(6)
51.445	TEST STOPPED		

SECTION VI

TEE-REINFORCED SPLIT-SKIN SPECIMENS

Data and predictions are presented in this section for the 14 tee-reinforced split-skin specimens. The configuration and initial damage conditions are summarized in Figure B-1 (Appendix B) and Tables 3 and 4 of Volume I.

The format of data presentation is nearly identical to that of the preceding section, with minor differences in the notation and notes.

Specimens 4.8-3-1 and -2 were 80-flight Spectrum tested. Simplified crack growth life predictions were made for these specimens based upon corresponding constant amplitude data, but no detailed prediction of crack sequence was done.

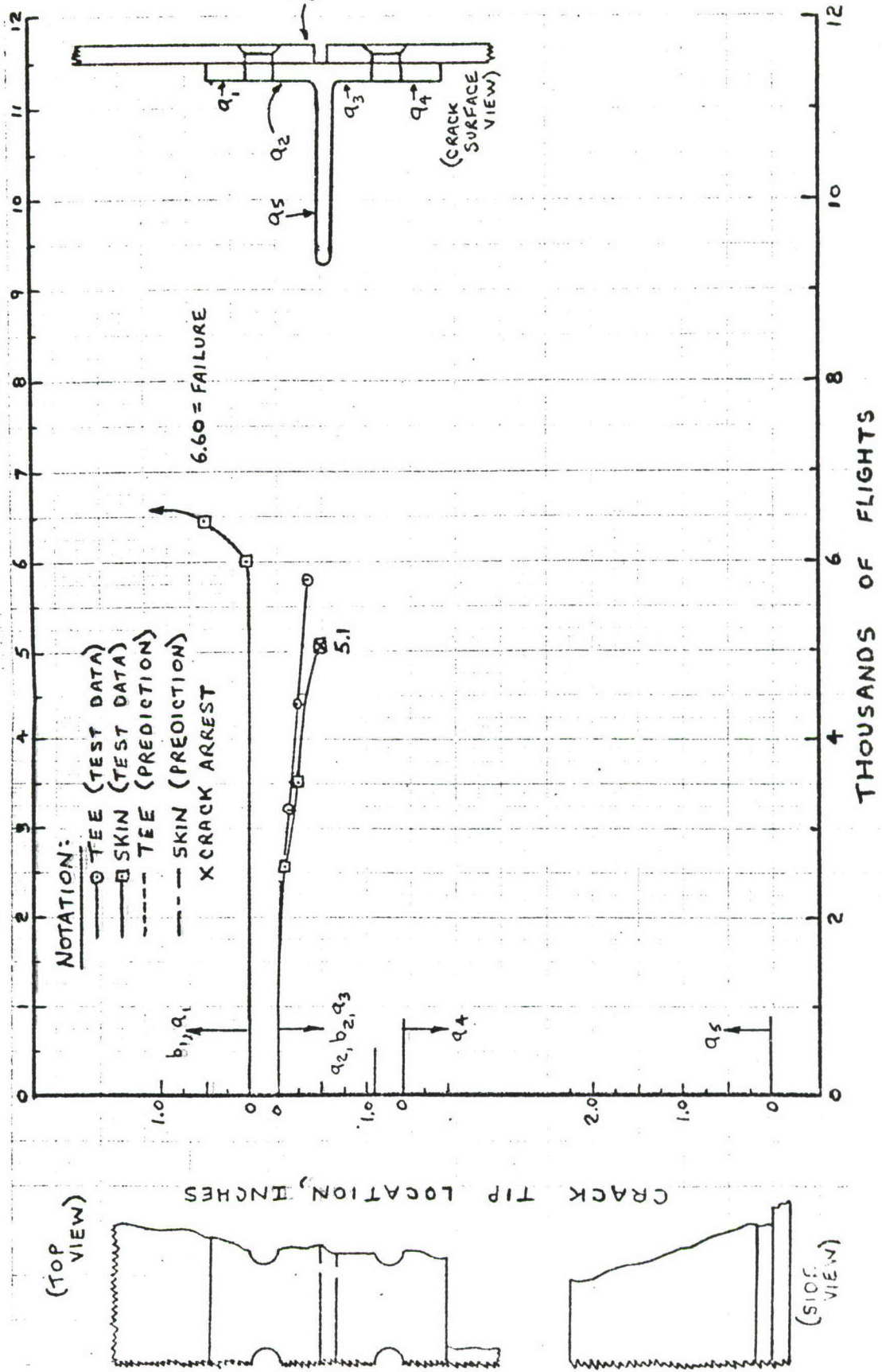
NOTES FOR ALL SPLIT-SKIN SPECIMENS

- ① Initial crack lengths measured at faying surface before assembly. All other length measurements are at externally-visible surfaces.
- ② Initial crack depths measured on fracture surface after test.
- ③ Crack reaches fillet radius.
- ④ Viewed through gap between skin pieces. (Faying surface length)
- ⑤ a_3 measured from edge of hole, like a_2 . Measurements include the distance to scribe mark, where crack broke through protruding leg of tee.
- ⑥ Arrests at hole.
- ⑦ Arrests at edge.

- ⑧ Arrests at edge. Tee breaks completely.
- ⑨ a_5 measured from faying surface. Measurements include the distance up to scribe mark used for reference during the test.
- ⑩ Stop drill 0.378-inch hole; install clearance-fit HL50-12-6 Hi-Lok fastener with steel washers under collar and 190 in-lb. torque.
- ⑪ No visual detection during test. Measured on fracture surface after test. (Marking cycle mark is evident.)
- ⑫ Marking cycles A, B, C, D produce thin marks on the fracture surface. (See fracture surface view on drawing.) Numbers in parentheses indicate 5,000 or 10,000 marking cycles. $S_{\max} = 17.0$ ksi, $R = 0.82$.
- ⑬ Popping noises just prior to crack measurement. (4.8-3-7)
- ⑭ Failure of loading stud (4.8-3-5)
- ⑮ Crack at interference-fit fully-torqued fastener measured from edge of collar (D = inch) or edge of head (D = inch).
- ⑯ Crack disappears under collar of fastener.
- ⑰ Razor-blade-induced continuing damage flaws. These are mechanical flaws simulating a 0.005-inch fatigue-induced corner crack.
- ⑱ Corner crack on faying surface, seen on fracture surface after test (spec. 4.8-3-9 and 4.8-3-13).
- ⑲ Length at faying surface.
- ⑳ Length of b_1 , including stop-drill hole.
- ㉑ No recorded data on a_1 , but fatigue cracking evident on fracture surface (spec. 4.8-3-14).
- ㉒ Protruding leg of Tee broke near grip area.

SPECIMEN 4:8-3-1

FORNED CARBON FIBER COMPOSITE
 TYPE 48-2



DATA SHEET NO.'S:
769744 TO 746

SPECIMEN 4.8-3-1

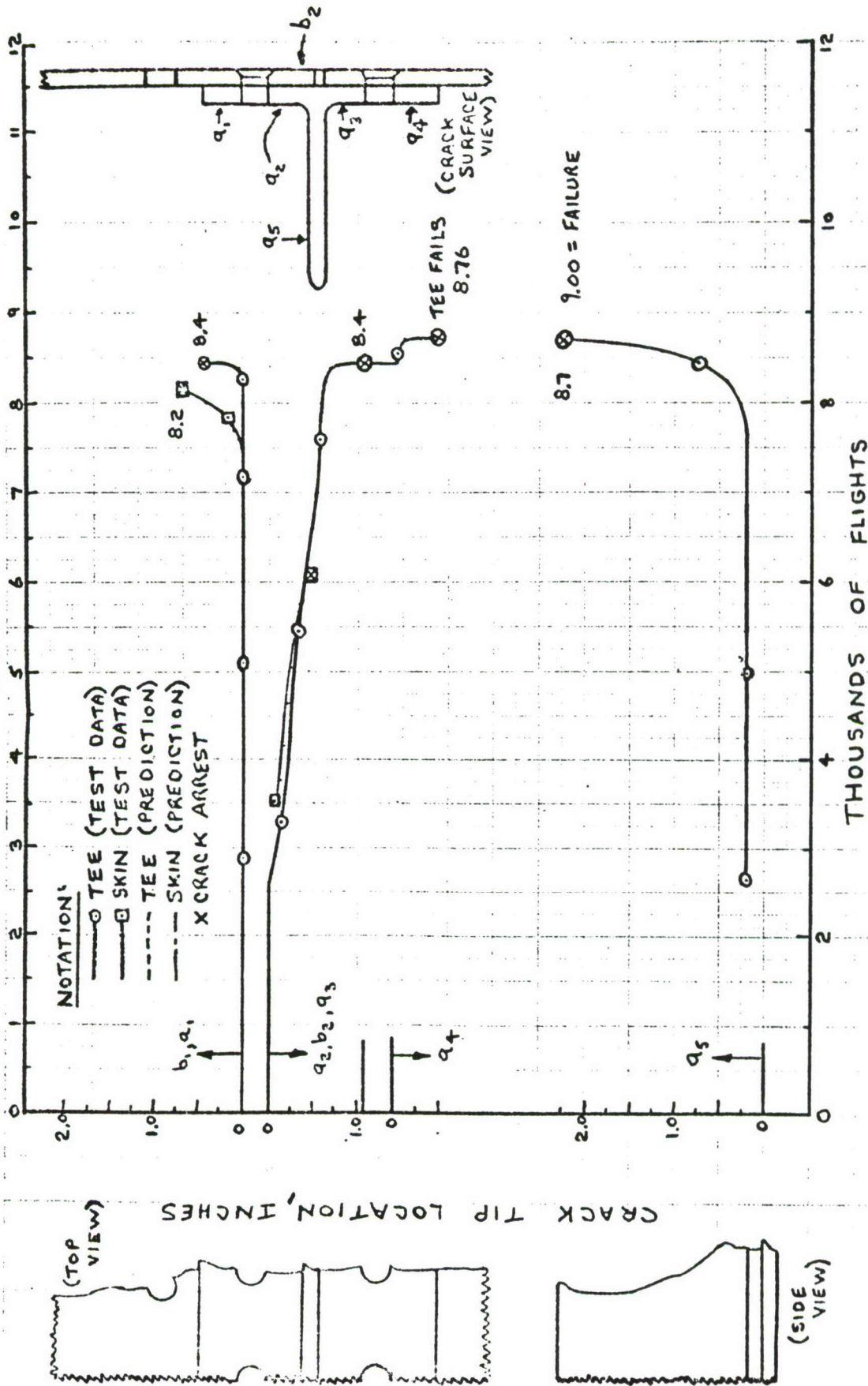
DATES TESTED:
9-10 TO 9-14-'76

THOUSANDS OF FLTS.	a_1	a_2	a_5	b_1	b_2	DEPTH OF b_2
0		0.050 ⁽¹⁾	0.07 ⁽²⁾		0.041 ⁽¹⁾	0.05 ⁽²⁾
2.4		0.028				
2.48		0.051				
2.56		0.072			0.098	
2.72		0.094			0.136	
2.96		0.117			0.170	
3.2		0.141			0.199	
3.52		0.164			0.231	
4.4		0.209			0.292	
5.08		0.269			0.46 ⁽⁷⁾	
5.80		0.313				
5.92		(3)				
6.04				0.060		
6.20				0.194		
6.28				0.293		
6.36				0.453		
6.44				0.525		
6.52		0.52 ⁽²¹⁾	0.29 ⁽²¹⁾	0.643		
6.599	F	A	I	L	U	R E

SPECIMEN 4.8-3-2

LOGGED CALIFORNIA COUNTY

FIG. 1



DATA SHEET NO.'S
573601 TO 604

SPECIMEN 4.8-3-2

DATES TESTED:
9-20 TO 9-27-1976

THOUSANDS OF FLIGHTS	a ₁	a ₂	a ₃	a ₄	a ₅	b ₁	b ₂	b ₃	BLOCKS BEFORE FAILURE
0		0.046 ⁽¹⁾					0.045 ⁽¹⁾		
2.64		0.022							
2.72		0.039							
2.88		0.079							
3.04		0.111							
3.28		0.142							
3.32 (22)		—							
3.6		0.171					0.095		
3.76		0.181					0.132		
4.16		0.213					0.167		
4.64		0.248					0.225		
5.04		0.272					0.242		
5.44		0.320					0.288		
5.68		0.349					0.325		
6.08		0.376					0.48 ⁽⁷⁾		- 36.5
6.48		0.474							- 31.5
6.88		0.505							- 26.5
7.36		0.537				0.028			- 20.5
7.6		0.567				0.065			- 17.5
7.68						0.102			- 16.5
7.76						0.148			- 15.5
7.84		0.583				0.219			- 14.5
7.92						0.304			- 13.5
8.0		0.596			0.32	0.421			- 12.5
8.24		0.636			0.41	1.06 ⁽²⁰⁾			- 9.5
8.40	0.048		0.68		0.46	↑			- 7.5
8.439	0.46 ⁽⁷⁾		1.06 ⁽⁶⁾		0.74	↑			- 7.0
8.48					0.83	↑			- 6.5
8.56				0.020	1.14	↑			- 5.5
8.64				0.052	1.45	↑			- 4.5
8.679					2.25 ⁽⁷⁾	↑			- 4
8.72				0.110		↑			- 3.5
8.759				0.46 ⁽⁸⁾		↑			- 3
8.919						↓			- 1
8.96						1.06 ⁽²⁰⁾		0.096	- 0.5
8.999	F	A	I	L	U	R	E		0

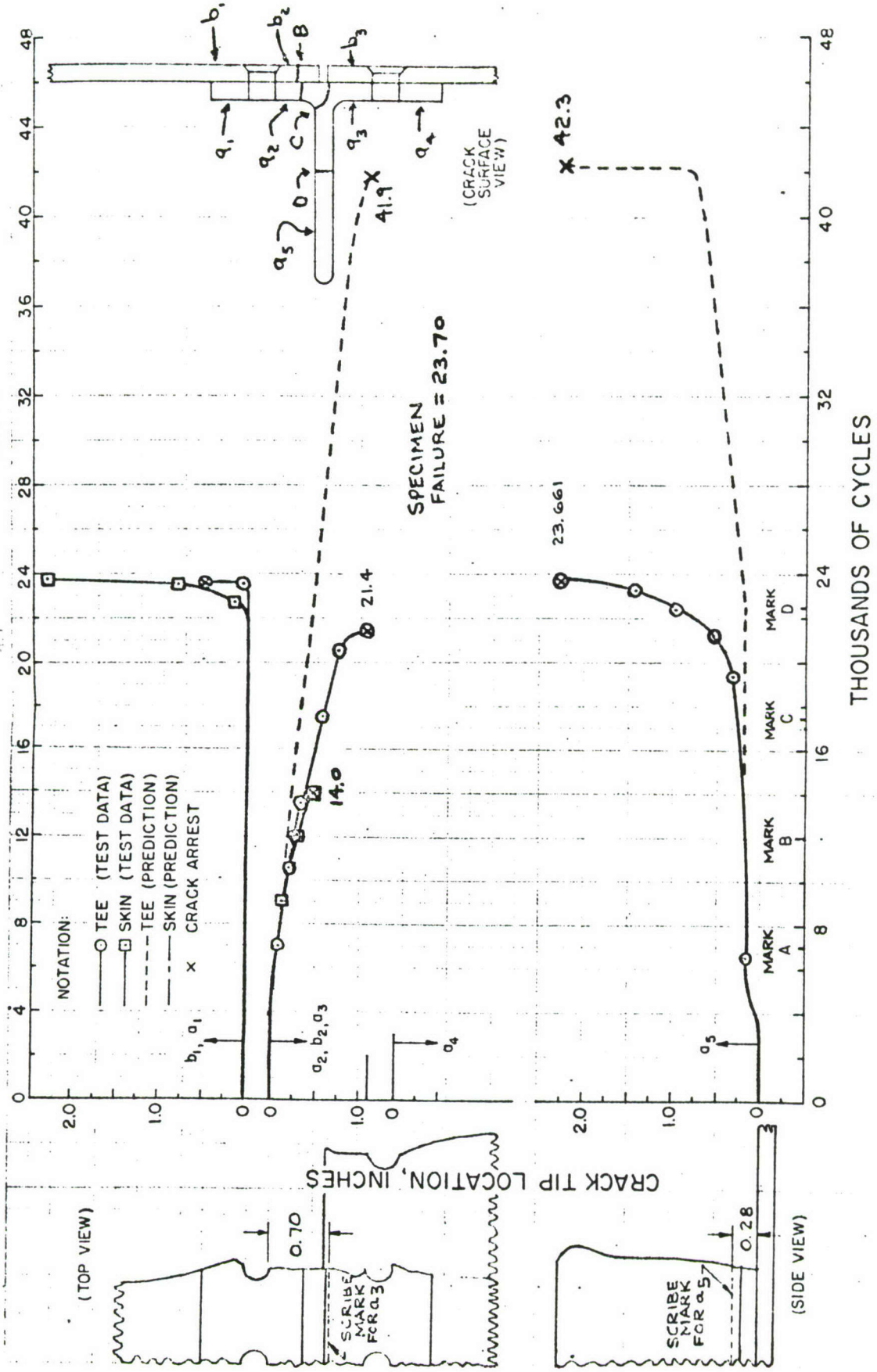
DATA SHEET NO.'s
569987-90

SPECIMEN 4.8-3-3

DATE TESTED
6-1-1976

N	a ₁	a ₂	a ₃	a ₄	a ₅	b ₁	b ₂	DEPTH OF b ₂
0		0.066 ^①			~0.115 ^②		0.052 ^①	~0.05 ^②
5.0		0.062			0.188			
6.0		0.101			↓		0.040	0.182
7.0		0.140					0.053	
A ^⑫ MARK (10)		0.150					0.053	
10.0		0.251					0.159	
12.0		0.333 ^③			0.188		0.210	
B ^⑬ MARK (10)		—					0.21	
13.0		0.365					0.264	
14.0							0.306	
15.6							0.420	
15.79							0.48 ^⑦	
17.0		0.54 ^④			~0.27 ^⑨			
C ^⑭ MARK (10)		0.58 ^④						
18.0					0.30			
20.0			0.71 ^⑤		0.36			
20.6			0.774		0.40			
21.0			0.846		0.44			
21.5			1.10 ^⑥		0.56			
22.0					0.84			
23.0					1.31			
23.681					1.92			
23.691	0				2.25 ^⑦			
23.93	0.075							
23.938	0.178							
23.943	0.45 ^⑧							
23.978						DIMPLE		DIMPLE
24.0							0.22	
24.05							0.34	
24.1					0.050		0.64	
24.117					0.44 ^⑧		1.08	
24.130	F	A	I	L	U	R	E	

