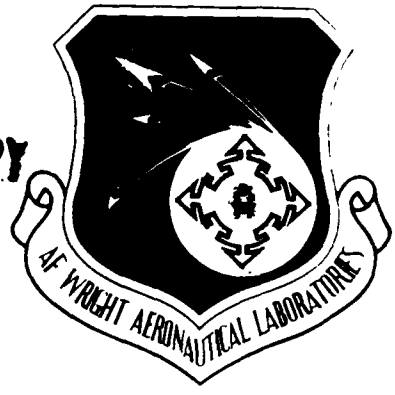

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CONSTANT AMPLITUDE FATIGUE LIFE DATA FOR NOTCHED AND UNNOTCHED ANNEALED Ti-6Al-4V SHEET

Torsten M. Rhode, Capt, USAF
Systems Acquisition and
Logistics Support Branch
Systems Support Division

Patrick W. Ertel
University of Dayton
Research Institute
300 College Park Avenue
Dayton, OH 45469

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This report has been reviewed by the Office of Public Affairs (ASD/PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

Torsten M. Rhode

TORSTEN M. RHODE, Capt, USAF
Project Engineer
Materials Engineering Branch

Clayton L. Harmsworth

CLAYTON L. HARMSWORTH
Technical Manager for
Engineering & Design Data
Materials Engineering Branch

FOR THE COMMANDER

Theodore J. Reinhart

THEODORE J. REINHART, Chief
Materials Engineering Branch
Systems Support Division
Materials Labororatory

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Three lots of annealed Ti-6Al-4v sheet material in thicknesses of 0.063 inch, 0.070 inch, and 0.078 inch, supplied by two manufacturers, were tested to develop fatigue life curves for MIL-HDBK-5. Notched (K_t=3.0) and unnotched configurations of longitudinal and transverse specimens were tested at R-ratios of +0.5, +0.1, and -0.5. Fatigue life data are presented in both tabular and graphical forms. Results were forwarded to the Battelle Memorial Institute, Columbus, Ohio, for analysis, reduction, and inclusion in MIL-HDBK-5.

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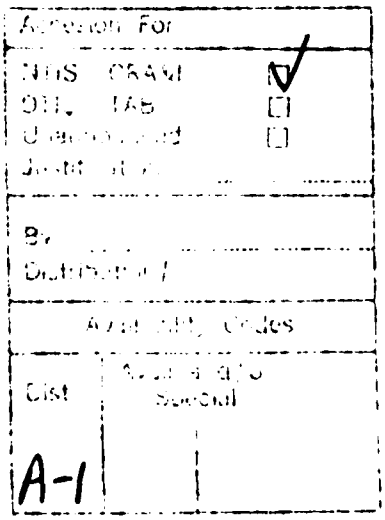
PREFACE

This report was prepared by the Materials Engineering Branch (AFWAL/MLSE), Systems Support Division, Materials Laboratory, Air Force Wright Aeronautical Laboratories, Wright-Patterson Air Force Base, Ohio. The work was conducted under Project 2418, "Aerospace Structural Materials," Task 07, "Systems Support," Work Unit 03, "Engineering and Design Data."

Testing was performed from January 1983-September 1986; the report was submitted by the authors in August 1987.



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SECTION I

INTRODUCTION

The fatigue data published in MIL-HDBK-5 for annealed Ti-6Al-4V bar and extrusion prior to 1987 was based on material produced during the 1950's. It does not represent material produced using current production techniques. As a cooperative government-industry effort, three lots of annealed Ti-6Al-4V sheet material supplied by two manufacturers were tested to develop fatigue life curves for MIL-HDBK-5. Notched (K_t=3.0) and unnotched configurations of longitudinal and transverse specimens were tested at three different stress ratios. Although fatigue data are not considered as design allowables in MIL-HDBK-5, they are presented in the handbook as typical properties of a material.

The results of the fatigue testing were forwarded to the Battelle Memorial Institute, Columbus, Ohio, for analysis, reduction, and inclusion in MIL-HDBK-5.

SECTION II

MATERIALS AND SPECIMENS

Three lots of annealed Ti-6Al-4V sheet were supplied by two different manufacturers. The Titanium Metals Corporation of America, Toronto, Ohio, (Timet) supplied 0.070 inch sheet, while the RMI Company, Niles, Ohio supplied sheet in thicknesses of 0.063 inch and 0.078 inch. Material was manufactured to meet the requirements of MIL-T-9046H, Type III, Composition C. The RMI supplied material was production annealed at 1450°F for 15 minutes and air cooled; the Timet material was annealed for 30 minutes at 1400°F and air cooled.

Chemical compositions of each lot of material are presented in Table 1. Tensile properties are listed in Table 2.

Longitudinal and transverse notched and unnotched fatigue specimens were excised from each sheet of titanium as shown in Figures 1 and 2. Specimens were designed in accordance with ASTM Standard E466, "Constant Amplitude Axial Fatigue Tests of Metallic Materials." Notched specimens had a stress concentration factor (K_t) of 3, calculated using R.E. Peterson's Stress Concentration Design Factors (New York: John Wiley and Sons, Inc., 1953), p. 26.

Each notched specimen was inspected using an optical comparator to confirm that the notch root radius and depth were the specified dimensions to yield a K_t of 3. It was noted that the surface texture of the notch walls resembled the texture of

orange peels. This characteristic indicated that the notches had originally been cut on an electro-discharge machine (EDM). Since the surface heat affected zone (HAZ) caused by an EDM could affect fatigue crack initiation and consequently the fatigue life, the notches were remachined on a grinding wheel to remove 0.005 inch of material in the HAZ of each notch. The new notch dimensions were specified to maintain a K_t of 3, however.

All specimens were machined to a surface finish of 32 RMS or better; care was taken to keep the specimens and the raw sheet material free from scratches. The gage sections of all specimens were lightly polished with 400-grit emery paper to remove surface scratches. Notch roots were left in the as-machined condition.

Eighty-eight specimens, as noted in Tables 4 through 15, were polished with a high-speed buffing wheel. There was concern that surface work hardening due to the buffing would affect the fatigue life of the specimens. Of the 88, the visual effects of buffing were removed from the specimen edges only on 18 specimens by lightly sanding with 400-grit emery paper. For the remaining 70 specimens, the buffing effects were removed by sanding the entire gage section with 400-grit paper. See Tables 4 through 15.

Mr. M. R. Mitchell of the Rockwell International Corporation Science Center, Thousand Oaks, California, performed residual surface stress measurements on selected specimens. Stresses were measured on a PSD System using Cu radiation.