SPECIMEN 4.8-3-4



DATA SHEET NO'S
569702-706

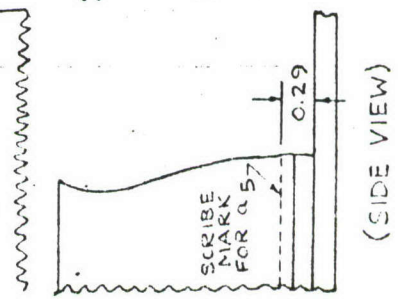
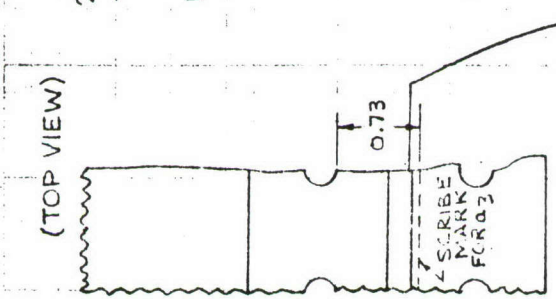
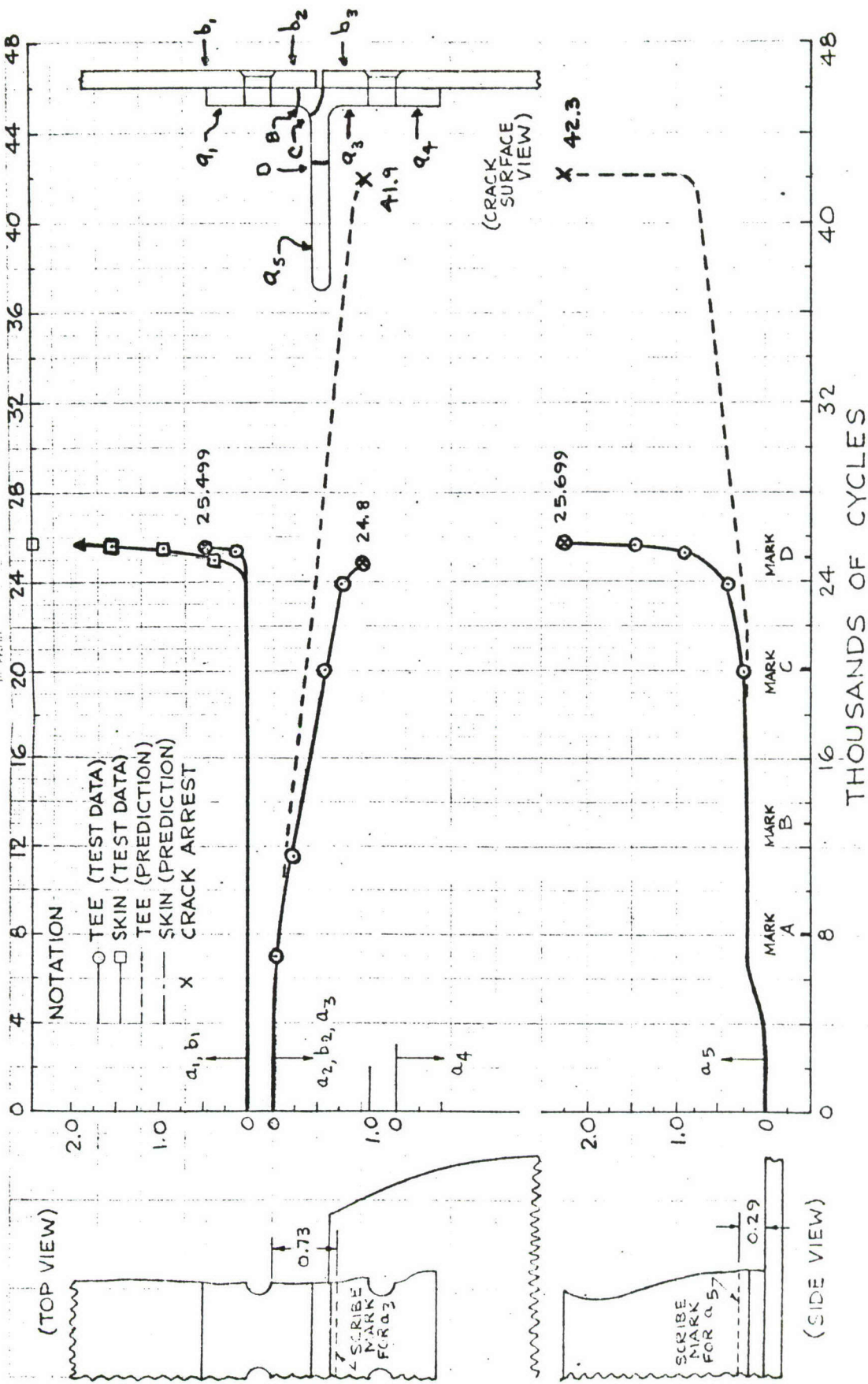
SPECIMEN 4.8-3-4

DATES TESTED:
6/9 TO 6/10/76

N	a ₁	a ₂	a ₃	a ₄	a ₅	b ₁	b ₂		
0		0.042 ^①					0.037 ^①		
5.5		DIMPLE							
6.5		0.048							
7.0		0.073							
A ^⑫ MARK (10)		0.083							
9.0		0.156					0.137		
10.5		0.214					0.208		
12.0		0.271					0.282		
B ^⑬ MARK (10)		0.282					0.292		
13.5		0.333 ^③					0.391		
14.0							0.46 ^⑦		
17.4		0.56 ^④							
C ^⑬ MARK (10)		0.58 ^④							
19.4					0.33				
20.5			0.73		0.39				
21.0			0.836		0.44				
21.3			0.958		0.50				
21.4			1.075 ^⑥		0.56				
21.7					0.70				
22.4					0.98				
D ^⑫ MARK (5)					1.00	0.067			
22.7					1.13	0.141			
23.0					1.26	0.297			
23.3					1.42	0.521			
23.4	DIMPLE				-	-			
23.553	0.050				1.58	0.780			
23.575	0.112				1.62	0.825			
23.596	0.48 ^⑥				1.67	0.945			
23.624					1.78	1.152			
23.640					1.85	1.208			
23.653					1.94	1.320			
23.661					2.25 ^⑦	1.421			
23.67				DIMPLE		1.605			
23.685				DIMPLE		2.28			
23.695		F	A	I	L	U	R	E	

SPECIMEN 4.8-3-5

LOCKHEED-CALIFORNIA COMPANY
 A DIVISION OF THE LOCKHEED CORPORATION



DATA SHEET NO.'S:
569707 TO 711

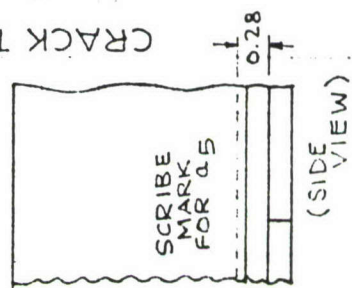
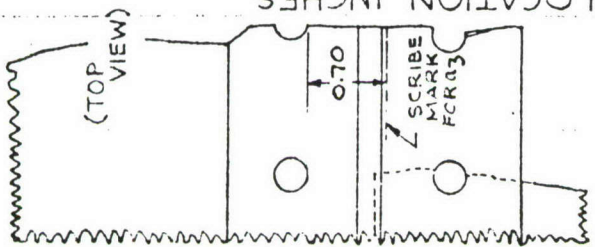
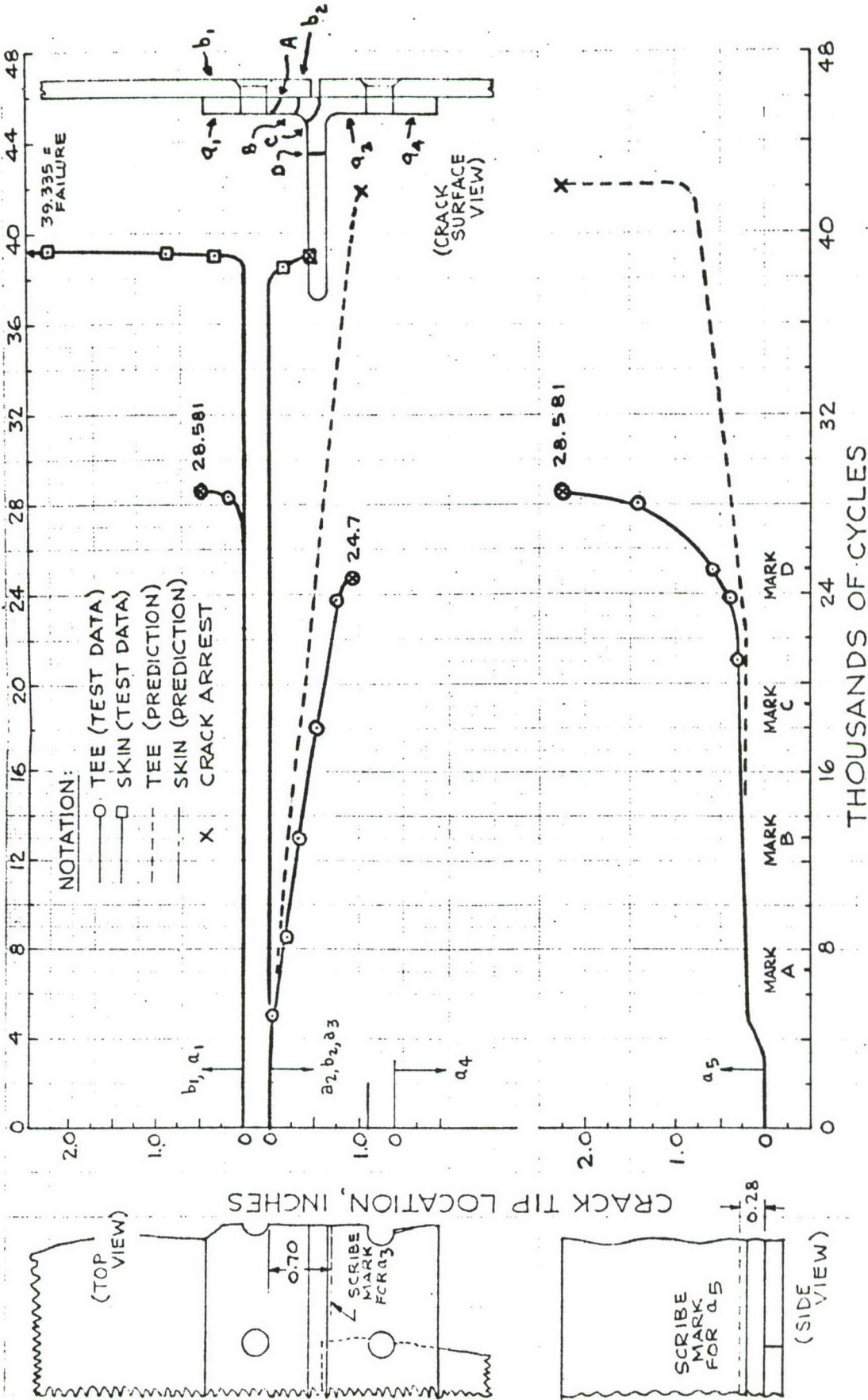
SPECIMEN 4.8-3-5

DATES TESTED:
6/11 TO 6/17/76

N	a ₁	a ₂	a ₃	a ₄	a ₅	b ₁	b ₂		
0		0.047 ⁽¹⁾			0.065 ⁽²⁾		0.040 ⁽¹⁾		
6.3		DIMPLE							
7.0		0.049							
8.0		0.099							
A ⁽¹²⁾ MARK (10)		0.105							
9.5		0.165							
11.5		0.224					—		
13.0		0.277					0.128		
B ⁽¹³⁾ MARK (10)		0.279					0.135		
14.0		0.310					0.170		
15.5		0.351 ⁽³⁾					0.226		
17.0							0.280		
18.7		0.510 ⁽⁴⁾					0.379		
19.3		0.539 ⁽⁴⁾					0.475 ⁽⁷⁾		
20.0		0.571 ⁽⁴⁾			0.26 ⁽¹¹⁾				
C ⁽¹³⁾ MARK (10)									
20.105	(14)								
22.0					0.33 ⁽⁹⁾				
23.0					0.37				
23.882			0.786		0.42				
24.0			0.819						
24.2			0.864		0.47				
24.4			0.909		0.49				
24.6			0.934		0.54				
24.8			1.07 ⁽⁶⁾						
25.0					0.73	0.395			
D ⁽¹³⁾ MARK (10)					0.79	0.575			
25.2					0.91	0.690			
25.4	DIMPLE				1.03	0.790			
25.457	0.125								
25.478	0.204								
25.499	0.48 ⁽⁷⁾				1.15	0.945			
25.6					1.45	1.55			
25.66					1.65	2.055			
25.69					1.83	2.44			
25.699				DIMPLE ⁽¹⁵⁾	2.25 ⁽⁷⁾	2.575			
25.71				DIMPLE ⁽¹⁵⁾		2.78			
25.717									
		F	A	I	L	U	R	E	

SPECIMEN 4.8-3-6

LOG FILED CALIFORNIA COMPANY



DATA SHEET NO. 5:

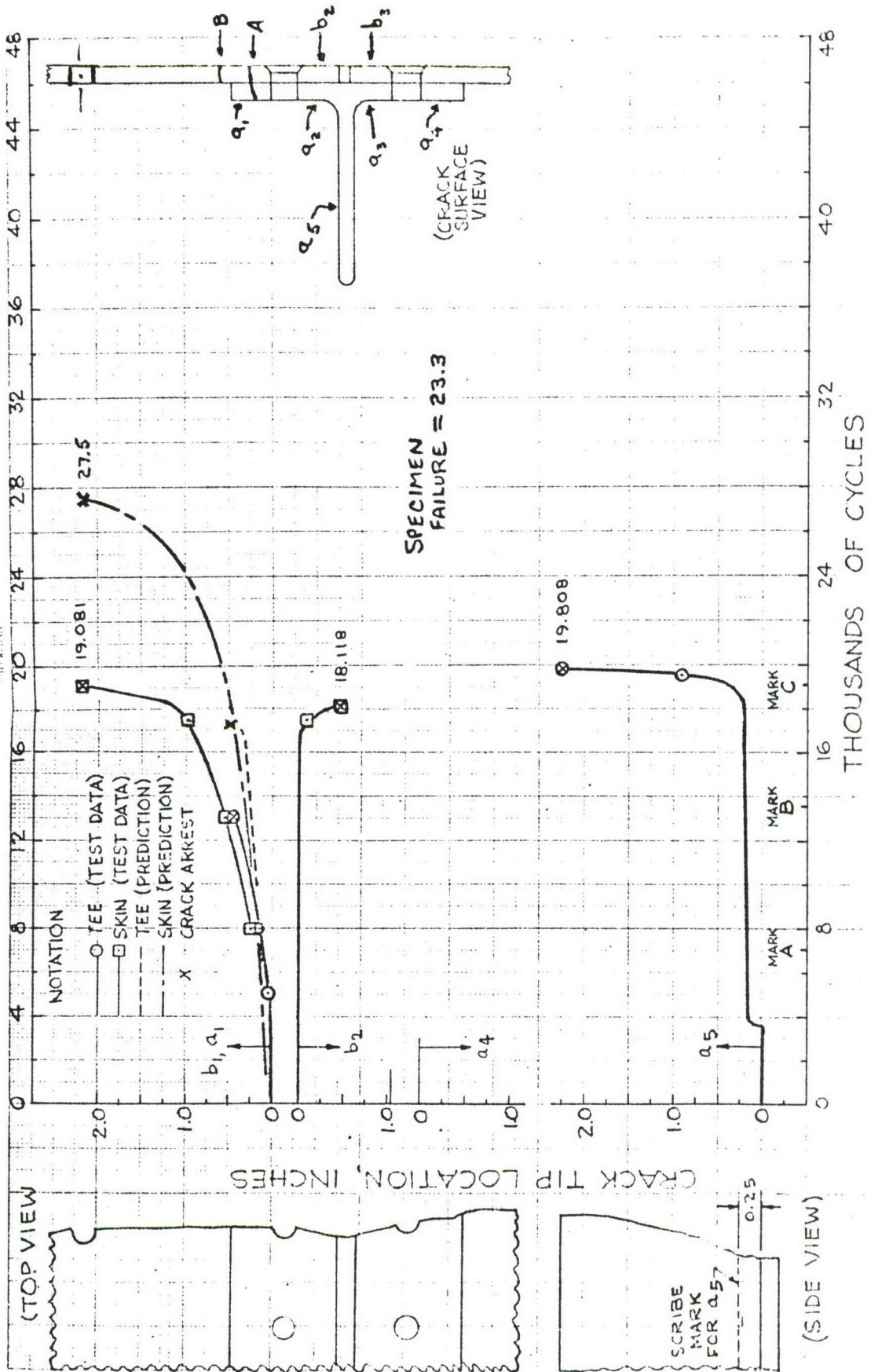
SPECIMEN 4.8-3-6

DATE TESTED:

N	a ₁	a ₂	a ₃	a ₄	a ₅	b ₁	b ₂
0		0.059 ⁽¹⁾			0.1 ⁽²⁾		
4.5		DIMPLE					
5.0		0.046					
5.9		0.097					
7.0		0.135					
A. MARK(10)		0.139					
8.5		0.194					
10.5		0.258					
13.0		0.332					
B. MARK(10)		3					
18.0		0.534 ⁽⁴⁾					
19.0		0.570 ⁽⁴⁾					
C. MARK(10)		0.575 ⁽⁴⁾					
21.0					0.31 ⁽⁹⁾		
23.8			0.756		0.40		
24.2			0.828		0.43		
24.7			0.926		0.48		
25.0			16		0.56		
D. MARK(10)					0.58		
26.0					0.90		
27.0					1.10		
28.0					1.42		
28.439	0.115				1.72		
28.5	0.152				1.84		
28.581	0.47 ⁽⁷⁾				2.25 ⁽⁷⁾		
38.5						0.170	
38.8						0.309	
39.01						0.495 ⁽⁷⁾	
39.033 ⁽¹³⁾						0.239	
39.091						0.440	
39.125						0.601	
39.169						0.857	
39.224						1.277	
39.294						1.806	
39.319						2.205	
39.327						2.740	
39.333						3.640	
39.335							
	F	A	I	L	U	R	E

SPECIMEN 4.8-3-7

PREPARED BY
LOY WHEED CALIFORNIA COMPANY
430 UNIVERSITY AVENUE
BERKELEY, CALIFORNIA



DATA SHEET NO.'S
569991-995

SPECIMEN 4.8-3-7

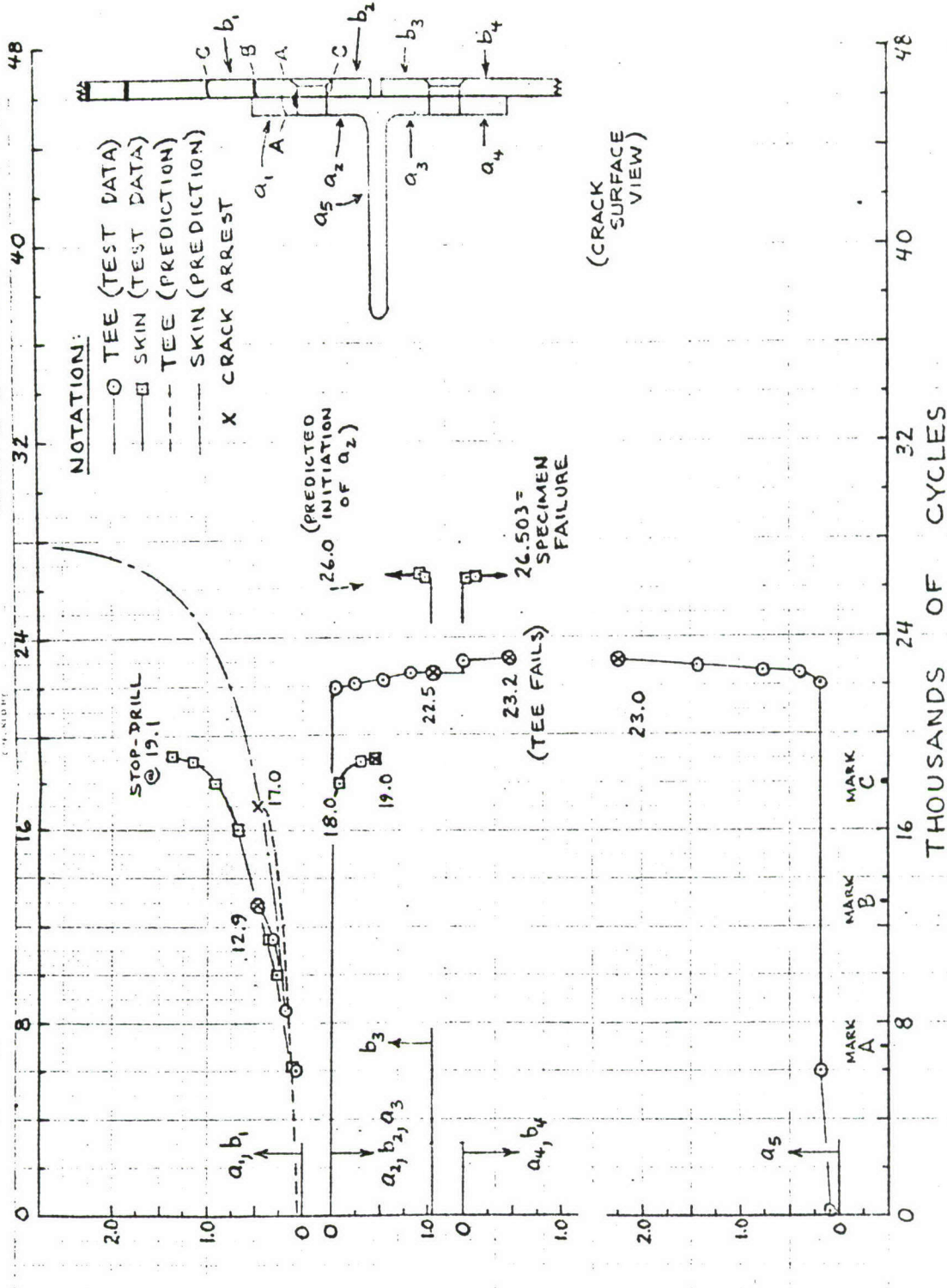
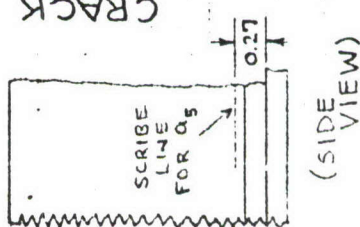
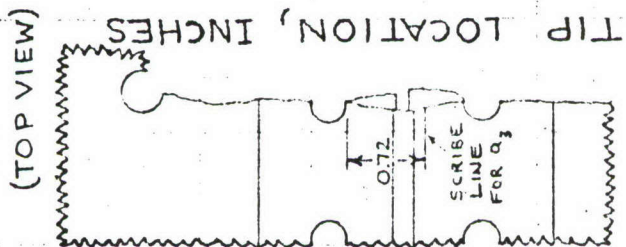
DATES TESTED:
6/2 TO 6/7/76