SECTION III

PROCEDURES

Constant-amplitude fatigue life curves were compiled for each lot of material at three different R-ratios (+0.5, +0.1, and -0.5) in both the longitudinal and transverse orientations. Maximum stress levels were chosen so that failure of the specimens would occur between 10^4 and 10^7 cycles in all cases. The test matrix is presented as Table 3.

Fatigue testing of all specimens run at positive R-ratios was conducted on a Rumul resonance-type fatigue machine at a frequency of 105 Hz. The Rumul proved unsuitable for the specimens tested at negative R-ratios, however. The combination of the relatively high maximum stresses with the compressive half-cycles caused the machine to behave in an unstable manner. The Rumul repeatedly triggered its limit switches during trial runs. Therefore, negative R-ratio tests were conducted on an MTS servohydraulic fatigue testing machine at 10-25 Hz.

During the negative R-ratio tests, two aluminum C-channel doublers were placed back-to-back to "sandwich" the specimens to prevent buckling. Teflon fabric was used to reduce friction between the specimen and the stiffening channels.

SECTION IV

RESULTS AND DISCUSSION

Raw fatigue data are presented in Tables 4 through 15. Those data were compiled into fatigue life curves (S-N curves) in Figures 3 through 14.

An attempt was made to compare the residual surface stresses measured by Rockwell International with the fatigue lives of certain specimens. Because of the limited number of replicate tests that were possible, however, a meaningful correlation could not be drawn. The listing of those residual stresses and the corresponding fatigue life data are presented in Table 16. It should be noted, however, that the residual stresses in any of the specimens were probably not high enough to affect specimen behavior.

The measurement of residual surface stresses will be included in a future MIL-HDBK-5 standard for analysis of fatigue data.

SECTION V

CONCLUSIONS

The inclusion of these data into MIL-HDBK-5 will add fatigue life curves for annealed Ti-6Al-4V sheet to the curves already in the handbook for solution treated and aged Ti-6Al-4V sheet.

The residual surface stresses were measured and recorded in an effort to correlate those stresses with specimen fatigue life. Although that correlation could not be made based on the limited specimens that had had residual surface stresses measured, the technique will be included in the future in a new MIL-HDBK-5 standard for analysis of fatigue data.

TABLE 1. CHEMICAL COMPOSITION OF Ti-6Al-4V SHEET
DATA SUPPLIED BY MANUFACTURERS

MANUFACTURER	SHEET THICKNESS, IN.	CHEMISTRY %							
		C	N	Fe	Al	V	Y	O	H
RMI	0.063	0.02	0.011	0.17	6.0	3.9	<50ppm	0.137	61ppm
RMI	0.078	0.02	0.014	0.16	6.2	4.0	<50ppm	0.148	57ppm
TIMET	0.070	0.016	0.010	0.15	6.4	4.0	<10ppm	0.14	70ppm

TABLE 2. TENSILE DATA OF ANNEALED Ti-6Al-4V SHEET
DATA SUPPLIED BY MANUFACTURERS

MANUFACTURER	THICKNESS (IN)	SPECIMEN ORIENTATION	YIELD STRENGTH (KSI)	ULTIMATE STRENGTH (KSI)	ELONGATION (%)
RMI	0.063	L	140	149.4	11
		T	142.9	151.8	12.5
RMI	0.078	L	146.1	150.3	10
		T	136	145.1	13
TIMET	0.070	L	142	150	12
		T	138	147	12

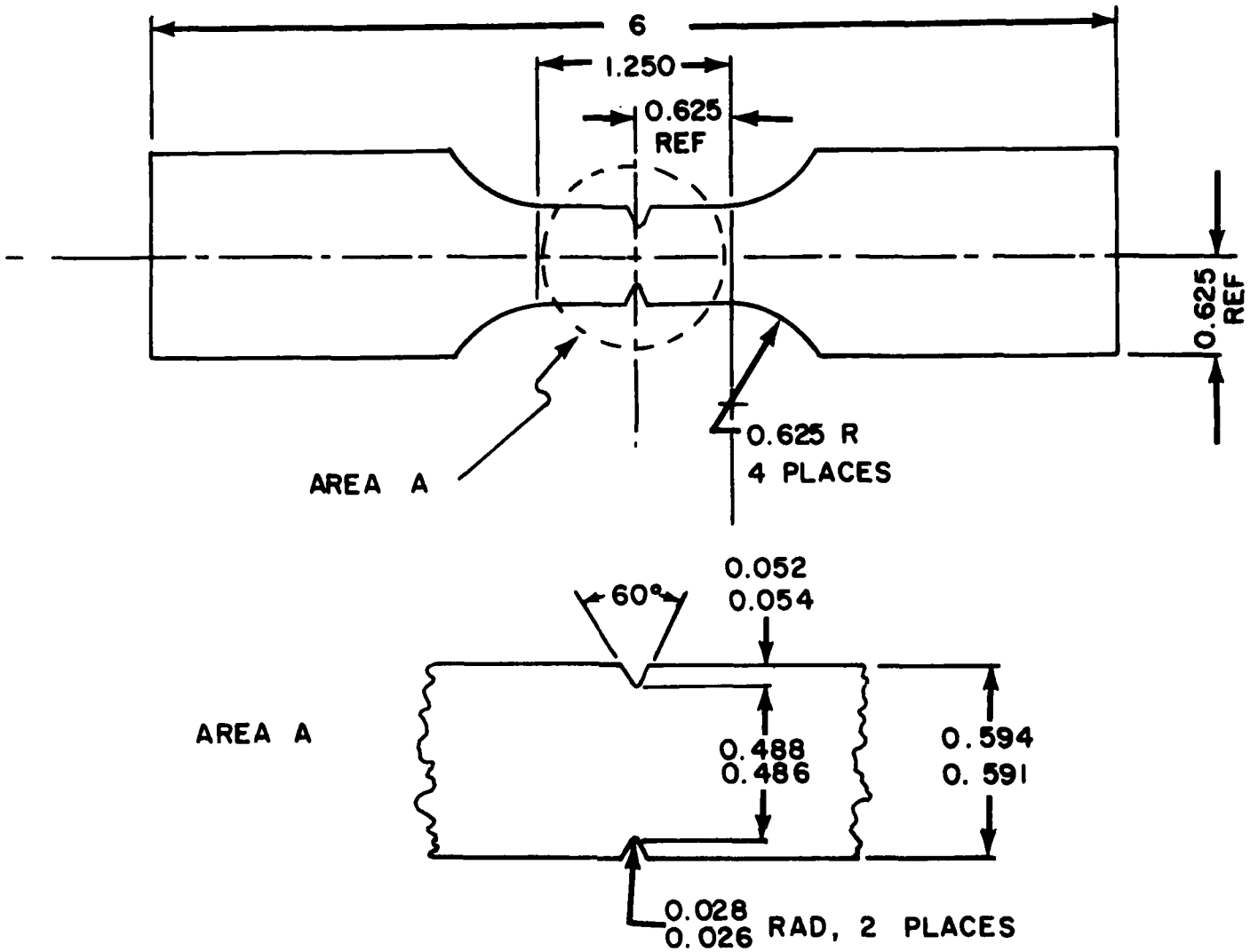

Figure 1. Notched Specimen Geometry.