N	a ₁	a ₂	a ₃	a ₄	a ₅	b ₁	b ₂	b ₃	b ₄
0									
5.0	0.047								
6.0	0.088					0.072			
7.0	0.119					0.124			
A. ⁽¹²⁾ MARK(10)	0.128					0.135			
8.0	0.163					0.208			
9.5	0.217					0.300			
11.5	0.289					0.426			
13.016	0.445 ⁽⁷⁾					0.526			
13.5						0.562			
B. ⁽¹²⁾ MARK(5)						0.578			
15.5						0.743			
17.5						0.984	0.085		
18.0						1.106	0.288		
18.118						1.167	0.46 ⁽⁷⁾		
18.5						1.464			
18.8						1.800			
19.081						2.18 ⁽¹⁰⁾			
19.1									
C. ⁽¹²⁾ MARK(10)		⑪							
19.576 ⁽¹³⁾		③	⑥			SCRIBE @0.25"			
19.6						0.90			
19.64						1.05			
19.66						1.19			
19.66						1.29			
19.7						1.41			
19.72						1.49			
19.74						1.57			
19.76						1.66			
19.78						1.79			
19.8						1.89			
19.808						DIMPLE 2.25 ⁽⁷⁾			
19.908						0.47 ⁽⁸⁾			
23.24								DIMPLE	DIMPLE
23.254		F	A	I	L	U	R	E	

SPECIMEN 4.8-3-8

LOCKHEED-CALIFORNIA COMPANY
A DIVISION OF LOCKHEED CORPORATION

W. P. H. B. R. Y
TEST
C. H. N. D. P. E.



(CRACK SURFACE VIEW)

DATA SHEET NO.'S
569712-716

SPECIMEN 4.8-3-8

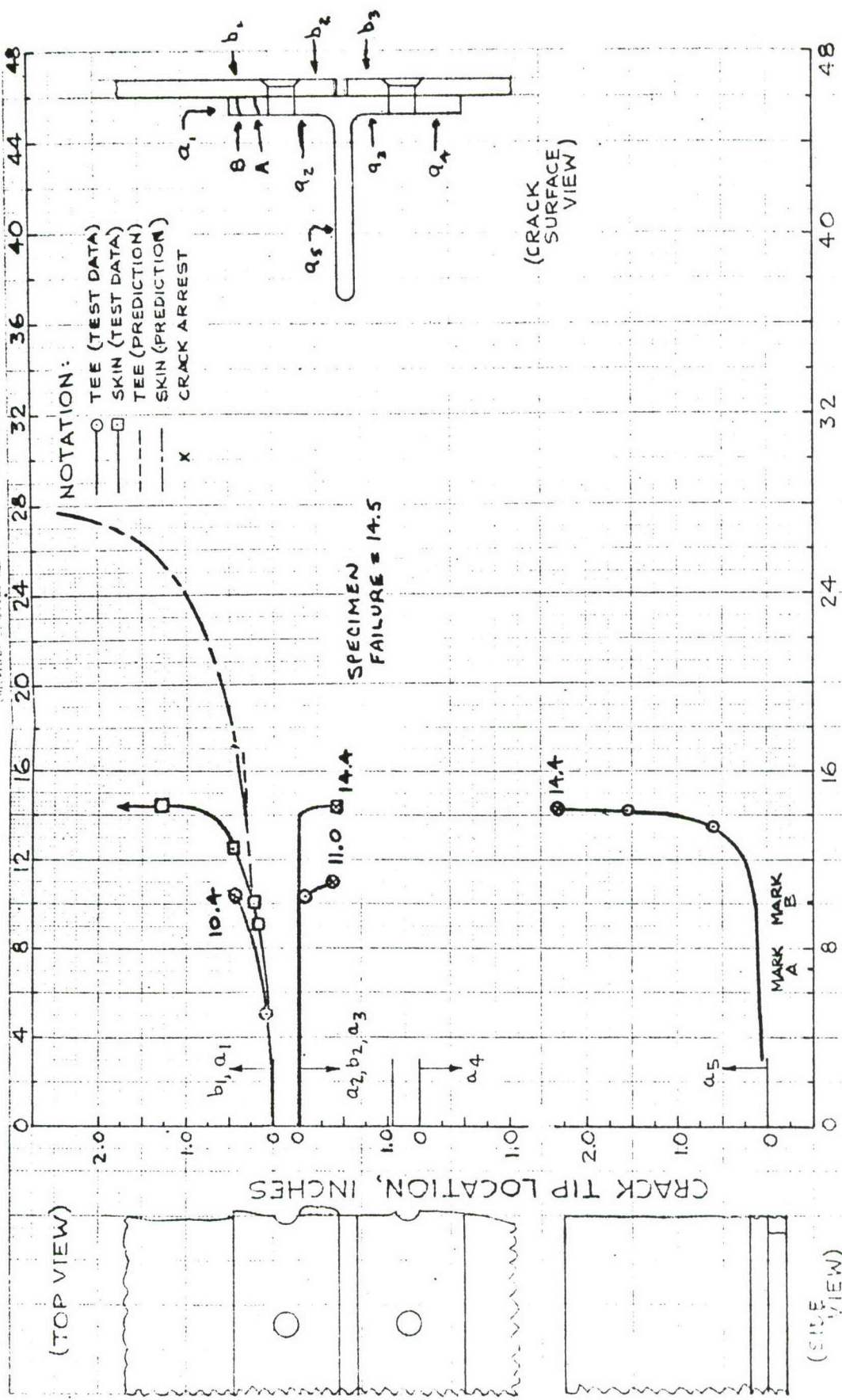
DATE TESTED:
6/18 TO 6/21/76

N	a ₁	a ₂	a ₃ ⁽⁵⁾	a ₄	a ₅ ⁽⁹⁾	b ₁	b ₂	b ₃	b ₄
0	0.046 ⁽¹⁾				0.09 ⁽²⁾	0.073 ⁽¹⁾			
5.0	DIMPLE								
6.1	0.065					0.076			
7.0	0.112					0.143			
A ⁽¹²⁾ MARK(10)	0.118					0.146			
8.5	0.180					0.221			
10.0	0.237					0.274			
11.5	0.317					0.346			
12.876	0.47 ⁽⁷⁾								
13.0						0.414			
B ⁽¹²⁾ MARK(10)						0.450			
16.0						0.687			
18.0						0.909			
C ⁽¹²⁾ MARK(5)						0.932	0.050 ⁽¹¹⁾		
18.5						1.014	0.108		
18.9						1.154	0.304		
18.97							0.45 ⁽⁷⁾		
19.1						1.378 ⁽¹⁰⁾			
21.9		0.033							
22.0		0.060							
22.1		0.254							
22.13		0.330 ⁽³⁾							
22.27		0.54 ⁽⁴⁾							
22.5			0.78		0.40				
22.54			0.92						
22.55			1.06 ⁽⁶⁾		0.55				
22.6					0.76				
22.7					1.07				
22.85					1.43				
23.0					1.84				
23.01					1.99				
23.014					2.25 ⁽⁷⁾				
23.02				DIMPLE					
23.147				0.112					
23.155				0.47 ⁽⁸⁾					
26.45								0.070	0.065
26.5								0.124	0.167
26.503		F	A	I	L	U	R	E	

SPECIMEN 4.8-3-9

LOCKHEED-CALIFORNIA COMPANY
A DIVISION OF SPANISH AIRCRAFT, S.A.

DATE: _____
BY: _____



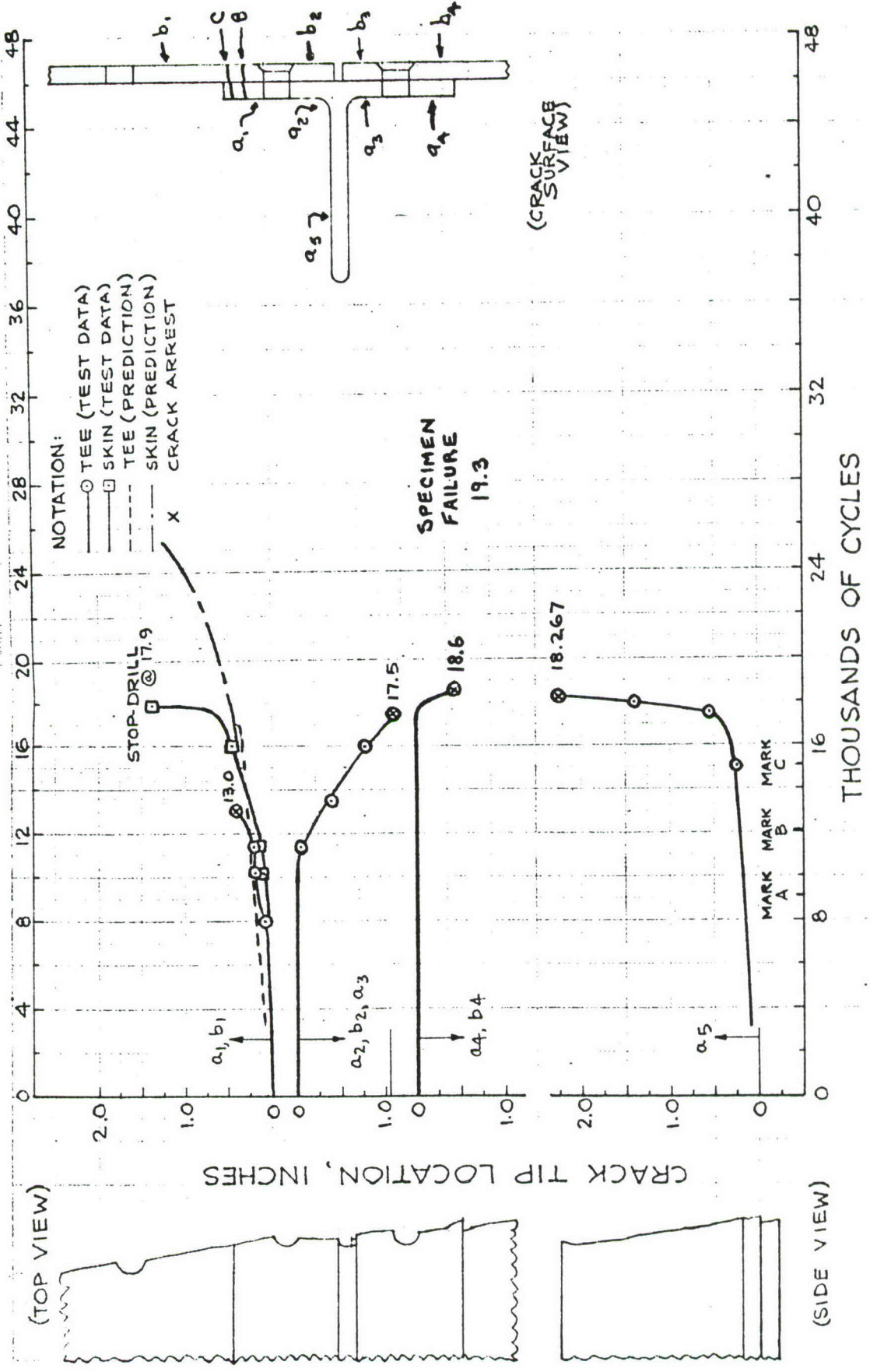
DATA SHEET NO'S:
569722 TO 725

SPECIMEN 4.8-3-9

DATES TESTED:
8/11 TO 8/12/76

N	a ₁	a ₂	a ₃	a ₄	a ₅	b ₁	b ₂	b ₄
0	0.050 ⁽¹⁾	0.020 ⁽¹¹⁾				0.043 ⁽¹⁾		0.020 ⁽¹⁷⁾
5.0	0.069							
6.0	0.112							
7.0	0.151							
A. MARK(10)	0.153							
8.0	0.204							
9.1	0.260					0.177		
10.0	0.323					0.218		
B. MARK(10)	0.331					0.231		
10.1	0.347	DIMPLE				0.238		
10.2	0.364	DIMPLE				0.242		
10.3	0.394	DIMPLE				0.253		
10.363	0.46 ⁽⁷⁾	0.076				0.255		
10.4		0.093				0.256		
10.5		0.147				0.266		
10.6		0.192				0.283		
10.7		0.253				0.288		
10.8		0.302				0.301		
10.9		0.352 ⁽³⁾				0.312		
11.0		0.370				0.319		
11.5						0.364		
12.0						0.415		
12.5					0.33	0.450		
13.0			DIMPLE		0.38	0.488		
13.5			1.075 ⁽⁶⁾		0.58	0.560		
13.6					0.72	0.598		
13.7					0.88	0.613		
13.8					0.99	0.636		
13.9					1.13	0.665		
14.0					1.26	0.711		
14.1					1.38	0.762		
14.2					1.55	0.816		
14.3					1.69	0.881		
14.375					1.94	0.919		
14.381				DIMPLE	2.25	0.946		
14.449				0.03 ⁽¹⁸⁾		1.275	0.50 ⁽⁷⁾	0.05 ⁽¹⁹⁾
14.463	F	A	I	L	U	R	E	

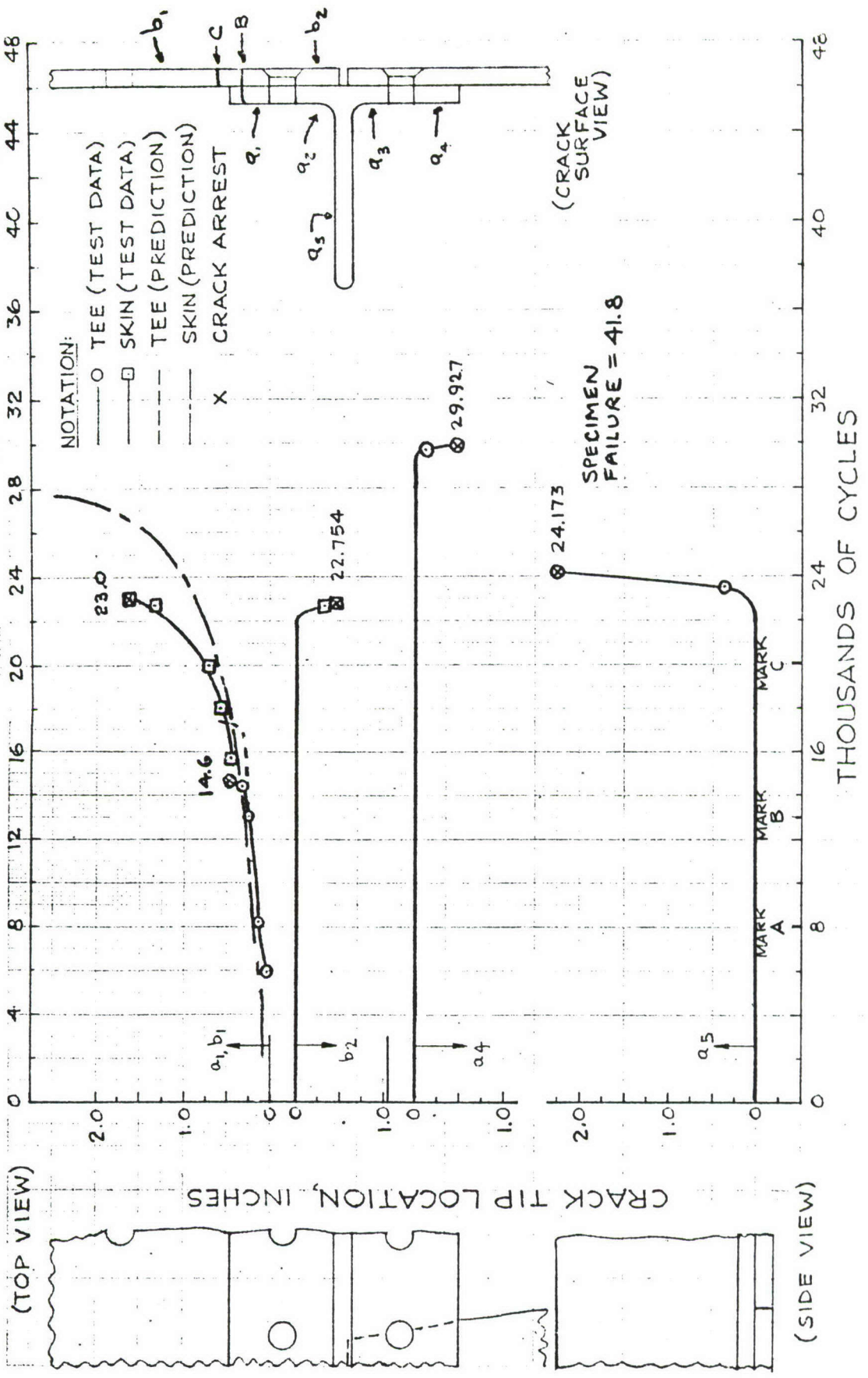
SPECIMEN 48-3-10



SPECIMEN 4.8-3-10

N	a ₁	a ₂	a ₃	a ₄	a ₅	b ₁	b ₂	b ₃	b ₄
0	0.055 ⁽¹⁾	0.025 ⁽¹⁷⁾				0.050 ⁽¹⁾			0.027 ⁽¹⁷⁾
6.0	DIMPLE								
6.301	0.030								
7.4	0.040								
8.0	0.070								
9.0	0.146								
A ⁽¹²⁾ MARK (10)	0.154								
10.251	0.182					0.094			
11.402	0.201	0.031				0.147			
12.0	0.248	0.105				0.168			
B ⁽¹²⁾ MARK (10)	0.258	0.115				0.180			
12.5	0.285	0.158				0.205			
13.0	0.41 ⁽⁷⁾	0.230				0.241			
13.5		0.372				0.273			
14.0		③				0.287			
15.0						0.354			
C ⁽¹²⁾ MARK (10)			0.55 ⁽¹¹⁾		0.24 ⁽¹¹⁾	0.366			
15.5					0.29	0.408			
16.0			0.792		0.31	0.458			
16.5			0.906		0.35	0.500			
17.0			0.995		0.41	0.548			
17.5			1.12 ⁽⁶⁾		0.55	0.633			
17.816					0.95	0.900	0.47 ⁽⁷⁾		
17.9					1.13	1.380 ⁽⁸⁾			
18.0					1.39				
18.1					1.59				
18.2					1.89				
18.267					2.25 ⁽⁷⁾				
18.6				0.44 ⁽⁸⁾					
18.7									0.147
18.8									0.216
18.9									0.282
19.0									0.370
19.1									0.454
19.2									0.578
19.25									0.714
19.3									0.832
19.318									
		F	A	I	L	U	R	E	

SPECIMEN 4.8-3-11



(TOP VIEW)

(SIDE VIEW)