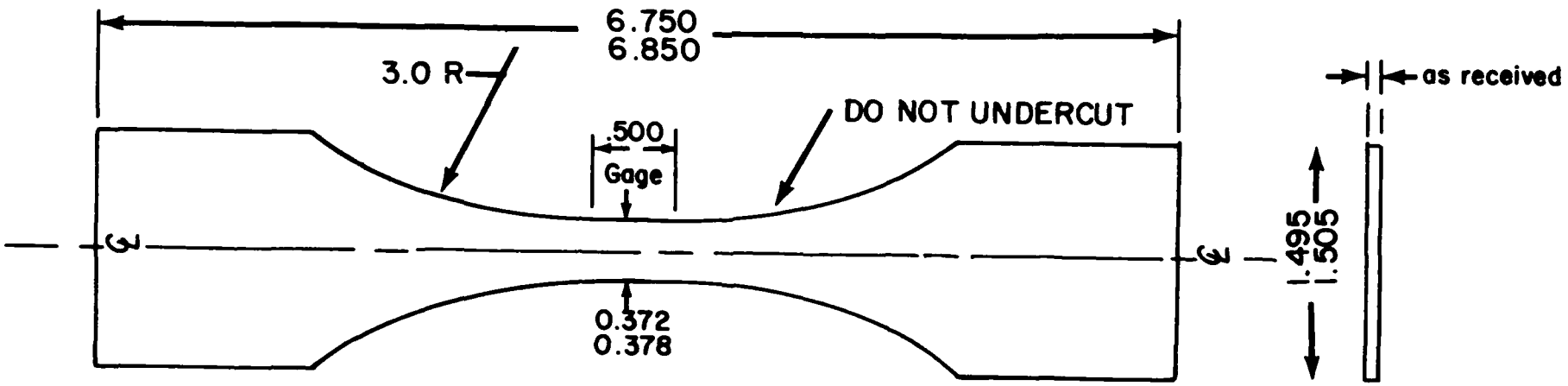

Figure 2. Unnotched Specimen Geometry.

TABLE 3 TEST MATRIX

STRESS RATIO (R)	MFG: RMI						MFG TMCA	
	HEAT A			HEAT B			HEAT C	
	LONGIT		TRANSV	LONGIT		TRANSV	LONGIT	TRANVS
	NOTCH	UN	N U	N	U	N U	N U	N U
+0.5	15	15	5 5	5	5	5 5	15 15	6 6
+0.1	15	15	5 5	5	5	5 5	15 15	6 6
-0.5	15	15	5 5	5	5	5 5	15 15	6 6

TABLE 4. Raw Room-Temperature Fatigue Life Data for Longitudinal Unnotched Annealed Ti-6Al-4V Sheet. R-Ratio is +0.5 at a Test Frequency of 105 Hz.

Specimen ID	Sheet Thickness (in)	Maximum Stress (KSI)	Cycles to Failure	Comments
16LU	0.070	95	18093200	RUNOUT; MB/ES (See Note Below)
17LU		105	9635000	RUNOUT; MB/ES
18LU		110	9690700	RUNOUT; MB/ES
19LU		115	9066200	MB/ES
20LU		120	5833200	MB/ES
21LU		125	4846800	MB/ES
22LU		130	3091200	MB/ES
23LU		135	3023200	MB/ES
24LU		140	405600	MB/ES
25LU		140	134300	MB/ES
26LU		145	275400	MB/ES
27LU		--	--	
28LU		150	34120	MB/ES
29LU		155	14090	MB/ES
30LU		160	--	FAILED DURING LOADING; MB/ES
16LUA	0.078	125	8453100	
17LUA		120	11424100	
18LUA		120	3230000	
19LUA		120	7362800	
20LUA		110	16098800	
21LUA		130	3265900	
22LUA		130	5309600	
23LUA		135	2922900	
24LUA		135	3108100	
25LUA		140	2104100	
26LUA		140	3037400	
27LUA		145	342700	
28LUA		150	46800	
29LUA		150	97000	
30LUA		145	1768000	
6LUB	0.063	148	25100	
7LUB		144	39800	
8LUB		158	--	FAILED DURING LOADING
9LUB		156	--	"
10LUB		152	--	"

NOTE: MB/ES designates "Mechanically Buffed" specimens whose Edges were Sanded.

TABLE 5. Raw Room-Temperature Fatigue Life Data for Longitudinal Unnotched Annealed Ti-6Al-4V Sheet. R-Ratio is +0.1 at a Test Frequency of 105 Hz.

Specimen ID	Sheet Thickness (in)	Maximum Stress (KSI)	Cycles to Failure	Comments
1LU	0.070	140	27300	MB (See Note Below)
2LU		140	16300	MB
3LU		135	27100	MB
4LU		130	1906500	MB
5LU		130	906500	MB
6LU		125	1915200	MB
7LU		125	1695100	MB
8LU		120	83800	MB
9LU		120	1996400	MB
10LU		115	2874400	MB
11LU		132.5	34700	MB
12LU		131	35100	MB
13LU		131.5	910200	MB
14LU		131	140900	MB
15LU		143	7700	MB
1LUA	0.078	100	4655250	
2LUA		120	70600	MISALIGNED
3LUA		90	24418700	
4LUA		110	150750	
5LUA		105	2332100	
6LUA		107.5	41800	
7LUA		102.5	--	
8LUA		80	16353600	RUNOUT
9LUA		90	36881000	RUNOUT
10LUA		100	10005600	
11LUA		102.5	11215000	RUNOUT
12LUA		105	10430000	
13LUA		120	2975000	
14LUA		115	5613000	
15LUA		117.5	7584300	
1LUB	0.063	135	26800	
2LUB		110	10510000	
3LUB		112.5	4785200	
4LUB		120	216500	
5LUB		130	--	

NOTE: "MB" designates "Mechanically Buffed" specimens which were then sanded lightly overall with 400 grit sand paper.