DATA SHEET NO. 5: 569727-730

SPECIMEN 4.8-3-11

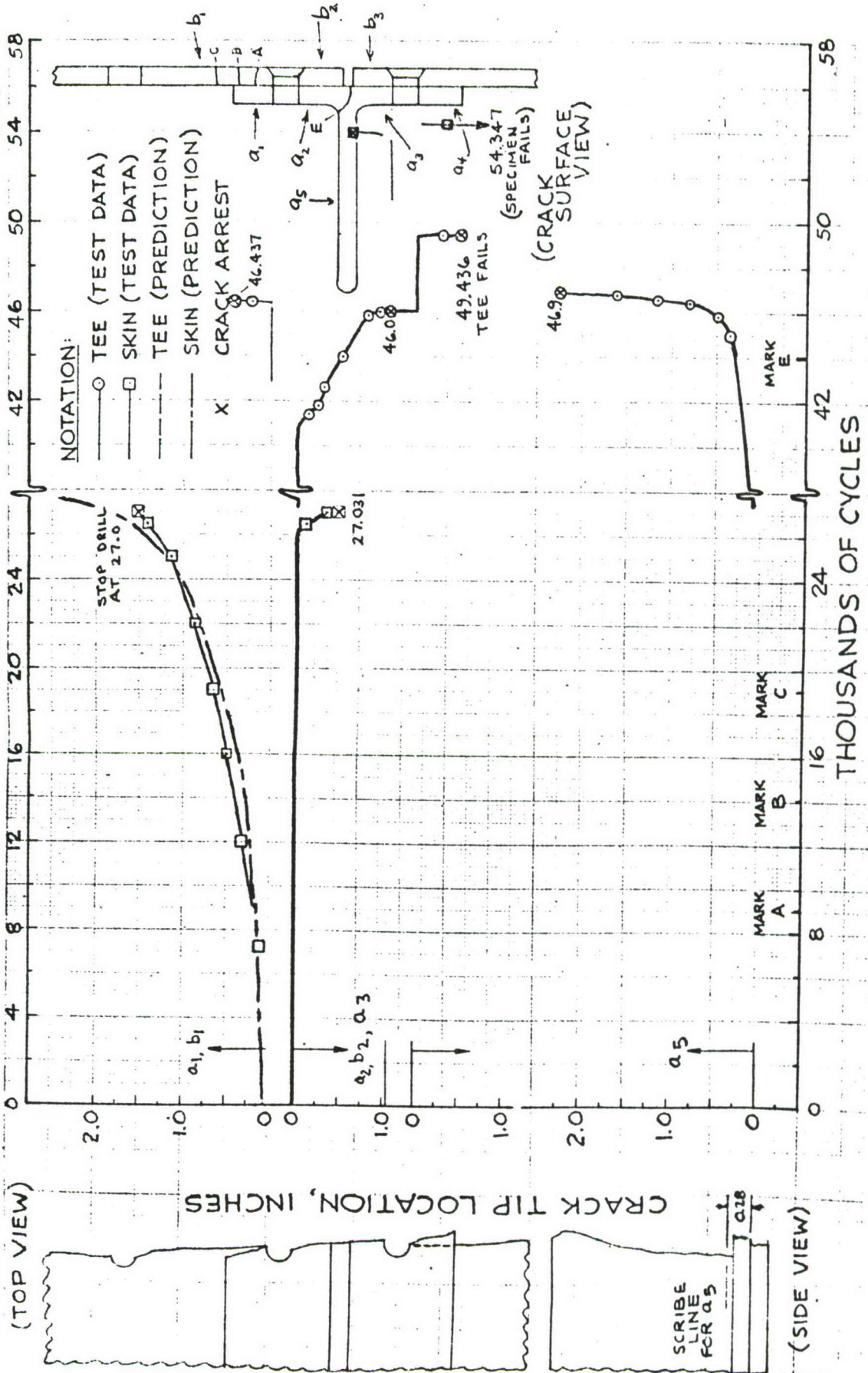
DATES TESTED: 8/13 TO 8/16/1976

N	a ₁	a ₂	a ₃	a ₄ ⁽¹⁵⁾	a ₅	b ₁	b ₂	b ₃ ⁽¹⁵⁾
0	0.056 ⁽¹⁾					0.048 ⁽¹⁾		
6.0	0.028							
7.0	0.092							
8.0	0.119							
A ⁽¹²⁾ MARK (10)	0.126							
8.2	0.129					0.101		
11.0	0.191					0.217		
13.0	0.253					0.308		
B ⁽¹²⁾ MARK (10)	0.264					0.318		
14.353	0.339					0.383		
14.652	0.46 ⁽⁷⁾					0.401		
15.7						0.456		
18.0						0.585		
C ⁽¹²⁾ MARK (10)						0.610		
20.0						0.814		
22.719						1.315	0.317	
22.754						1.375	0.46 ⁽⁷⁾	
23.0						1.615 ⁽¹⁰⁾		
23.5		③			0.37			
23.7			⑥		0.81			
23.8					1.13			
23.9					1.39			
24.0					1.64			
24.1					1.87			
24.173					2.25 ⁽⁷⁾			
29.7				0.13				
29.8				0.17				
29.9				0.26				
29.927				0.48 ⁽⁸⁾				
41.5								0.26
41.564								0.47 ⁽⁷⁾
41.757		F	A	I	L	U	R	E

SPECIMEN 4.8-3-12

LOCKHEED CALIFORNIA COMPANY

PROPERTY OF



DATA SHEET NO.'s:

569732 - 736

SPECIMEN 4.8-3-12

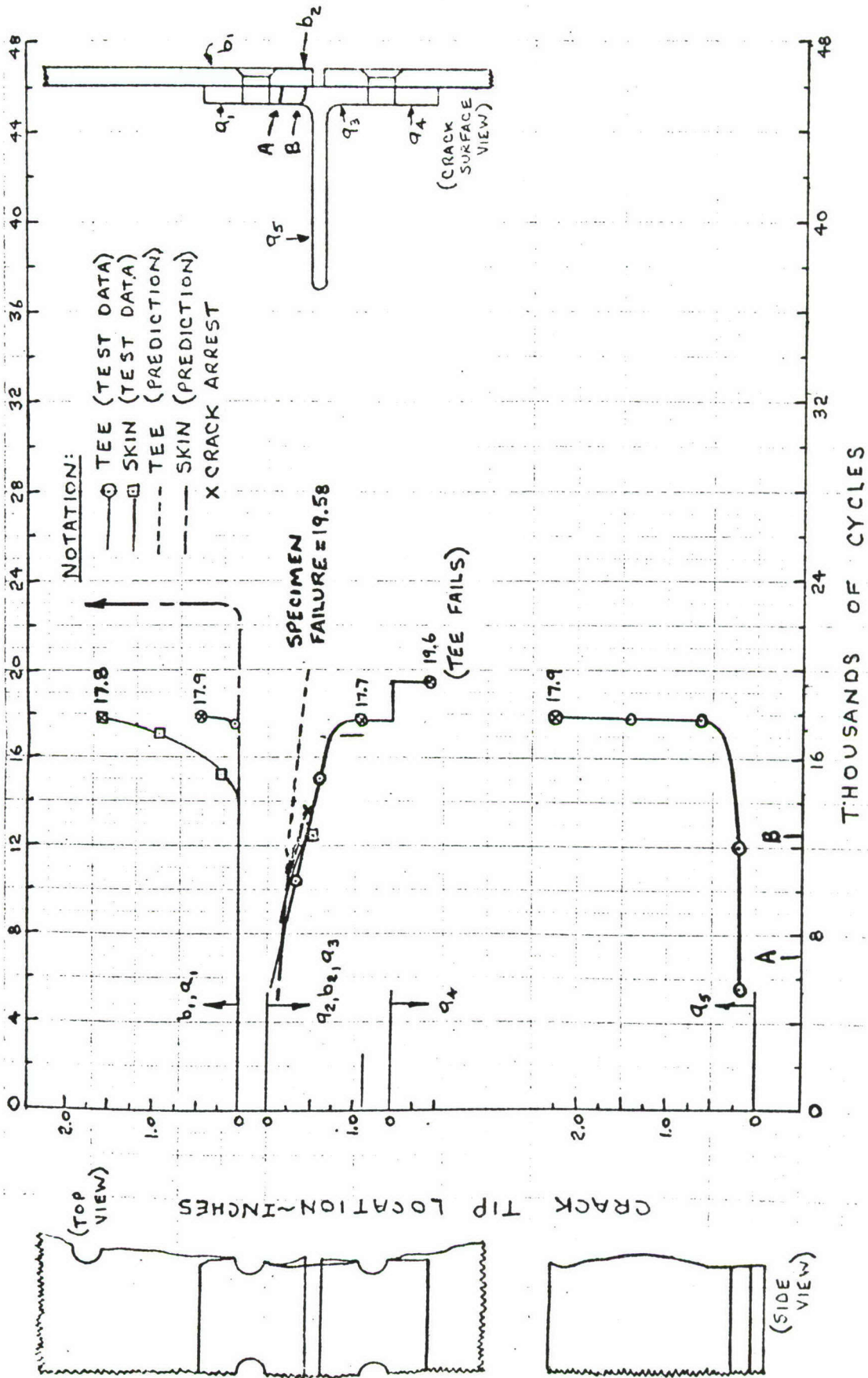
DATES TESTED:

8/17 TO 8/19/76

N	a ₁	a ₂	a ₃	a ₄	a ₅	b ₁	b ₂	b ₃
0						0.052 ⁽¹⁾		
7.2						0.093		
8.0						0.135		
9.0						0.183		
A MARK (10)						0.190		
10.0						0.225		
12.0						0.311		
14.0						0.401		
B. MARK (10)						0.403		
16.0						0.499		
19.0						0.650		
C. MARK (10)						0.669		
22.0						0.862		
25.0						1.132		
26.5						1.405	0.105	
27.0						1.512 ⁽¹⁰⁾	0.339	
27.031							0.48 ⁽⁷⁾	
29.0								
D. MARK (10)								
41.0		DIMPLE						
41.4		0.133						
41.8		0.219						
42.2		0.302						
42.6		0.358 ⁽³⁾						
44.0								
E. MARK (10)			0.52					
45.0					0.36			
45.5			DIMPLE		0.39			
45.85			0.797		0.49			
46.0			0.914 ⁽¹⁶⁾		0.55			
46.4	DIMPLE				0.81			
46.432	0.223				0.84			
46.437	0.50 ⁽⁷⁾							
46.55					1.16			
46.75					1.62			
46.9					2.25 ⁽⁷⁾			
49.432				0.29				
49.436				0.48 ⁽⁸⁾				
54.0								0.48
54.347								
		F	A	I	L	U	R	E

SPECIMEN 4.8-3-13

PREPARED BY: LOCKHEED-CALIFORNIA COMPANY
 DATE: 11/15/58
 LOCATION: CALIFORNIA



DATA SHEET NO's.: SPECIMEN 4.8-3-13
569737-740

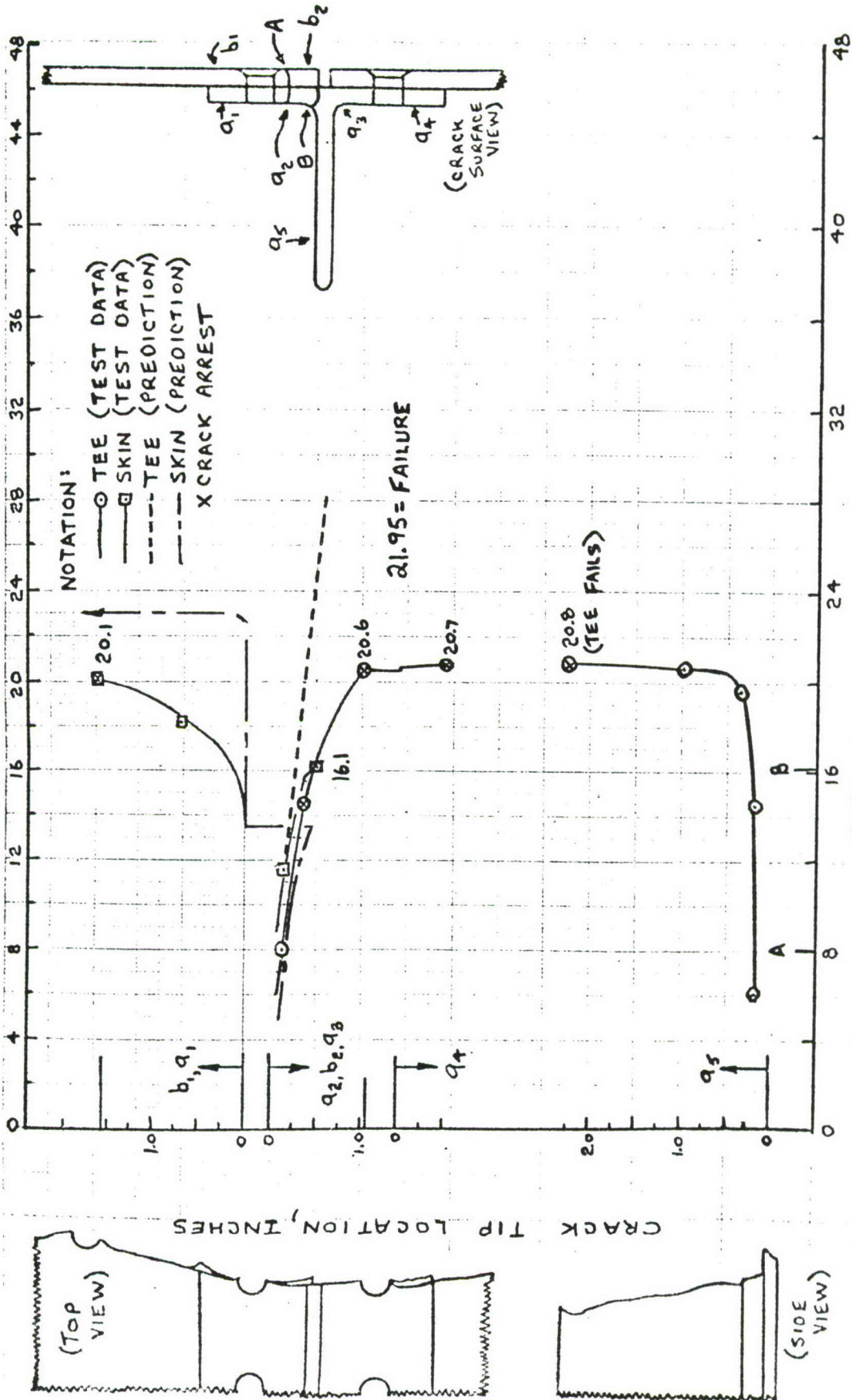
DATE TESTED:
9/1/1976

N	a ₁	a ₂	a ₃ ⁽⁵⁾	a ₄ ⁽¹⁷⁾	a ₅ ⁽⁹⁾	b ₁ ⁽¹⁷⁾	b ₂ ⁽¹⁾	DEPTH OF b ₂ ⁽²⁾	b ₄ ⁽¹⁷⁾
0		0.045 ⁽¹⁾		0.025 ⁽¹⁷⁾	0.09 ⁽²⁾	0.021 ⁽¹⁷⁾	0.037 ⁽¹⁾	0.04 ⁽²⁾	0.021 ⁽¹⁷⁾
5.5		0.039							
6.0		0.079							
7.0		0.144							
A ⁽¹²⁾ MARK (10)									
8.5		0.219					0.142		
10.0		0.290					0.232		
11.0		0.331					0.307		
12.0		0.375 ⁽³⁾					0.381		
12.5		0.383	0.41 ⁽¹⁹⁾				0.48 ⁽⁷⁾		
B ⁽¹⁴⁾ MARK (10)			0.42 ⁽¹⁹⁾						
14.5			0.545 ⁽⁴⁾						
15.0			0.575 ⁽⁴⁾						
15.1									
15.246						0.233			
16.1						0.469			
17.1						0.947			
17.2					0.37	1.015			
17.4					0.41	1.157			
17.5			0.765		0.43	1.237			
17.6			0.826		0.47	1.331			
17.7	0.031		0.906		0.51	1.434			
17.735	0.105		1.078						
17.744	0.106		1.080 ⁽⁶⁾						
17.8	0.193				0.65	1.602 ⁽¹⁰⁾			
17.85	0.48 ⁽⁷⁾				1.13				
17.875					1.56				
17.9					1.91				
17.925					2.25 ⁽⁷⁾				
19.325									0.120
19.375									0.150
19.425									0.197
19.475									0.240
19.525									0.294
19.575				0.16 ⁽¹⁸⁾					0.380
19.583		F	A	I	L	U	R	E	

SPECIMEN 4.8-3-14

PREPARED BY
DATE
CHECKED BY

LOCKHEED-CALIFORNIA COMPANY
AERONAUTICAL DIVISION



DATA SHEET NO.'s
569747-750

SPECIMEN 4.8-3-14

DATE TESTED
9-15-1976

N	a ₁	a ₂	a ₃	a ₄	a ₅	b ₁	b ₂	b ₃	b ₄
0		0.051 ⁽¹⁾		0.022 ⁽¹⁷⁾	0.07 ⁽²⁾	0.021 ⁽¹⁷⁾	0.043 ⁽¹⁾		0.022 ⁽¹⁷⁾
6.0		0.048							
7.0		0.082							
8.0		0.132							
A ⁽¹²⁾ MARK (10)		0.138							
9.152		0.185					0.111		
11.0		0.247					0.185		
13.0		0.315					0.256		
14.5		0.353 ⁽³⁾					0.315		
15.5							0.386		
16.0							0.447		
16.133							0.51 ⁽⁷⁾		
B ⁽¹²⁾ MARK (10)			0.51 ⁽¹⁹⁾			0.185			
17.133						0.386			
18.133						0.697			
19.133						0.932			
19.633					0.35	1.170			
20.133					0.41	1.525 ⁽¹⁶⁾			
20.5			1.01		0.56	2.00 ⁽²⁰⁾			
20.55			1.04 ⁽⁶⁾		0.81	↑			
20.6				0.017	1.01				
20.65				0.273	1.31				
20.7				0.50 ⁽⁷⁾	1.61				
20.75					1.96				
20.775					2.25 ⁽⁸⁾				
21.575									0.181
21.675									0.260
21.775									0.350
21.875									0.480
21.925						2.00 ⁽²⁰⁾			0.620
21.949									
		F	A	I	L	U	R	E	

SECTION VII
EDGE STRINGER SPECIMENS

The following pages present crack growth data and predictions for 12 edge stringer specimens. Specimen configurations and their initial damage conditions are shown in Figure B-2 (Appendix B) and Table 3 of Volume I.

For each specimen there is a plot showing the entire crack growth history and comparing it to the prediction. In addition, a one-page table gives the crack length versus cycles test data along with explanatory notes and sketches.

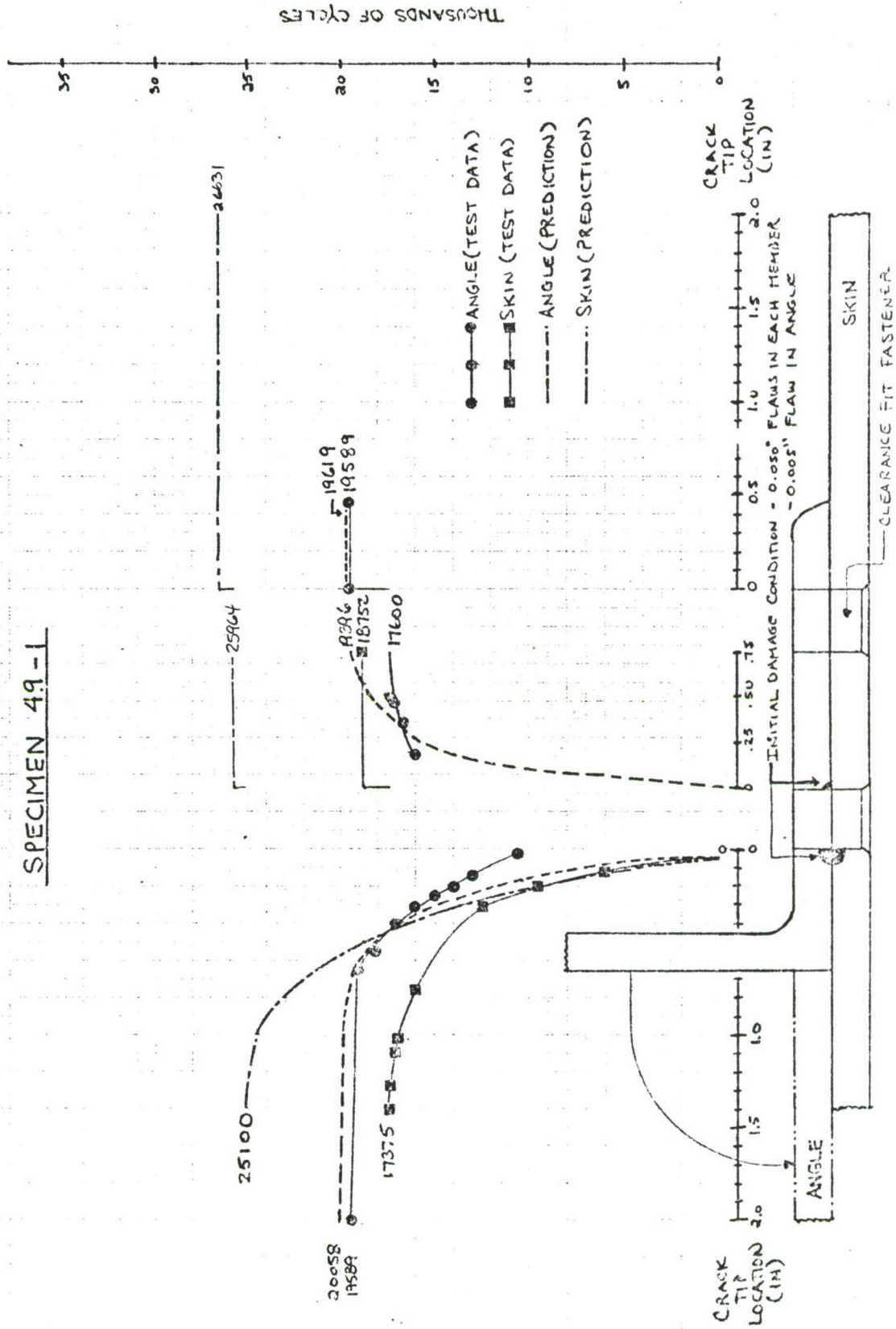
All crack lengths are as measured from the edge of a hole, not from the edge of a countersink or collar.

As previously, a stop-drill hole was often put in the skin about 1.6 inches* inside the innermost fastener to prevent unstable growth of the skin crack and allow time for further stable growth elsewhere in the specimen. A (nominally) 0.375-inch diameter hole was used, and a clearance-fit fully-torqued Hi-lok fastener was placed in the hole to prolong the arrestment of the crack.

For specimens with initial outside cracks the stop drilled hole was usually drilled after arrestment but before reinitiation of the skin crack in the innermost fastener.

*Dimension given is from the edge of the fastener hole to the edge of the stop-drill hole.

SPECIMEN 49-1

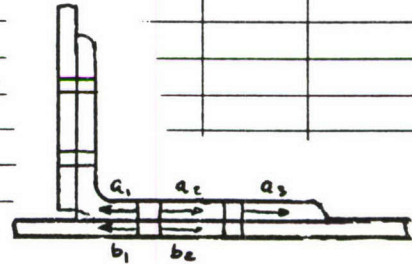


DATE SHEET NO S: 573637-38

TEST DATE(S): 1/27/77 - 1/28/77

SPECIMEN 4.9-1

N	a_1	a_2	a_3	b_1	b_2				
0	.029*	.023*		.06*					
6000	—	—		.17					
7500	—	—		.21					
9000	—	—		.24					
9500	—	—		.27					
10200	—	—		.33					
10600	.02	—		.38					
11200	.04	—		.43					
12400	.12	—		.48					
13000	.14	—		.52					
14000	.20	—		.62					
15000	.25	—		.70					
16000	.31	.22		.83					
16200	.32	.27		.89					
16600	.36	.33		.98					
16900	.38	.42		1.09					
17100	.40	.46		1.17					
17300	.46	.50		1.34					
17375	.46	.50		TO EDGE					
17600	.50	TO NEXT FASTENER							
18100	.55								
18600	.60								
18752	—					TO NEXT FASTENER			
19052	.65								
19340	.85								
19350	1.05								
19355	1.20								
19366	1.57								
19382	1.94								
19480	2.16								
19510	—		DIMPLE						
19520	2.20		.18						
19525	2.26		.26						
19526	—		TO EDGE						
19565	2.35								
19585	2.40								
19589		F	A	I	L	U	R	E	

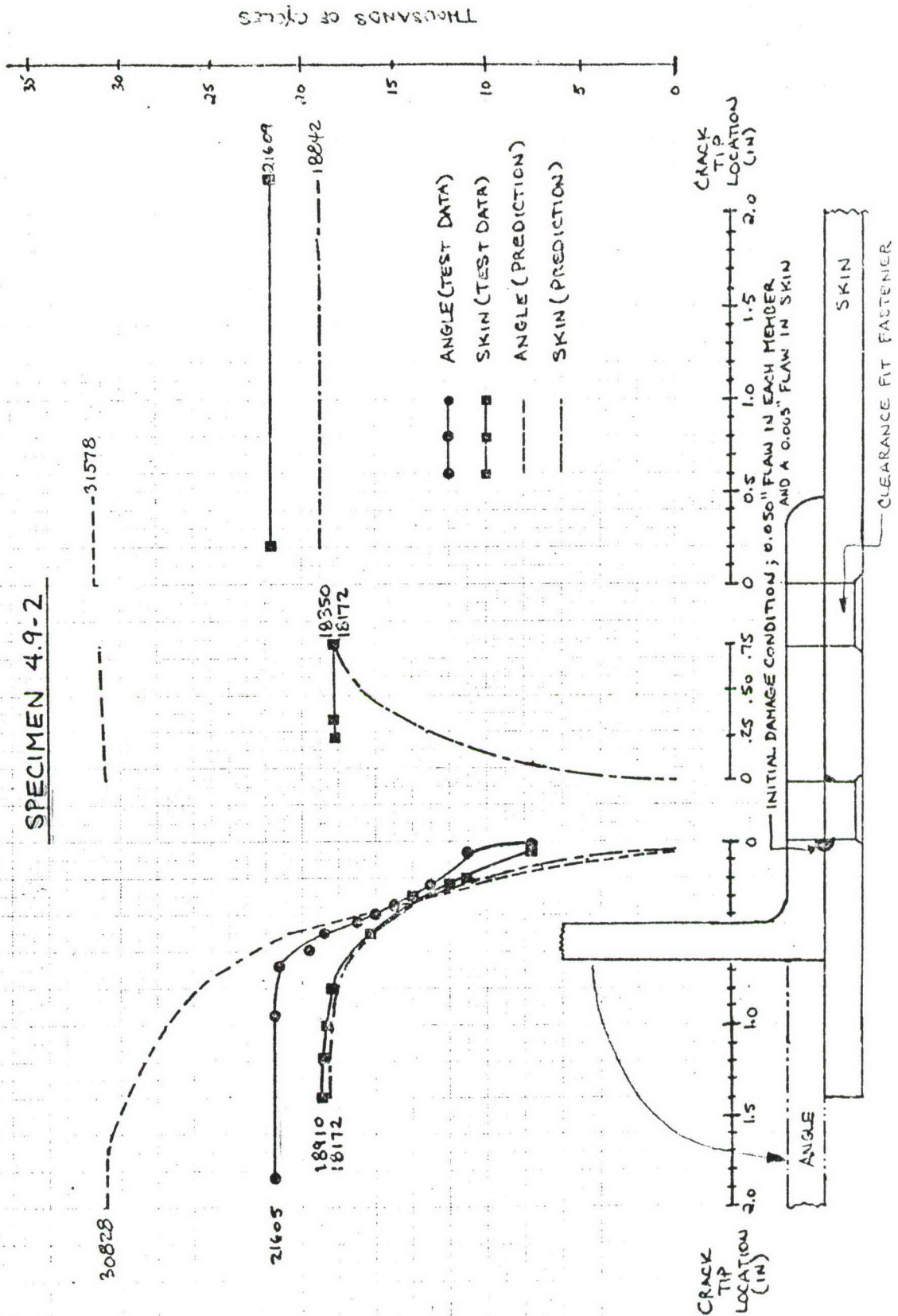


DATA IDENTIFICATION

NOTES

* INITIAL MEASUREMENTS ARE FOR CORNER FLAW. SUBSEQUENT MEASUREMENTS ARE FOR THE CRACK LENGTH AT THE SURFACE
 * CRACK GREW TO ARRESTMENT UN-NOTICED.

SPECIMEN 4.9-2

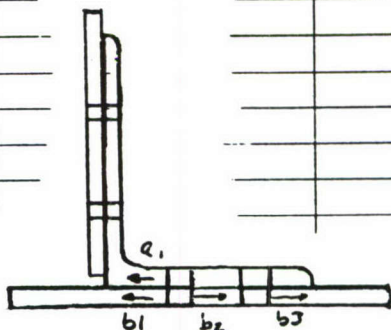


DATA SHEET NO.S : 573641-42

TEST DATE(S): 1/31/77 - 2/1/77

SPECIMEN 4.9-2

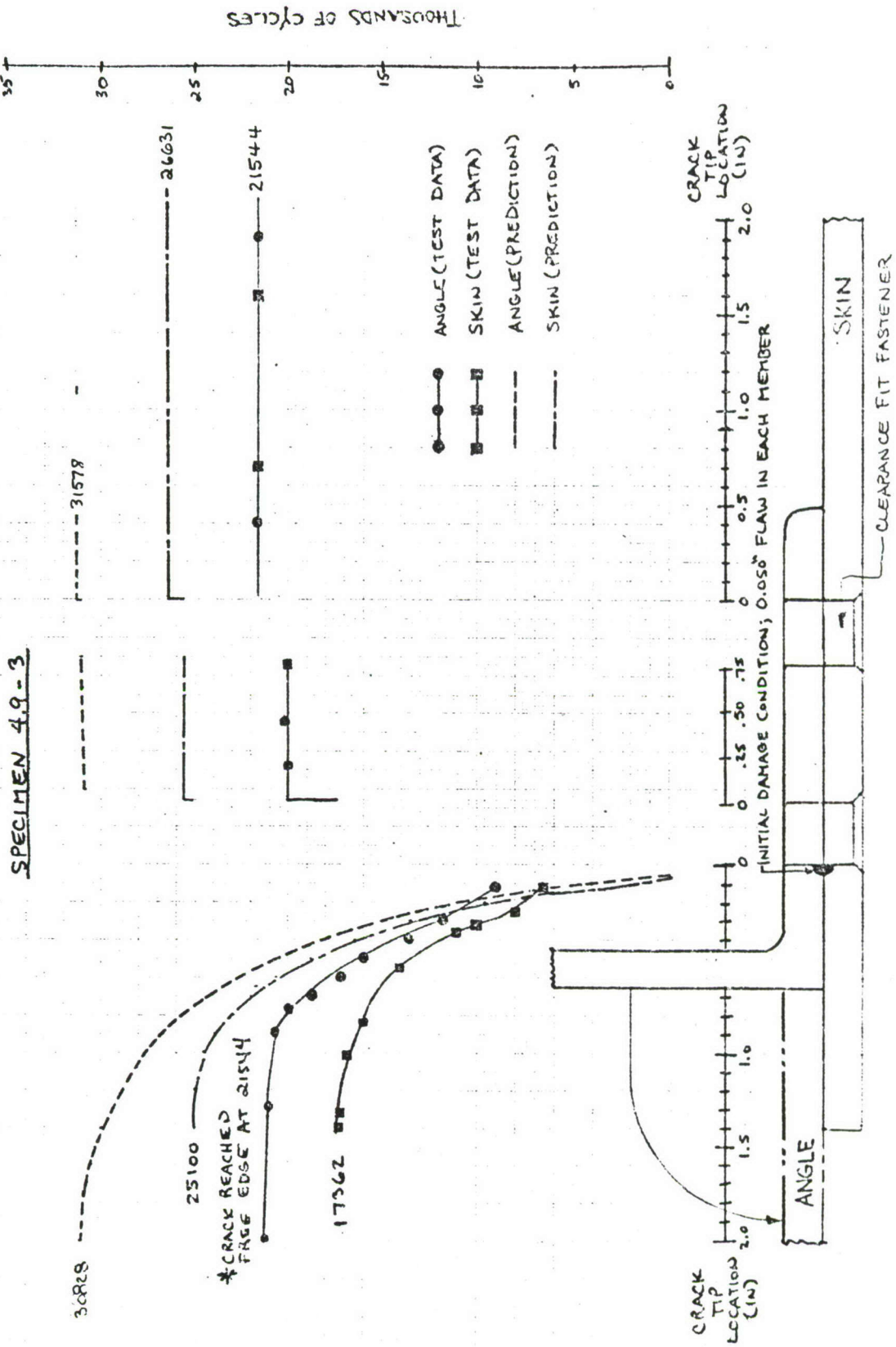
N		a ₁	b ₁	b ₂	b ₃				
0		.041*	.050*	.021*					
7600		.01	.12	—					
7900		.01	.18	—					
9500		.05	.23	—					
11000		.06	.27	—					
12000		.22	.30	—					
14000		.34	.37	—					
15000		.35	.49	—					
16000		.40	.56	—					
17000		.44	.64	—					
18200		.47	.71	.31					
18250		.47	.75	.35					
18300		.47	.75	.41					
18350		.48	.75	TO NEXT FASTENER					
18400		.48	.87						
18500		.48	.96						
18650		.48	1.07						
18800		.50	1.16						
18850		.50	1.25						
18900		.52	1.32						
18910		.52	TO EDGE						
19620		.60							
20620		.68							
21420		.95							
21431		1.08							
21443		1.30							
21453		1.40							
21473		1.50							
21533		1.70							
21573		1.78							
21605		1.84			.31				
21609	F	A	I	L	U	R	E		



DATA IDENTIFICATION

NOTES

* THESE MEASUREMENTS ARE FOR THE INITIAL CORNER FLAW. SUBSEQUENT MEASUREMENTS ARE FOR THE CRACK LENGTHS AT THE SURFACE



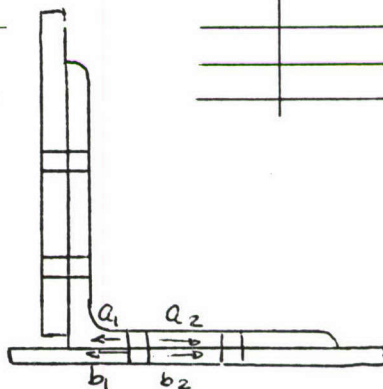
DATE SHEET NO. S: 573639-40

SPECIMEN 4.9-3

TEST DATE(S): 1/28/77

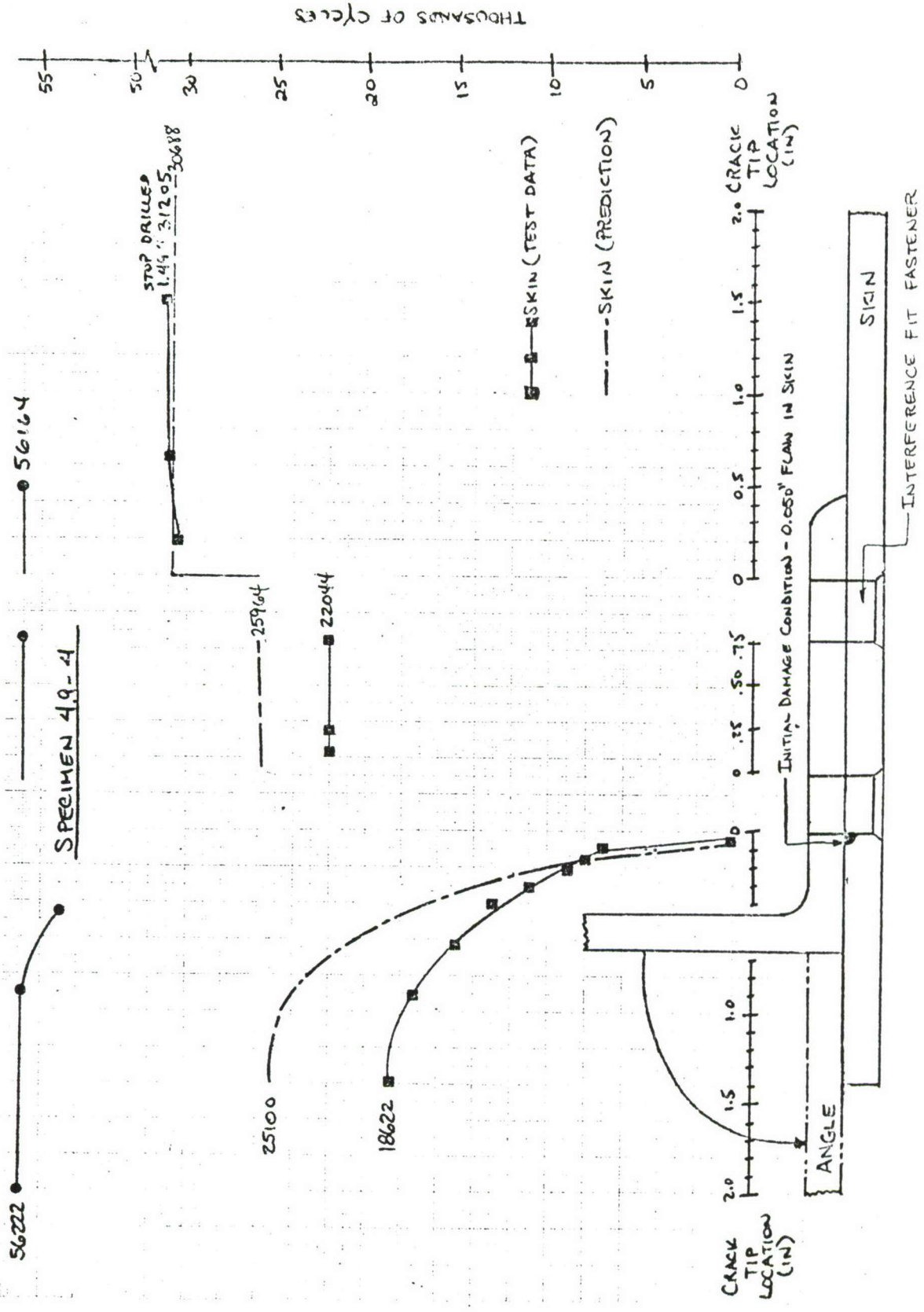
- 1/31/77

N	a_1	a_2	b_1	b_2
0	.053*		.065*	
6540	—		.12	
7540	—		.22	
9068	.04		.27	
10068	.11		.32	
11200	.17		.43	
12800	.23		.54	
13600	.30		.57	
14400	.32		.68	
15200	.37		.80	
16000	.40		.91	
16400	.43		.99	
16800	.45		1.08	
17200	.50		1.39	
17362	.50		TO EDGE	
18162	.55			
18762	.60			
20022	.68			
20042	.68			.38
20044	.68			TO NEXT FASTENER
20962	.80			
20994	.98			
21012	1.20			
21052	1.30			
21138	1.57			
21157	1.68	TO NEXT FASTENER		
21187	1.85			
21237	2.00			
21457	2.26			
21537	2.30			
21544	F	A	I	L
				U
				R
				E



DATA IDENTIFICATION

NOTE * THESE MEASUREMENT ARE THE MANUFACTURED INITIAL CORNER FLAW. SUBSEQUENT MEASUREMENTS ARE FOR THE CRACK LENGTH AS VIEWED AT THE SURFACE