TABLE 6. Raw Room-Temperature Fatigue Life Data for Longitudinal Unnotched Annealed Ti-6Al-4V Sheet. R-Ratio is -0.5 at a Test Frequency of 20 Hz, except as noted.

Specimen ID	Sheet Thickness (in)	Maximum Stress (KSI)	Cycles to Failure	Comments
31LU	0.070	125	6900	MB/ES (See Note 1)
32LU		120	23400	MB/ES
33LU		115	29700	MB/ES
34LU		110	27900	MB/ES
35LU		105	--	MB/ES
36LU		98	41600	10Hz; MB (See Note Below)
37LU		97.5	59800	10Hz; MB
38LU		95	3407400	10Hz; MB
39LU		95	4500100	10Hz
40LU		92.5	6618900	10Hz
41LU		95	54500	10Hz
42LU		100	17700	
43LU		100	73700	
44LU		90	2546200	10Hz
45LU		95	--	10Hz
46LU		97	71900	10Hz
31LUA	0.078	80	1194300	105Hz
32LUA		75	--	
33LUA		70	2205700	105Hz
34LUA		75	14665800	RUNOUT, 25Hz
35LUA		--	--	
36LUA		85	10075800	RUNOUT, 25Hz
37LUA		125	15900	
38LUA		115	34000	25Hz
39LUA		100	45400	25Hz
40LUA		90	2004300	
41LUA		95	1127300	25Hz
42LUA		105	24000	
43LUA		120	15000	
44LUA		110	17200	
45LUA		95	78600	
11LUB	0.063	90	10319200	RUNOUT
12LUB		105	45700	
13LUB		100	482900	
14LUB		120	--	BROKE DURING LOADING
15LUB		115	35600	

NOTE: "MB/ES" designates "Mechanically Buffed" specimens whose Edges were Sanded. "MB" designates mechanically buffed specimens that were lightly sanded overall with 400-grit sandpaper.

TABLE 7. Raw Room-Temperature Fatigue Life Data for Transverse Unnotched Annealed Ti-6Al-4V Sheet. R-Ratio is +0.5.

Specimen ID	Sheet Thickness (in)	Maximum Stress (KSI)	Cycles to Failure	Comments
7TU	0.070	136	230400	10HZ; MB (See Note Below)
8TU		144	52500	10HZ; MB
9TU		134	355500	10HZ; MB
10TU		146	44000	10HZ; MB
11TU		128	1741200	20HZ; MB
12TU		126	1499100	20HZ; MB
6TUA	0.078	126	--	HYDRAULIC MACHINE FAILURE
7TUA		120	10000000	RUNOUT, 20HZ
8TUA		140	56500	10HZ
9TUA		130	3330000	10HZ
10TUA		150	200	10HZ
6TUB	0.063	124	--	HYDRAULIC MACHINE FAILURE
7TUB		142	56300	15HZ
8TUB		132	3860200	20HZ
9TUB		138	114600	15HZ
10TUB		133	257000	15HZ

NOTE: "MB" designates "Mechanically Buffed" specimens which were then sanded lightly overall with 400-grit sandpaper.

TABLE 8. Raw Room-Temperature Fatigue Life Data for Transverse Unnotched Annealed Ti-6Al-4V Sheet. R-Ratio is +0.1 at a Test Frequency of 15 Hz, except as noted.

Specimen ID	Sheet Thickness (in)	Maximum Stress (KSI)	Cycles to Failure	Comments
1TU	0.070	115	920700	
2TU		135	31300	10HZ
3TU		112	18500	
4TU		108	1372600	
5TU		118	899200	
6TU		126	73000	10HZ
1TUA	0.078	90	10000000	RUNOUT
2TUA		110	143000	
3TUA		110	34500	
4TUA		100	3452700	
5TUA		105	8506400	
1TUB	0.063	139	10500	
2TUB		124	787300	
3TUB		105	3320700	
4TUB		120	1224000	
5TUB		130	45000	

TABLE 9. Raw Room-Temperature Fatigue Life Data for Transverse Unnotched Annealed Ti-6Al-4V Sheet. R-Ratio is -0.5 at a Test Frequency of 20 Hz, except as noted.

Specimen ID	Sheet Thickness (in)	Maximum Stress (KSI)	Cycles to Failure	Comments
13TU	0.070	90	2410400	
14TU		85	6615500	
15TU		100	2225900	10HZ
16TU		115	24000	
17TU		95	1592500	
18TU		105	37400	
19TU		97.5	61100	
20TU		102.5	30800	
11TUA	0.078	110	49200	
12TUA		95	5002000	
13TUA		102.5	430900	
14TUA		90	5426000	
15TUA		120	37000	
11TUB	0.063	100	43400	
12TUB		95	1052300	
13TUB		97.5	1948600	
14TUB		105	35500	
15TUB		97.5	49000	

TABLE 10. Raw Room-Temperature Fatigue Life Data for Longitudinal Notched Annealed Ti-6Al-4V Sheet. R-Ratio is +0.5 at a Test Frequency of 95 Hz.

Specimen ID	Sheet Thickness (in)	Maximum Stress (KSI)	Cycles to Failure	Comments
31LN	0.070	--	--	
32LN		58	762300	MB (See Note)
33LN		66	904100	MB
34LN		84	49000	MB
35LN		68	102000	MB
36LN		62	1478600	MB
37LN		60	--	MB
38LN		72	70500	MB
39LN		50	3625800	MB
40LN		52	3805800	MB
41LN		56	2080500	MB
42LN		80	56400	MB
43LN		64	67200	MB
44LN		70	92700	MB
45LN		60	902600	MB
16LNA	0.078	90	--	BROKE DURING LOADING
17LNA		60	35900	
18LNA		30	297300	
19LNA		10	33648800	RUNOUT
20LNA		20	1144100	
21LNA		15	18365000	
22LNA		20	16045200	RUNOUT
23LNA		25	623200	
24LNA		68	137200	
25LNA		62	1358700	
26LNA		64	2387100	
27LNA		54	4819400	
28LNA		78	40900	
29LNA		66	169800	
30LNA		46	8780000	
11LNB	0.063	64	3464400	
12LNB		74	79900	
13LNB		70	181700	
14LNB		60	4452200	
15LNB		66	4603500	

NOTE: "MB" designates Mechanically Buffed specimens that were lightly sanded overall with 400-grit sandpaper.

TABLE 11. Raw Room-Temperature Fatigue Life Data for Longitudinal Notched Annealed Ti-6Al-4V Sheet. R-Ratio is +0.1 at a Test Frequency of 95 Hz, except as noted.

Specimen ID	Sheet Thickness (in)	Maximum Stress (KSI)	Cycles to Failure	Comments
1LN	0.070	40	1729900	20Hz; MB (See Note Below)
2LN		46	826100	MB
3LN		50	38400	20Hz; MB
4LN		52	1240700	MB
5LN		35	5311700	20Hz; MB
6LN		50	57500	MB
7LN		45	1160000	20Hz; MB
8LN		44	1642600	MB
9LN		55	43300	25Hz; MB
10LN		48	612800	MB
11LN		58	48200	10Hz; MB
12LN		62	28600	MB
13LN		60	35600	10Hz; MB
14LN		38	1784300	MB
15LN		48	1133100	20Hz; MB
1LNA	0.078	46	2638500	
2LNA		54	82600	
3LNA		50	5353200	
4LNA		62	48500	
5LNA		52	47800	20Hz
6LNA		50	59500	
7LNA		50	537400	20Hz
8LNA		64	28200	
9LNA		48	82700	
10LNA		52	753400	
11LNA		48	832400	
12LNA		54	106300	
13LNA		42	1593500	
14LNA		50	1412300	
15LNA		56	112900	
1LNB	0.063	50	1554600	
2LNB		46	2404300	
3LNB		52	1153800	
4LNB		36	3980800	
5LNB		58	77800	

NOTE: "MB" designates Mechanically Buffed specimens that were lightly sanded overall with 400-grit sandpaper.

TABLE 12. Raw Room-Temperature Fatigue Life Data for Longitudinal Notched Annealed Ti-6Al-4V Sheet. R-Ratio is -0.5 at a Test Frequency of 20 Hz.

Specimen ID	Sheet Thickness (in)	Maximum Stress (KSI)	Cycles to Failure	Comments
16LN	0.070	28	2097500	MB (See Note Below)
17LN		42	40700	MB
18LN		34	3031700	MB
19LN		40	67100	MB
20LN		38	1457400	MB
21LN		46	33800	MB
22LN		24	10666900	MB
23LN		36	109000	MB
24LN		40	996500	MB
25LN		42	80700	MB
26LN		44	807500	MB
27LN		26	8860500	MB
28LN		32	1713800	MB
29LN		50	15800	MB
30LN		48	20800	MB
31LN		30	4623800	MB
31LNA	0.078	20	3612500	
32LNA		15	10000000	RUNOUT
33LNA		30	81800	
34LNA		22	8462600	
35LNA		42	1374200	
36LNA		48	13900	
37LNA		38	440000	
38LNA		34	786900	
39LNA		36	59600	
40LNA		40	1357600	
41LNA		46	33900	
42LNA		26	5919100	
43LNA		28	10000000	RUNOUT
44LNA		32	2452100	
45LNA		46	10200	
7LNB	0.063	50	1554600	
8LNB		46	2404300	
9LNB		52	1153800	
10LNB		36	3980800	

NOTE: "MB" designates Mechanically Buffed specimens that were lightly sanded overall with 400-grit sandpaper.

TABLE 13. Raw Room-Temperature Fatigue Life Data for Transverse Notched Anne Ti-6Al-4V Sheet. R-Ratio is +0.5 at a Test Frequency of 95 Hz.

Specimen ID	Sheet Thickness (in)	Maximum Stress (KSI)	Cycles to Failure	Comments
7TN	0.070	62	942400	
8TN		60	892300	
9TN		64	631600	10HZ
10TN		66	181300	
11TN		58	616600	
12TN		68	89500	
13TN		55	1587900	
11TNA	0.078	65	78300	
14TNA		55	4492300	
15TNA		45	25583400	
11TNB	0.063	52	12123400	
12TNB		58	3141500	
13TNB		70	71700	
14TNB		60	175400	
15TNB		80	40500	

TABLE 14. Raw Room-Temperature Fatigue Life Data for Transverse Notched Annealed Ti-6Al-4V Sheet. R-Ratio is +0.1 at a Test Frequency of 95 Hz, except as noted.

Specimen ID	Sheet Thickness (in)	Maximum Stress (KSI)	Cycles to Failure	Comments
1TN	0.070	100	2400	20HZ
2TN		85	6700	20HZ
3TN		70	8700	20HZ
4TN		60	41300	20HZ
5TN		50	438500	20HZ
6TN		40	1560700	20HZ
1TNA	0.078	48	1888300	
2TNA		50	1929400	
3TNA		56	48300	
4TNA		52	1444000	
5TNA		36	4743000	
1TNB	0.063	50	2032700	
2TNB		32	10000000	RUNOUT
3TNB		54	63200	
4TNB		44	2009700	
5TNB		54	41700	

TABLE 15. Raw Room-Temperature Fatigue Life Data for Transverse Notched Annealed Ti-6Al-4V Sheet. R-Ratio is -0.5 at a Test Frequency of 20 Hz.

Specimen ID	Sheet Thickness (in)	Maximum Stress (KSI)	Cycles to Failure	Comments
14TN	0.070	46	34100	
15TN		34	812300	
16TN		26	2390600	
17TN		36	1824600	
18TN		32	860900	
19TN		38	593900	
20TN		22	10378900	
6TNA	0.078	52	8900	
8TNA		18	5415800	
9TNA		30	2212500	
10TNA		40	64200	
6TNB	0.063	50	25300	
7TNB		30	103000	
8TNB		34	417400	
9TNB		24	10200000	
10TNB		28	3998300	