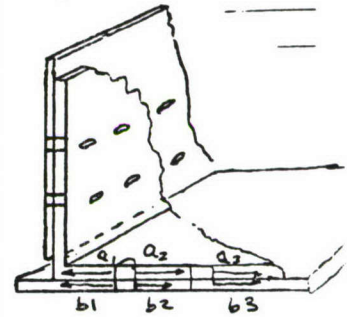


DATA SHEET NO. 8: 573646-48

TEST DATA(S): 2/15/77 - 2/17/77

SPECIMEN 4.9-4

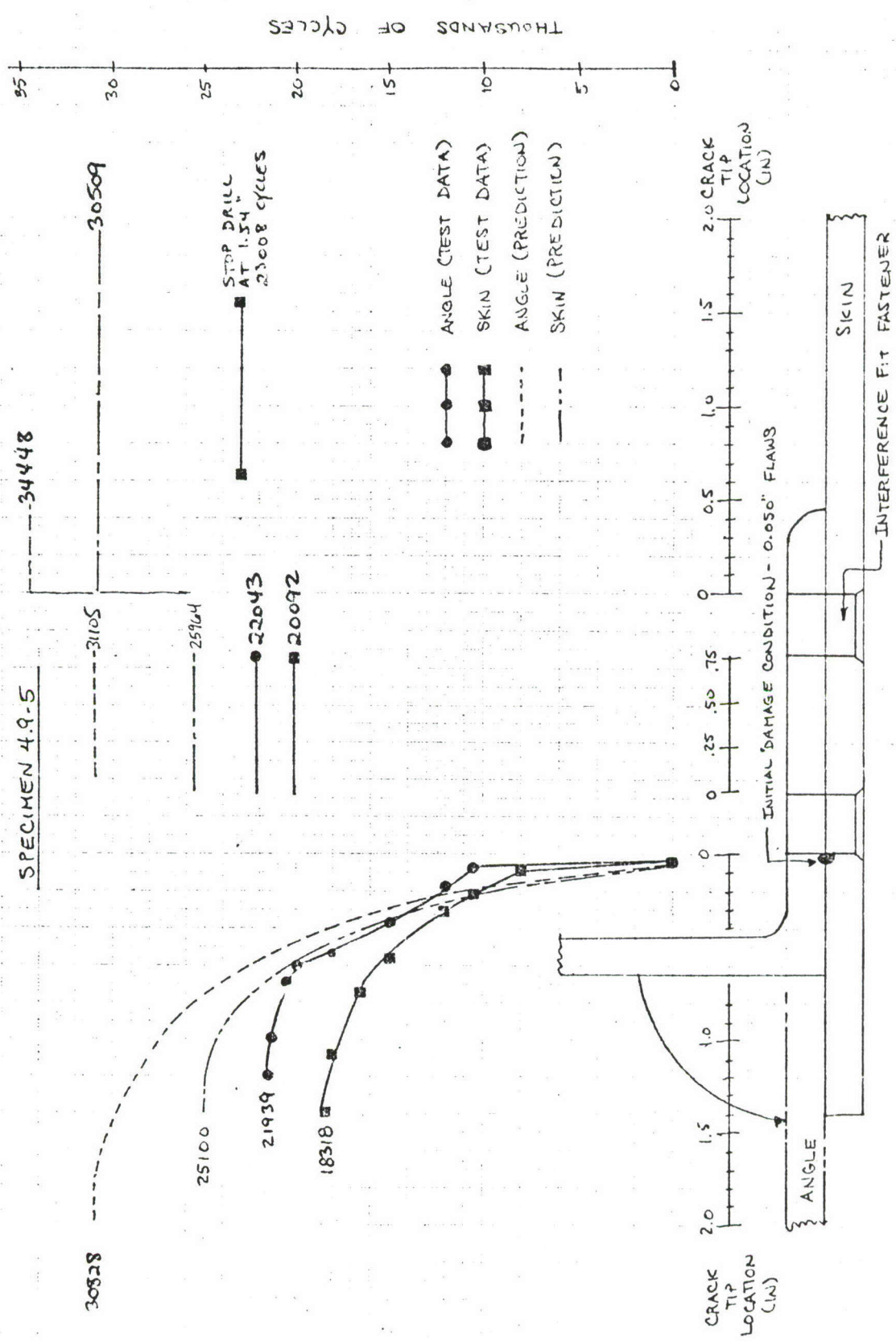
N	a ₁	a ₂	a ₃	b ₁	b ₂	b ₃	b _{3F}
0				.056*			
7010				.10			
8000				.17			
9000				.21			
11000				.32			
13000				.41			
15000				.64			
17200				.92			
17900				1.02			
18200				1.11			
18500				1.27			
18600				1.38			
18622				TO EDGE			
21984					.11		
22014					.20		
22034					.26		
22044					TO NEXT FASTENER		
30544						.19	
30785						.27	
30915						.45	
30965						.55	
31015						.65	
31085						.85	.77
31145						1.05	1.00
31185						1.25	1.23
31205						¹	¹
53905	.46						
55989	.90	TO NEXT FASTENER					
56164			TO EDGE				
56222	F	A	I	L	U	R	E



DATA IDENTIFICATION

NOTE * THESE MEASUREMENTS ARE FOR THE MANUFACTURED INITIAL CORNER FAW. SUBSEQUENT MEASUREMENTS ARE FOR CRACK LENGTH VIEWED AT SURFACE

- ¹ BROKE THRU TO STOP DRILLING AT A LENGTH OF 1.49 IN
- ² CRACK b_{3F} IS SAME AS CRACK b₃, BUT VIEWED FROM FRONT OF SPECIMEN.

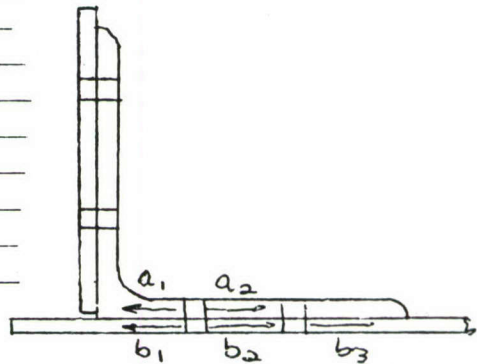


DATA SHEET NO. 5: 573302-3

TEST DATE(S): 2/18/77

SPECIMEN 4.9-5

N	a ₁	a ₂	b ₁	b ₂	b ₃				
0	.050*		.051*						
8000	—		.10						
10500	.08		.21						
12000	.18		.32						
13500	.27		.45						
15000	.38		.57						
16500	.48		.75						
18000	.53		1.08						
18318	—		TO EDGE						
20000	.60								
20092	—			TO NEXT FASTENER					
20592	.70								
21304	1.00								
21357	1.18								
21457	1.20								
21757	1.22								
21939	1.24 ¹								
22043		TO NEXT FASTENER							
23003					.63				
23008					1.54 ²				
23143 ³									
23420	F	A.	I	L	U	R	E		



DATA IDENTIFICATION

NOTES: * THESE MEASUREMENTS ARE FOR THE MANUFACTURED INITIAL CORNER FLAW. SUBSEQUENT MEASUREMENTS ARE FOR CRACK LENGTHS VIEWED AT THE SURFACE

¹ CRACK WENT UP THE OUTSTANDING LEG AND ARRESTED AT THE FIRST FASTENER JOINING WEB TO ANGLE

² CRACK BROKE THRU TO STOP DRILL AT 1.54 IN.

³ CRACK WENT FROM FIRST FASTENER IN OUTSTANDING LEG TO SECOND FASTENER IN LEG

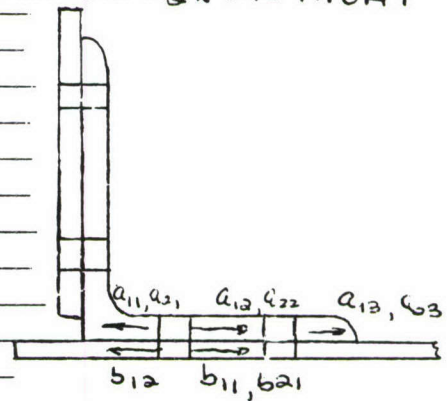
DATA SHEET NO. S : 573306-9

TEST DATE(S) : 2/24/77 - 3/1/77

SPECIMEN 4.9-6

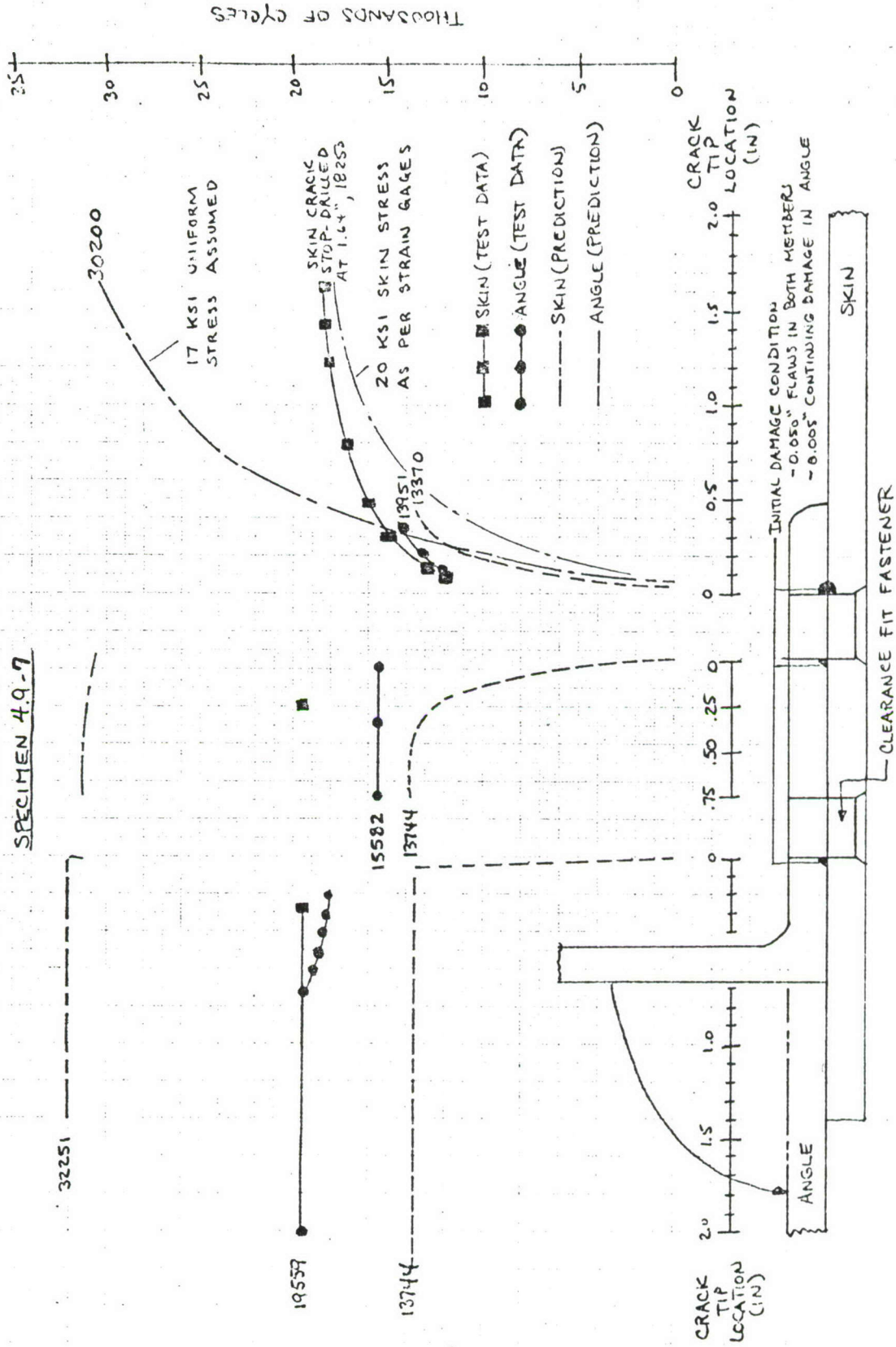
N	a ₁₁	a ₁₂	a ₁₃	a ₂₁	a ₂₂	a ₂₃	b ₁₁	b ₁₂	b ₂₁
0	.058*			.082*					
8000	.05			—					
8459	.06			.06					
8959	.16	.12		.12					
9860	.24	.30		.13					
10380	—	TO NEXT FASTENER		—					
11360	.43			.26					
15360	.66			.46	.10				
15860	.70			.50	.22				
17171	.78			.55	TO NEXT FASTENER				
17671	1.00			.64					
17971	1.36			.68					
18472	1.60			.70					
18872	1.83			.70					
18972	1			.70					
19972				1.00					
20672				1.34					
21072				1.59					
21472				1.87					
21572				1					
21852			.13						
22100			.22						
22239			TO EDGE						
30039						.14			
31190						.32			
31495						TO EDGE			
32872	TEST DELAY DUE TO STUD FAILURE IN GRIPS								
36500							.07		
26900	NOTES: *THESE MEASUREMENTS ARE						.17		
37600	FOR THE MANUFACTURED INITIAL CORNER						.27		
37900	FLAW. SUBSEQUENT MEASUREMENTS ARE						.42		
37910	FOR CRACK LENGTHS VIEWED AT THE SURFACE.						TO NEXT FASTENER		
38000	CRACK ARRESTED AT OUTERMOST							.13	.10
38100	FASTENER IN OUTSTANDING LEG OF						.34		.14
38225	ANGLE						.78		.19
38246							TO EDGE		.20
38642	F	A	I	L	U	R	E		

THESE PANELS HAD NO INITIAL DAMAGE CONDITION IN THE SKIN. HOWEVER BOTH ANGLES WERE CRACKED, WITH a_{1x} BEING THE LEFT SIDE AND a_{2x} THE RIGHT



DATA IDENTIFICATION

SPECIMEN 4.9-7



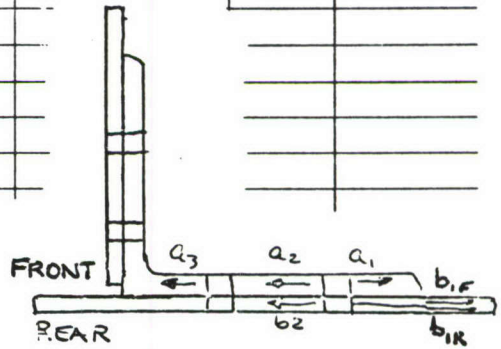
DATA SHEET NO. S' 573631-33

TEST DATE(S): 1/20/77

SPECIMEN 4.9-7

-1/24/77

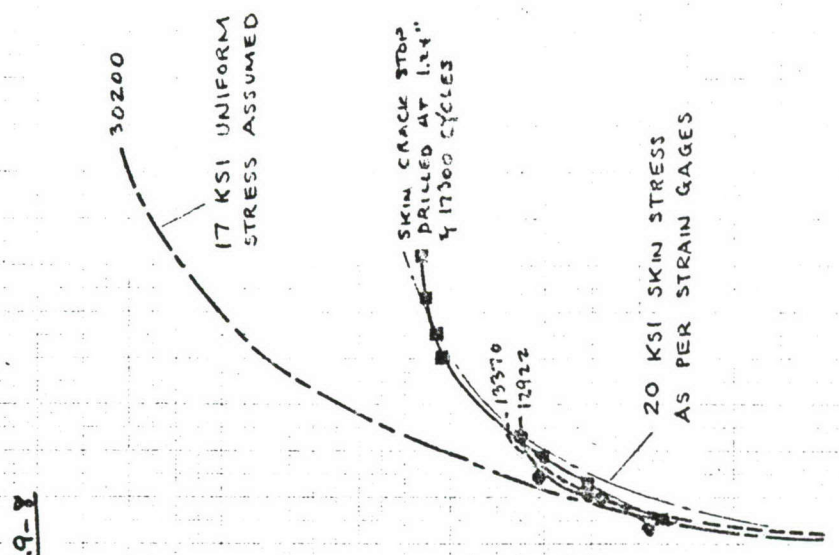
N	a_1/b_{1F} **	a_2	a_3	b_{1R}	b_a				
0	.048*	.017*	.022*	.052*					
10900	.06	—	—	.16					
11500	.09	—	—	.20					
12000	.12	—	—	.21					
13000	.14	—	—	.29					
13500	.28	—	—	.31					
13951	TO EDGE	—	—	.32					
15500**	.46	—	—	.45					
15582	—	34 TO NEXT FASTENER	—	—					
16000	.50	—	—	.48					
16500	.64	—	—	.60					
17000	.76	—	—	.80					
17300	.86	—	—	.86					
17500	.98	—	—	1.02					
17700	1.16	—	—	1.13					
18000	1.28	—	—	1.24					
18200	1.44	—	—	1.42					
18250	1.56 ¹	—	.24	1.64 ¹					
18300		—	.35						
18400		—	.42						
18500		—	.50						
18600		—	.53						
18700		—	.59						
19150		—	.60						
19550		—	.72		.27				
19559	F	A	F	L	U	R	E		



DATA IDENTIFICATION

NOTES: * THESE MEASUREMENTS ARE FOR THE MANUFACTURED INITIAL CORNER FLAW. SUBSEQUENT MEASUREMENTS ARE FOR CRACK LENGTHS VIEWED AT THE SURFACE
 ** THE NOTATION "b_{1F}" REFERS TO THE SKIN CRACK AS VIEWED FROM THE FRONT SIDE OF THE PANEL
 1 THE SKIN CRACK BROKE THRU TO THE STOP DRILLING AT 1.66 IN.

THOUSANDS OF CYCLES



SPECIMEN 4.9-8

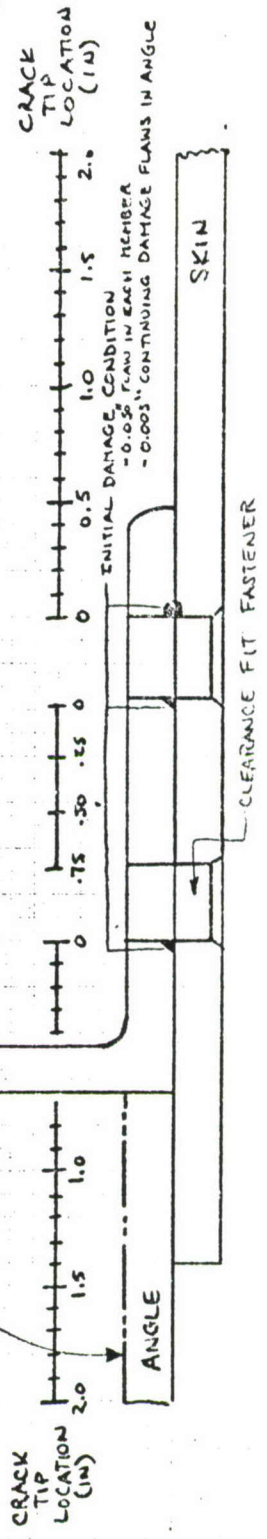
32251



18272
17043

13744

- ANGLE (TEST DATA)
- SKIN (TEST DATA)
- ANGLE (PREDICTION)
- - - SKIN (PREDICTION)



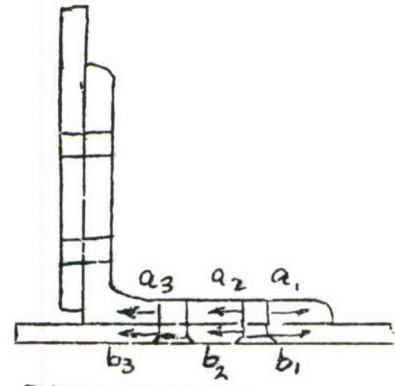
DATA SHEET NO.3: 573643-5

TEST DATE(S) .2/1/77

-2/3/77

SPECIMEN 4.9-8

N	a ₁	a ₂	a ₃	b ₁	b ₂	b ₃
0	.051*	.016*	.013*	.05*		
7600	.08	—	—	.15		
9100	.16	—	—	.25		
10600	.25	—	—	.28		
12600	.32	—	—	.41		
12800	.40	—	—	.42		
12922	TO EDGE	—	—	.42		
13800		—	—	.51		
14800		—	—	.71		
16722		"DIMPLE"	—	.94		
17048		TO NEXT FASTENER	—	1.05		
17300			—	1.24 ¹		
18200			—		"DIMPLE"	
18262			—		.18	
18272			—		TO NEXT FASTENER	
20800			"DIMPLE"			
20980			.11			
21260			.50			
21560			.58			.18
21590			.58			.42
21610			.58			.63
21618			.62			TO EDGE
21655			.80			
21665			.90			
21674			1.21			
21680			1.51			
21685			1.70 ²			
22076	F	A	I	L	U	R
						E