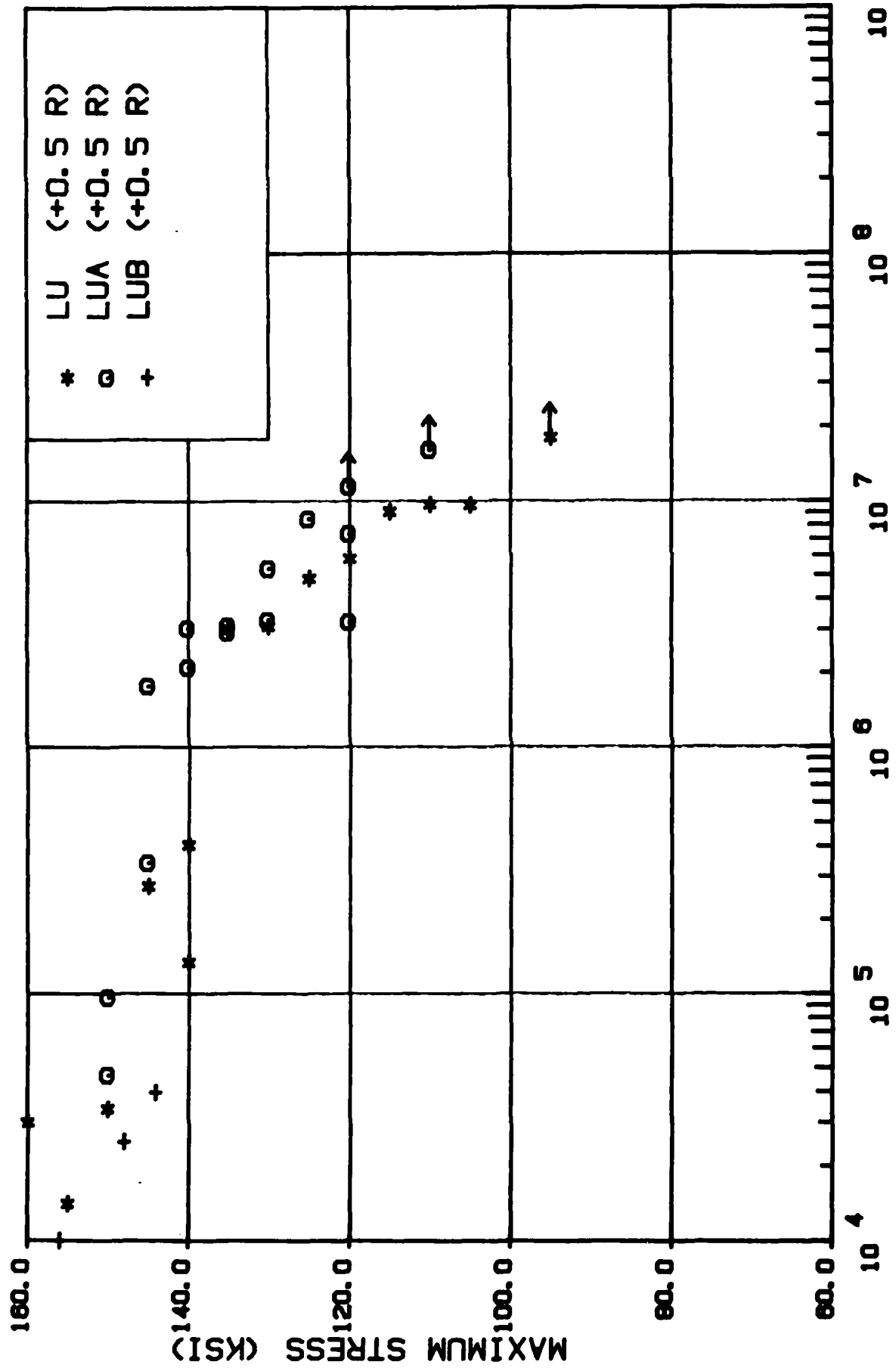

Figure 3. S-N Plot for Unnotched, Annealed Ti-6Al-4V Sheet at Room Temperature, Longitudinal Orientation, R-Ratio = +0.5.

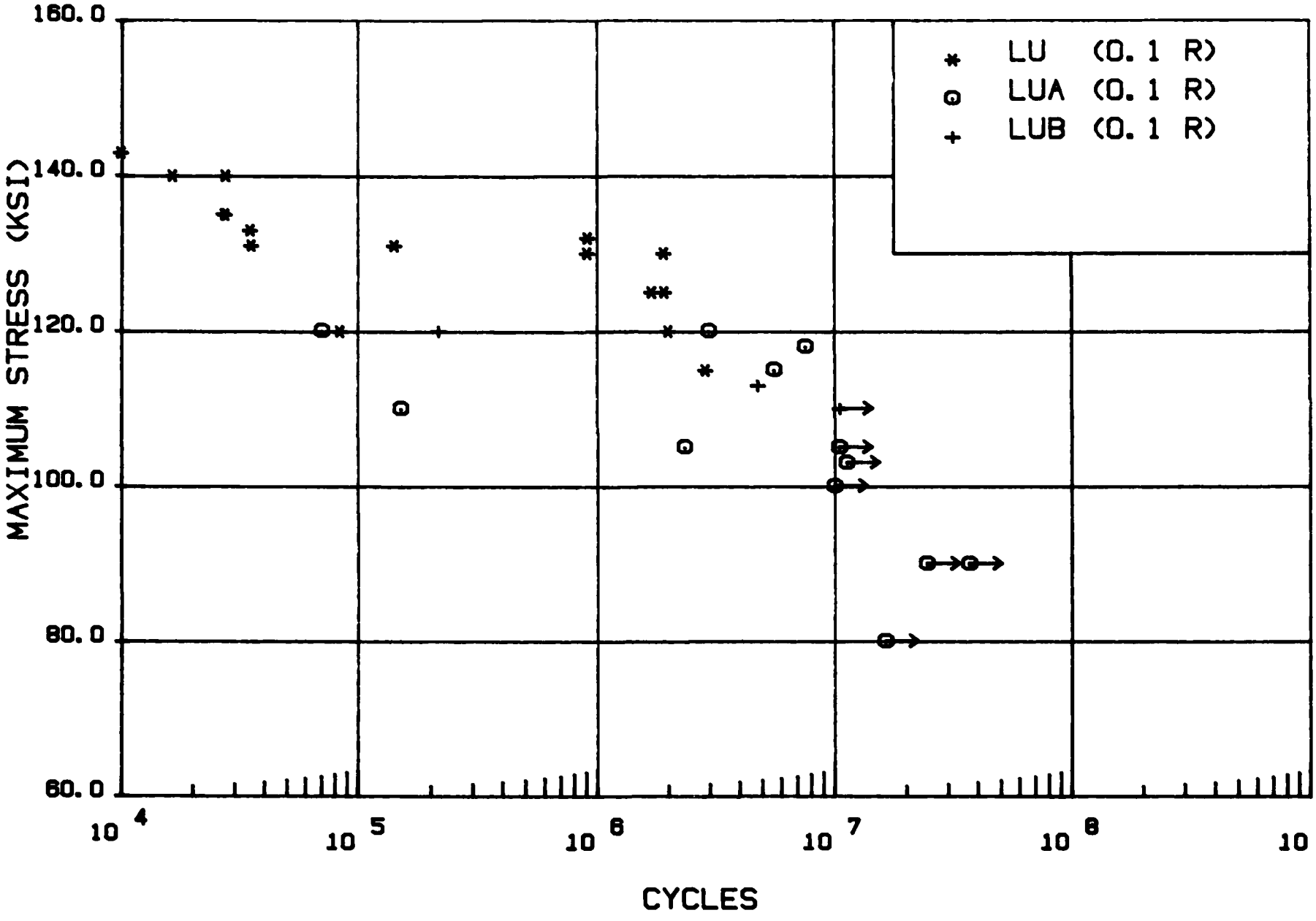

Figure 4. S-N Plot for Unnotched, Annealed Ti-6Al-4V Sheet at Room Temperature, Longitudinal Orientation, R-Ratio = +0.1.

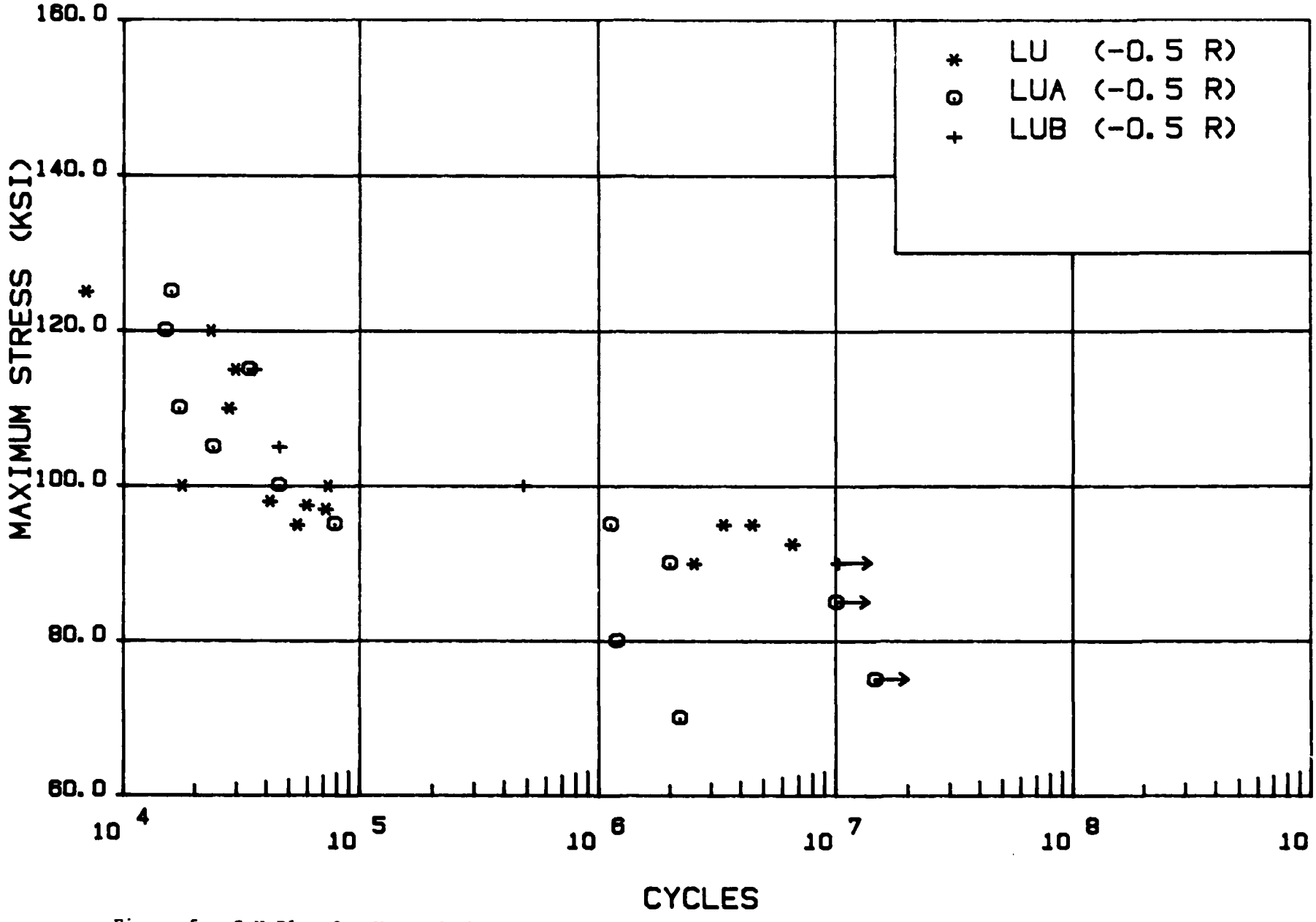

Figure 5. S-N Plot for Unnotched, Annealed Ti-6Al-4V Sheet at Room Temperature, Longitudinal Orientation, R-Ratio = -0.5.