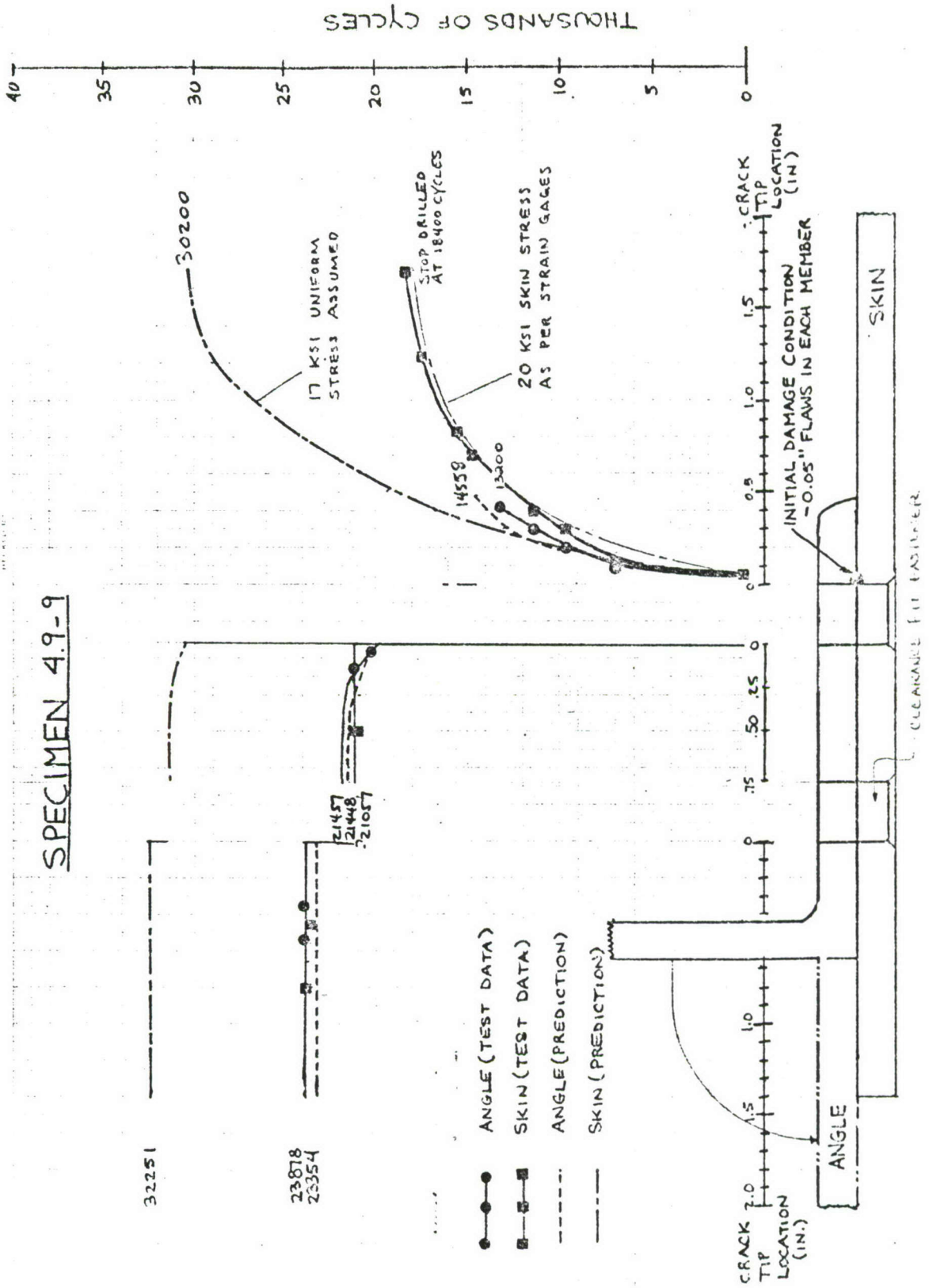
DATA IDENTIFICATION

NOTES: * THESE MEASUREMENTS ARE FOR THE MANUFACTURED INITIAL CORNER FLAWS, SUBSEQUENT MEASUREMENTS ARE FOR CRACK LENGTHS AS VIEWED FROM THE SURFACE

¹ THE CRACK TIP WAS STOP DRILLED

² THE CRACK GREW UP THE OUTSTANDING LEG AND ARRESTED AT THE FIRST FASTENER JOINING THE LEG TO THE WEB

SPECIMEN 4.9-9

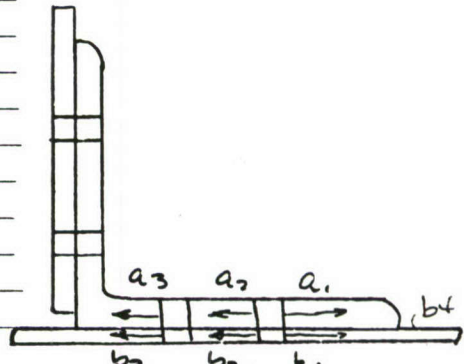


DATA SHEET NO.S: 573634-36

TEST DATE(S): 1/26/77-1/27/77

SPECIMEN 4.9-9

N	a_1/b_4^{**}	a_2	a_3	b_1	b_2	b_3			
0	.070*			.073*					
7000	.070			.10					
7800	.14			.19					
9600	.20			.30					
11400	.30			.40					
13200	.42 ²			.54					
14600	.70**			.70					
15600	.83			.84					
16200	.94			.94					
16800	1.07			1.07					
17400	1.22			1.24					
18000	1.45			1.45					
18400	1.70 ¹			1.70 ¹					
20400		.04							
20900		.08							
21057		.10							
21257		.15							
21457		TO NEXT FASTENER							
23721								.46	
23771								.80	
23793									
23858			.35						
23865			.52						
23878	F	A	I	L	U	R	E		



NOTES: * THESE MEASUREMENTS REFER TO THE MANUFACTURED INITIAL CORNER FLAWS. SUBSEQUENT MEASUREMENTS ARE FOR CRACK LENGTHS AS VIEWED FROM THE SURFACE.
 ** ONCE THE CRACK HAD REACHED PAST THE ANGLE, CRACK MEASUREMENTS WERE TAKEN FROM THE FRONT AND THE BACK OF THE PANEL
¹ THE CRACK TIP WAS STOP DRILLED AT 1.66 IN
² ANGLE CRACK a_1 ARRESTED AT EDGE AT 13,200 CYCLES.

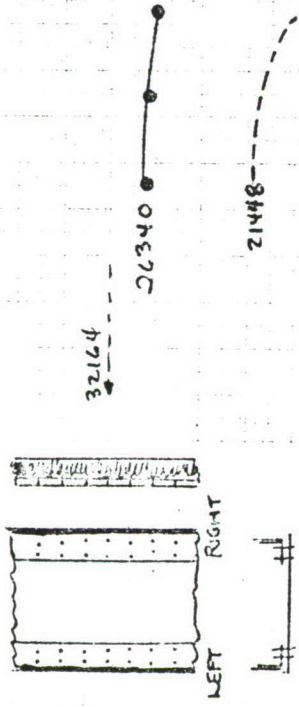
45924 ▲

CHECKED BY

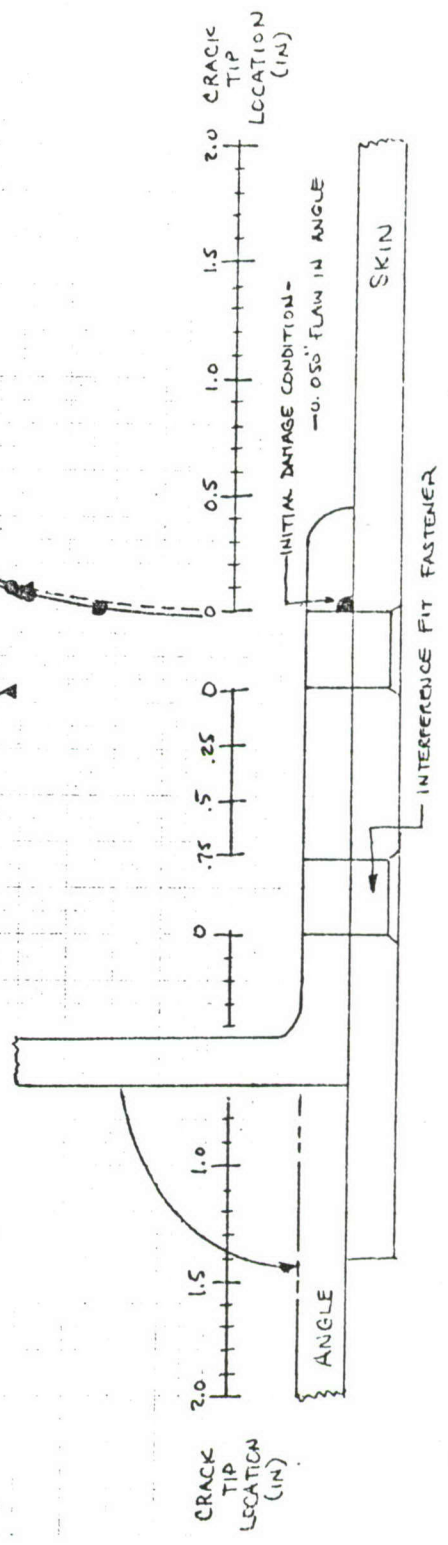


SPECIMEN 4.9-10

NOTE: INITIAL DAMAGE FLAWS WERE INDUCED TO BOTH THE RIGHT AND LEFT ANGLES



- ▲ RIGHT ANGLE (TEST DATA)
- LEFT ANGLE (TEST DATA)
- SKIN (TEST DATA), RIGHT SIDE
- SKIN (TEST DATA), LEFT SIDE
- ANGLE (PREDICTION)

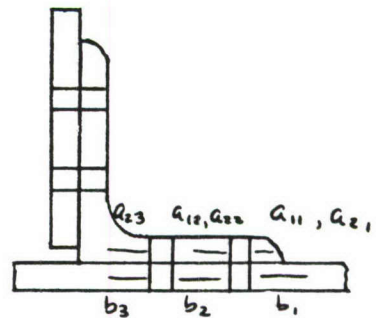


DATA SHEET NO. S: 573310-11

TEST DATE(S): 3/4/77 - 3/8/77

SPECIMEN 4.9-10

N	a ₁₁	a ₁₂	a ₂₁	a ₂₂	a ₂₃	b ₁	b ₂	b ₃
0	.048*		.064*					
6500	"DIMPLE"		"DIMPLE"					
7700	.06		.08					
8200	.09		.11		"DIMPLE"			
8400	.10		.13		.03			
10000	.17		.22		.18			
10800	.22		.34		.30			
11024	.23		TO EDGE		.45			
11400	.24				TO NEXT FASTENER			
13000	.32							
13800	TO EDGE							
26000		.26						
26301		.40						
26340		TO NEXT FASTENER						
34200						.12		
37000						.34		
39000						.66		
39500						.81		
40000						.9		
40500						1.28		
40700						1.54 ¹		
45118								
45123								
45220					.50			
45220					1.00 ²			
45924	F	A	I	L	U	R	E	



DATA IDENTIFICATION

NOTES: THE NOTATION USED TO DESCRIBE THE CRACK POSITION IN THE SKETCH ABOVE HAS BEEN SLIGHTLY ALTERED TO ALLOW FOR GROWTH IN THE ANGLE MEMBER ON BOTH THE RIGHT AND LEFT SIDES. THE NOTATION a_{1n} REFERS TO THE LEFT SIDE AND a_{2n} TO THE RIGHT

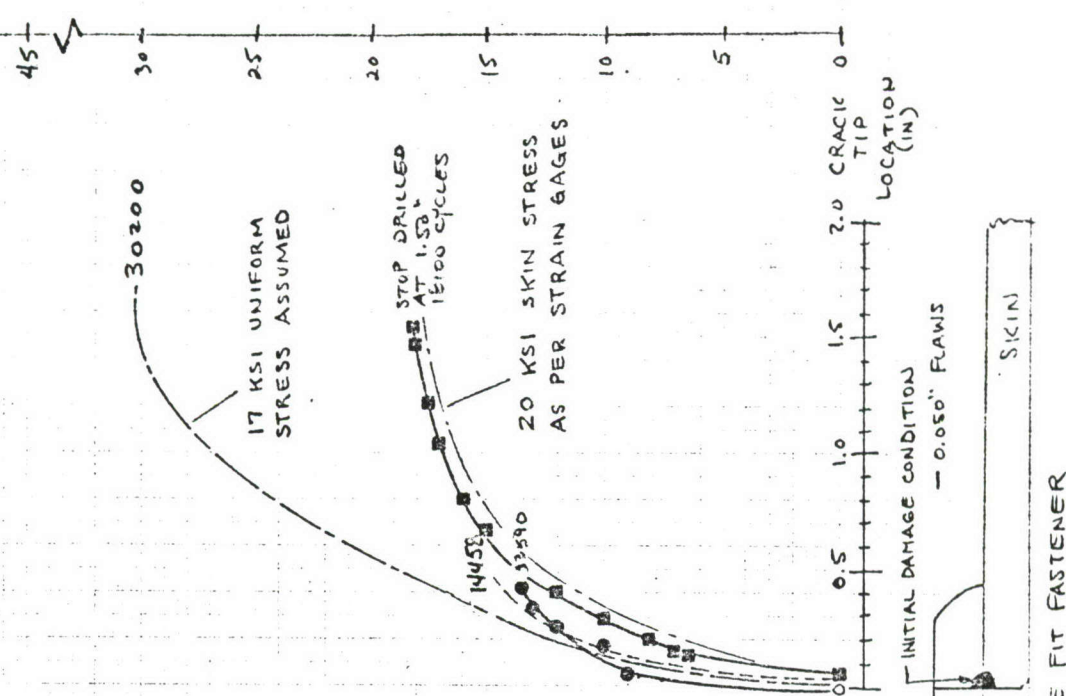
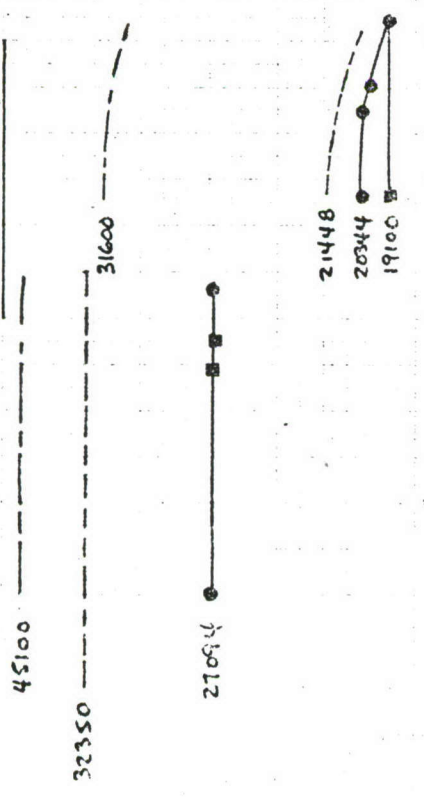
* THE MEASUREMENTS REFER TO THE MANUFACTURED INITIAL CORNER FLAW. SUBSEQUENT MEASUREMENTS ARE FOR CRACKLENGTHS AS VIEWED FROM THE SURFACE.

¹ THE CRACK TIP WAS STOP-DRILLED AT 1.53"

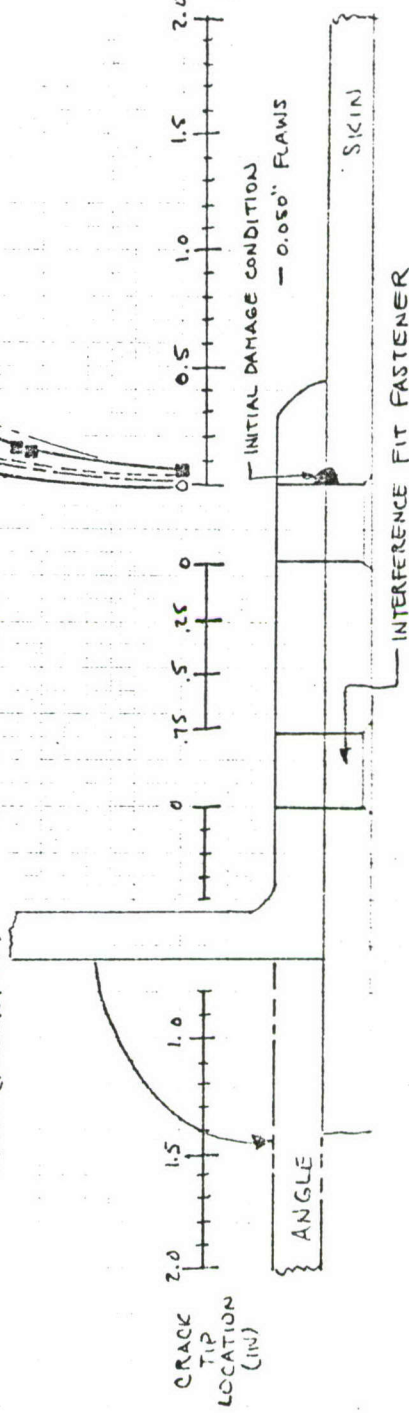
² THE CRACK GREW UP THE OUTSTANDING LEG AND ARRESTED AT THE FIRST FASTENER CONNECTING THE LEG TO THE WEB

DATE: 10/20/54 BY:

SPECIMEN 4.9-11

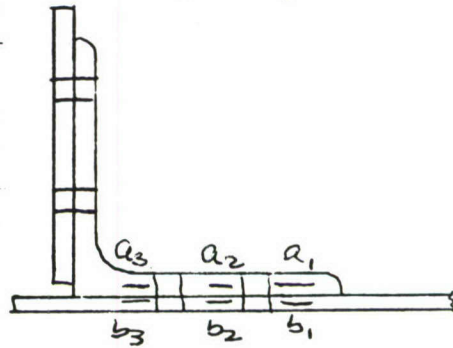


- ANGLE (TEST DATA)
- SKIN (TEST DATA)
- ANGLE (PREDICTION)
- - - SKIN (PREDICTION)



SPECIMEN 4.9-11

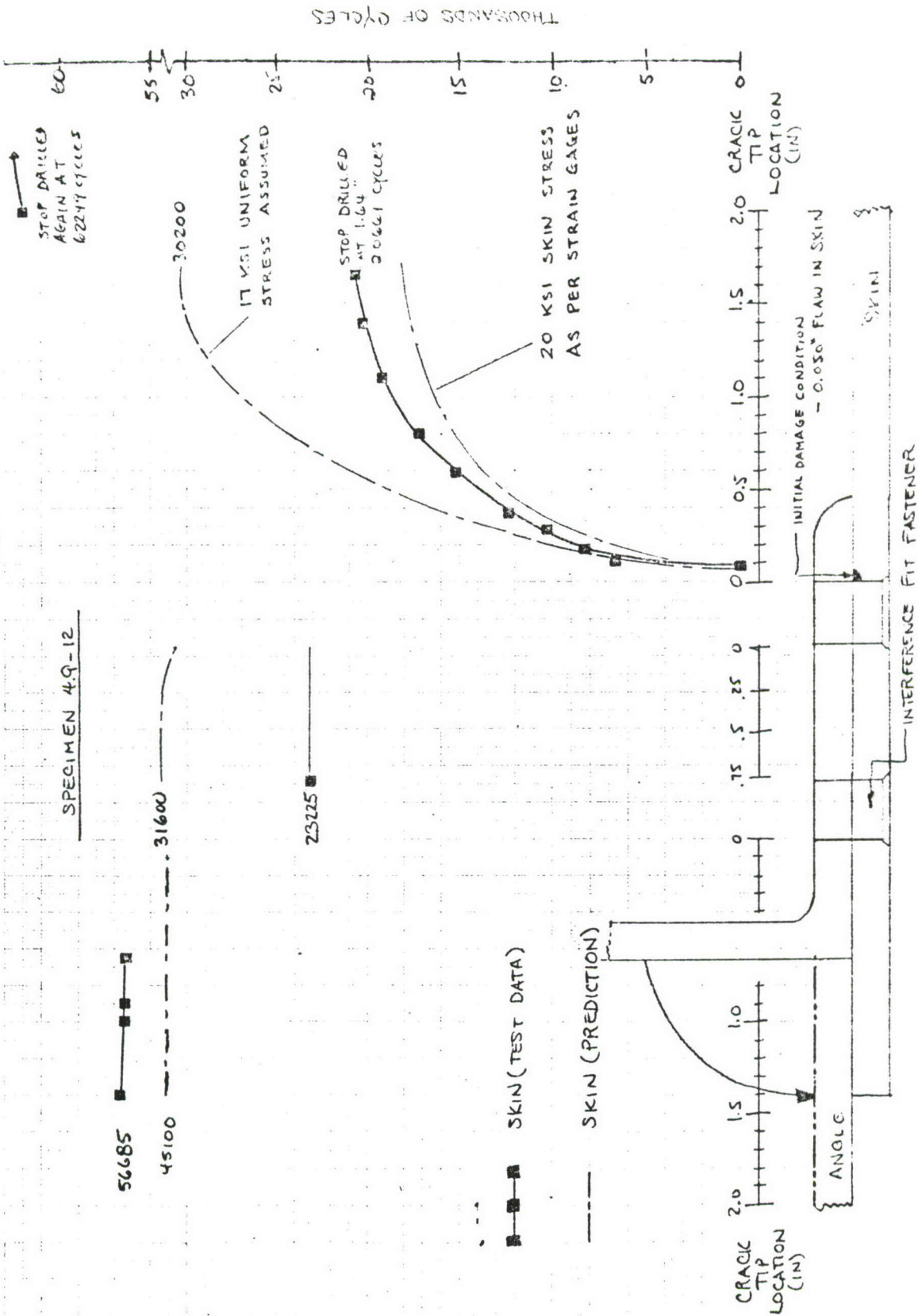
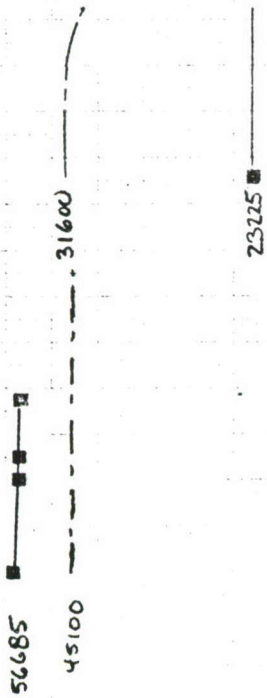
N	a ₁	a ₂	a ₃	b ₁	b ₂	b ₃
0	.047*			.079*		
6500	—			.14		
7000	—			.16		
8000	"DIMPLE"			.20		
8600	.03			.24		
9000	.05			.25		
10000	.17			.29		
12000	.25			.40		
13000	.33			.45		
13500	.42			.49		
13590	TO EDGE			—		
14000				.52		
15000				.65		
16000				.80		
16500				.92		
17000				1.04		
17500				1.21		
18000				1.46		
18100				1.53 ¹		
19100		.04			TO NEXT FASTENER	
19600		.14				
20000		.22				
20300		.36				
20341		TO NEXT FASTENER				
26831			.08			.30
26847			.11			.57
26863			.32			.63
26869			.52			TO EDGE
26912			.90			
26933			1.98			
27094	F	A	I	L	U	R



DATA IDENTIFICATION

NOTES * THESE MEASUREMENTS ARE FOR THE MANUFACTURED INITIAL CORNER FLAW. SUBSEQUENT MEASUREMENTS ARE FOR THE CRACK LENGTHS VIEW FROM THE SURFACE
¹ THE CRACK TIP WAS DRILLED OUT AT 1.53 IN

SPECIMEN 4.9-12

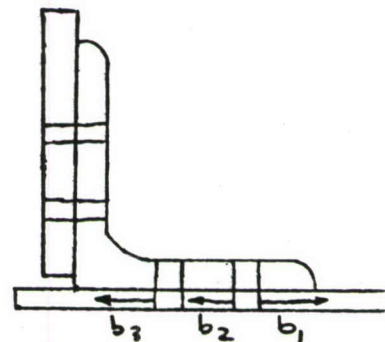


DATA SHEET NO.S: 573304-5

TEST DATE(S): 2/21/77-2/24/77

SPECIMEN 4.9-12

N	b ₁	b ₂	b ₃						
0	.058*								
2228	TEST DELAY DUE TO STUD FAILURE								
4000	-								
6741	.11								
8241	.17								
10241	.27								
12241	.37								
14241	.52								
15241	.59								
16241	.69								
17241	.80								
18241	.89								
19241	1.10								
20241	1.39								
20661	1.64 ²								
23225		TO NEXT FASTENER							
56429			.65						
56595			.90						
56645			1.03						
56685			TO EDGE						
62000	2								
62249	3								
69204 ⁴	F	A	I	L	U	R	E		



DATA IDENTIFICATION

NOTES: * THESE MEASUREMENTS ARE FOR THE MANUFACTURED INITIAL CORNER FLAW. SUBSEQUENT MEASUREMENTS REFER TO CRACK LENGTHS AS VIEWED FROM SURFACE.

¹ THE CRACK TIP WAS STOP DRILLED

² THE CRACK REINITIATED ON THE OPPOSITE SIDE OF THE STOP DRILL. A SECOND STOP DRILL WAS PUT IN

³ THE CRACK GREW INTO THE STOP DRILL

⁴ PANEL STARTED TO CRACK AT THE TOP-RIGHT FASTENER IN THE REAR OF THE PANEL. IT IS SIGNIFICANT TO NOTE THAT THE SAME STUD DEVELOPES A CRACK DURING THE NEXT TEST (SPEC. NO. 4.9-6)

SECTION VIII
TWO-BAY SPECIMENS

Tabulated crack growth for the four two-bay specimens are presented in this section. Specimen configurations and initial damage conditions for these specimens are shown in Figures B-3 (Appendix B) and 7 and Table 5B of Volume I. Specimens 4.10-2 and 4.10-4 were tested at $S_{\max} = 17$ ksi, $R = 0.1$. However, the other two specimens, 4.10-1 and 4.10-3, were tested at a lower stress level of $S_{\max} = 12$ ksi, $R = 0.1$.

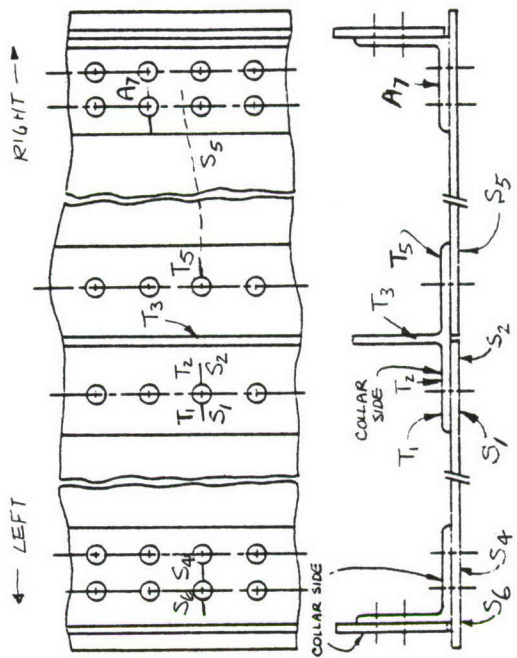
The insert on each table shows schematically the crack path and helps in clarifying the notation describing the location of each crack. Crack lengths S_i are measured on the skin; T_i in the tee, and A_i in the angles.

NOTES FOR ALL TWO-BAY SPECIMENS

- ① Initial crack lengths measured at faying surface before assembly. All other crack length measurements are at externally-visible surfaces.
- ② Marking cycles were at $S_{\max} = 17.0$ ksi, $R = 0.82$. Numbers in parentheses indicate numbers of marking cycles applied.
- ③ Crack extended to edge of the tee, angle, or skin member.
- ④ Crack reached radius at base of the vertical flange of tee (or angle) member.
- ⑤ Crack T_2 reappeared on other side of the vertical flange of tee member. Crack lengths measured from scribe mark.
- ⑥ Crack extended into the vertical flange of tee (or angle) member. Crack lengths measured from scribe mark.
- ⑦ Crack T_2 extended to fastener hole.
- ⑧ Failure of the vertical flange of tee (or angle) member.
- ⑨ Complete failure of the tee member.
- ⑩ Crack extended from fastener hole to fastener hole.
- ⑪ Complete failure of the right-side skin
- ⑫ Complete failure of the left-side skin
- ⑬ Complete failure of the right-side angle member.
- ⑭ Strain survey
- ⑮ Complete failure of the right-side angle member.
- ⑯ Complete failure of the left-side angle member.

SPECIMEN 4.10-1 DATA SHEETS : 573328-31 TEST DATE(S) : 5-5-77 TO 5-11-77

N	T ₁	S ₁	T ₂	T ₃	S ₂
15200	0.120				
(10000)	MARKING CYCLES A ②				
16200	0.140				
18200	0.190				
20200	0.240	0.07			
(10000)	MARKING CYCLES B				
22200	0.270	0.11			
24200	0.320	0.15			
26200	0.370	0.19			
27190	③	—			
27200	0.21	0.30			
30200	④	MARKING CYCLES C			
35200	0.44	0.62			
40200	0.86				
55200	MARKING CYCLES D				
(10000)	0.92	0.110			
56200	④	1.0	0.260		
60200	1.14	④			
60700	1.20				
(10000)	MARKING CYCLES E				
61200	④	1.30			
62700	1.42				
65200	1.70				
65600	1.73	0.08	⑤	0.39	③
66000	1.82	0.22	⑥	0.49	
66300	④	1.44	⑦	0.55	
66900	2.40			0.71	
67100	2.54			0.97	
67500	3.04			1.49	
				1.79	
(TO BE CONTINUED)					

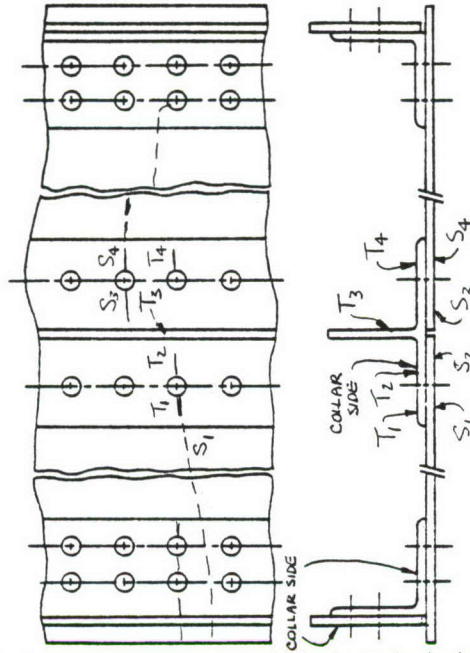


SPECIMEN 4.10-1 (CONTINUED)

N	T ₁	S ₁	T ₂	T ₃	T ₅	S ₄	S ₅	S ₆	A ₇
67500	(3)	3.04	(7)	1.50					
68200		4.20	(8)						
68400		4.68		0.10					
68450		4.90	(9)						
68500		(10)							
69000		MARKING CYCLES							
(10000)					(10)				
74000							1.10		
74150							5.0		
74200							(11)		
75095							(11) NO CRACK APPEARED AT FAILURE		
75700							0.14		
75800							0.60		
75811							(12)		
76918									(13)
76932		FAILURE OF PANEL							

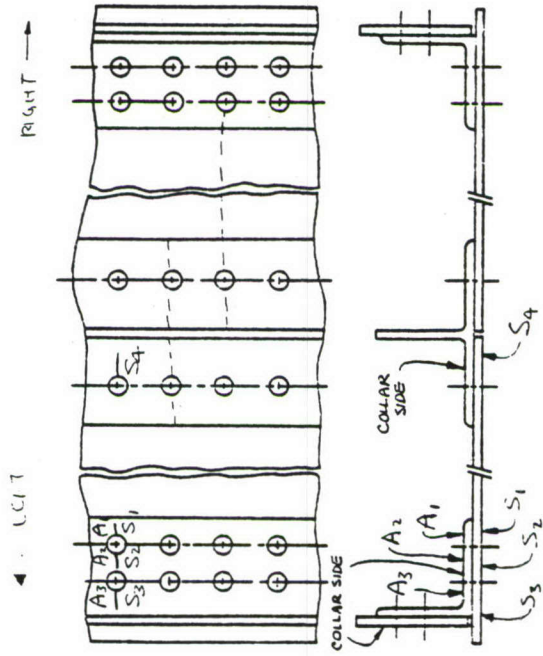
SPECIMEN 4.10-2 DATA SHEET(S): 573336-39 TEST DATE(S): 5-17-77 TO 5-24-77

N	T ₁	S ₁	T ₂	S ₂	T ₃	T ₄
4338	VIMPLE					
4599	0.03					
5500	0.09					
6000	0.12					
(10000)	0.13	MARKING CYCLES A (2)				
6500	0.16					
7500	0.22					
8000	0.26	0.11				
9000	0.40	0.18				
9080	(3)					
9500		0.23				
11000		0.34				
(10000)		MARKING CYCLES B				
12000		0.42				
14000		0.59				
16000		0.92				
(7000)		MARKING CYCLES C				
16500		1.10				
17200		1.48	(4)			
17365		1.80		(3)		
17400		2.0				0.08
17450		2.28	(10)			0.36
17500		5.30				1.30
17505						(8)
17575		7.20				(9)
17585		(12)				
18800		FAILURE OF PANEL				



SPECIMEN 4-10-3 DATA SHEET(S): 573333 - 25 TEST DATE(S): 5-13-77

N	A ₁	A ₂	A ₃	A ₄	A ₅
11500	DIMPLE				
13000	0.08 (1)				
15000	0.14				
(10000)	MARKING CYCLES A (2)				
16000	0.18	0.04			
18000	0.24	0.17			
20000	0.32	0.21			
22000	0.44	0.25			
22830	(E)				
(10000) (1)	MARKING CYCLES B				
24000	0.36				
26000	0.42				
28000	0.52				
30000	0.56				
33000	0.61				
(10000)	MARKING CYCLES C				
36000	0.78				
39000	0.92				
42000	1.07				
45000	1.24				
48000	1.46				
(10000)	MARKING CYCLES D				
49000	1.60				
52000 (1)	1.96				
54000	2.32	0.04			
55000	2.70	0.20			
55200	2.80	0.30			
55300	2.92	(10)			
55500	3.04				
56000	3.60				
56800	(10)				
(TO BE CONSTANT)					



SPECIMEN 4.10-3 (CONTINUED)

N	A ₁	S ₁	S ₂	A ₂	S ₃	A ₃	S ₄
56800	(3)	(10)	(10)	(10)	(3)	(4) (6)	
57925						1.30	
58000						(10)	
58200							
58834						(16)	(12)
58900							
	FAILURE OF PANEL						
	NOTE THAT FAILURE OF THE LEFT-SIDE SKIN,						
	THE TOP, AND THE RIGHT-SIDE SKIN MEMBERS,						
	DID NOT OCCUR ALONG THE SAME FASTENER ROW,						
	SEE THE INSERTED SKETCH ON THE PREVIOUS						
	PAGE.						

SECTION IX

SPECIMEN PRECRACKING DATA

Section VI of Volume I discusses the precracking of the component pieces of each structural specimen. The following tables summarize the records that were kept of precrack sizes and final crack growth rates during precracking. It was believed to be important to keep the final precrack growth rate equal to or slower than the initial crack growth rate in the test to avoid crude retardation effects.

It was generally attempted to keep the initial crack size between 0.040 and 0.060 inch and the final precrack growth rate below 10^{-5} inch per cycle. Some pieces were precracked outside these limits, but in none of the specimens involved did the precracking seem to significantly affect any aspect of the test results.

PRECRACK DATA - DOUBLE LAP JOINTS

Specimen Number	Initial Crack, a_i (Inches)			Max $\frac{da}{dN}$ during precrack: (microin./cyc.)		
	Doubler S1	Skin	Doubler S2	Doubler S1	Skin	Doubler S2
4.6A-1	0.046	0.049	0.047	8.3	9.0	1.5
4.6A-2	0.047	0.044	0.052	12.5	10.0	9.0
4.6A-3	0.047	0.050	0.048	5.0	10.0	8.5
4.6A-4	0.050	0.050	0.049	7.0	3.0	40.0
4.6A-5	0.045	0.057	0.048	30.0	12.5	25.0
4.6A-6	0.043	0.049	0.048	7.5	4.0	6.3
4.6A-7	0.044	--	--	10.0	--	--
4.6A-8	0.046	--	--	4.2	--	--
4.6A-9	0.049	--	0.052	23.0	--	25.0
4.6A-10	0.040	--	0.042	24.0	--	9.0
4.6B-1	0.047	0.057	0.046	7.0	5.0	4.0
4.6B-2	0.054	0.057	0.057	4.0	10.0	2.5
4.6B-3	0.053	0.042	0.051	4.0	4.0	7.0
4.6B-4	0.047	--	--	2.5	--	--

PRECRACK DATA - SINGLE LAP JOINTS

Specimen Number	a_i , (inch)		Precrack da/dN (microinch/cycle)	
	Skin	Doubler	Skin	Doubler
4.7-1	0.041	0.058	7.0	4.0
4.7-2	0.050	0.051	6.2	9.0
4.7-3	0.048	0.050	12.0	10.0
4.7-4	0.049	0.049	7.0	6.6
4.7-5	0.042	0.032	11.0	10.0
4.7-6	0.044	--	5.0	--
4.7-7	0.057	--	35.0	--
4.7-8	0.080	--	25.0	--
4.7-10	0.051	--	7.0	--
4.7-11	0.064	--	10.0	--
4.7-12	0.049	--	10.0	--
4.7-13	0.049	--	8.0	--

PRECRACK DATA - CONTINUOUS-SKIN TEE

Specimen Number	a_i , (inch)		(da/dN) max microinch/cycle	
	Tee	Skin	Tee	Skin
4.8-1-1	0.050	0.060	10.0	7.1
4.8-1-2	0.054	0.055	12.0	10.0
4.8-1-3	0.050	0.054	3.0	12.0
4.8-1-4	0.084	0.075	3.0	11.0
4.8-1-5	0.058	0.046	10.0	15.0
4.8-1-6	0.064	--	3.0	--
4.8-1-7	0.062	0.049	13.0	15.0
4.8-1-8	0.056	0.050	15.0	12.0
4.8-1-9	0.055	0.052	5.0	32.0
4.8-1-10	0.028	0.042	10.0	5.0
4.8-1-11	0.062	0.055	5.0	10.0
4.8-1-12	--	0.062	--	30.0

PRECRACK DATA - SPLIT SKIN TEE AND TWO-BAY

Specimen Number	a_i , (inch)		Precrack da/dN (microinch/cycle)	
	Tee	Skin	Tee	Skin
4.8-3-1	0.050	0.041	9.3	1.0
4.8-3-2	0.046	0.045	16.0	23.0
4.8-3-3	0.066	0.052	9.0	24.0
4.8-3-4	0.042	0.037	27.0	30.0
4.8-3-5	0.047	0.040	21.0	31.0
4.8-3-6	0.059	--	9.3	--
4.8-3-7	0.061	0.059	32.0	15.0
4.8-3-8	0.046	0.073	32.0	17.0
4.8-3-9	0.050	0.043	5.0	16.0
4.8-3-10	0.055	0.050	3.5	50.0
4.8-3-11	0.056	0.048	4.2	25.0
4.8-3-12	--	0.052	--	33.0
4.8-3-13	0.045	0.037	7.0	10.0
4.8-3-14	0.051	0.043	8.0	6.0
4.10-1	0.048	0.047	6.5	10.0
4.10-2	0.058	0.045	9.3	9.0

PRECRACK DATA - EDGE STRINGER AND TWO-BAY

Specimen Number	a_i , (inch)		Precrack (da/dN) (microinch/cycle)	
	Angle	Skin	Angle	Skin
4.9-1	0.029	0.060		
4.9-2	0.041	0.050		
4.9-3	0.053	0.065		
4.9-4	--	0.056		
4.9-5	0.050	0.051		
4.9-6	0.058/ 0.082	--		
4.9-7	0.048	0.052	NOT RECORDED	NOT RECORDED
4.9-8	0.051	0.050		
4.9-9	0.070	0.073		
4.9-10	0.048/ 0.064	--		
4.9-11	0.047	0.079		
4.9-12	--	0.058		
4.10-3	0.057	0.060	7.6	8.0
4.10-4	0.055	0.069	4.0	7.0