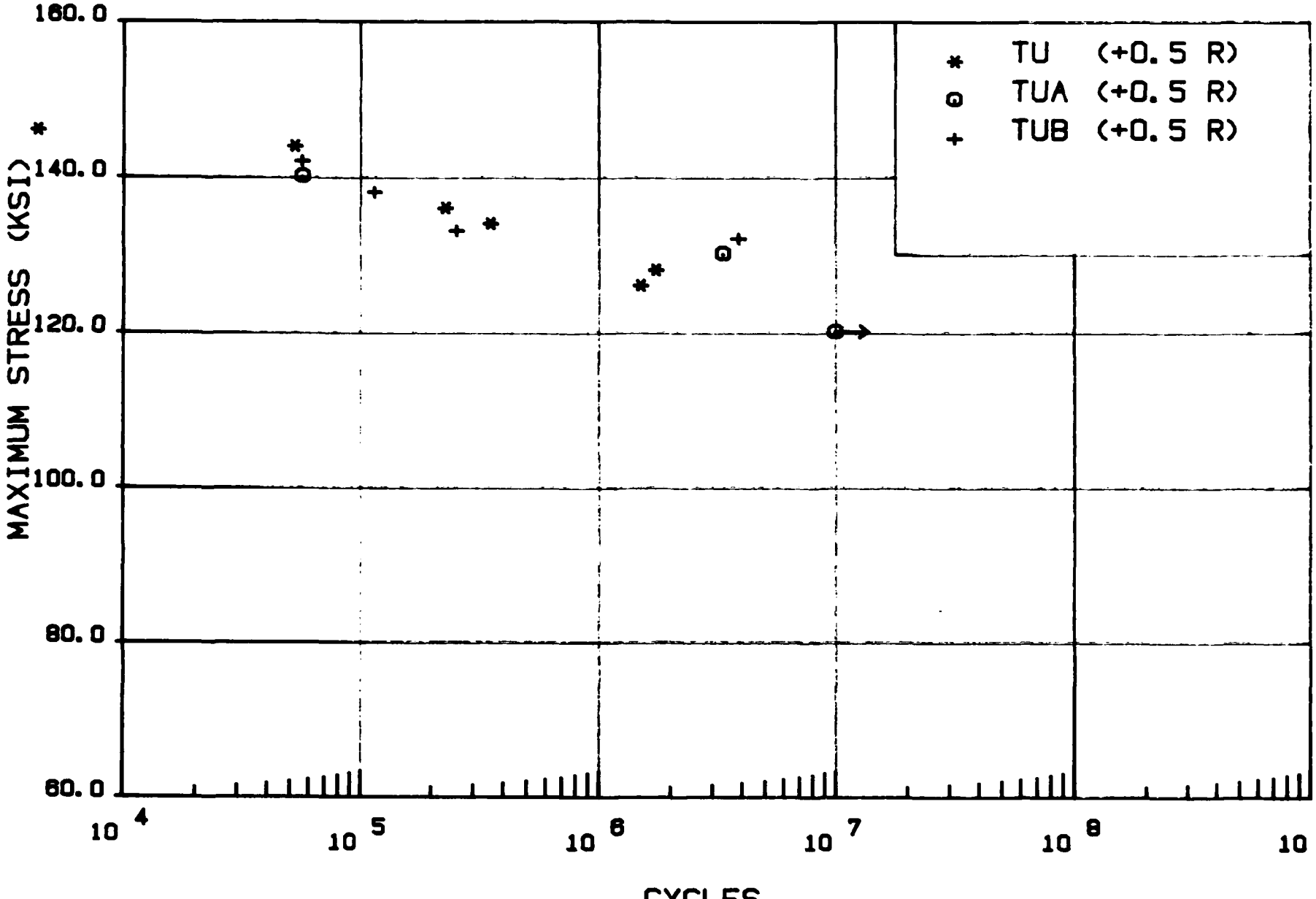

Figure 6. S-N Plot for Unnotched, Annealed Ti-6Al-4V Sheet at Room Temperature, Transverse Orientation, R-Ratio = +0.5.

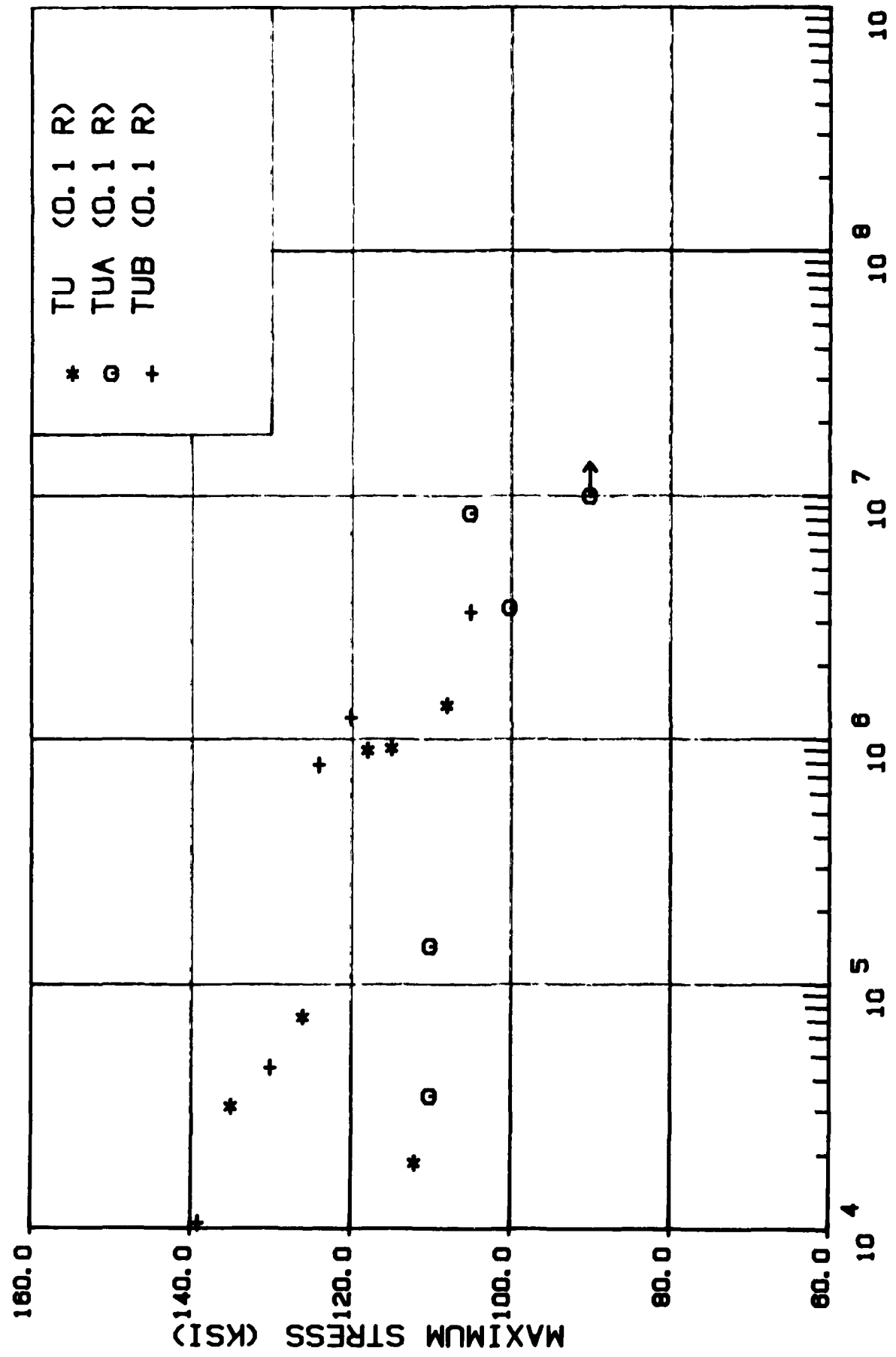

Figure 7. S-N Plot for Unnotched, Annealed Ti-6Al-4V Sheet at Room Temperature, Transverse Orientation, R-Ratio = +0.1.

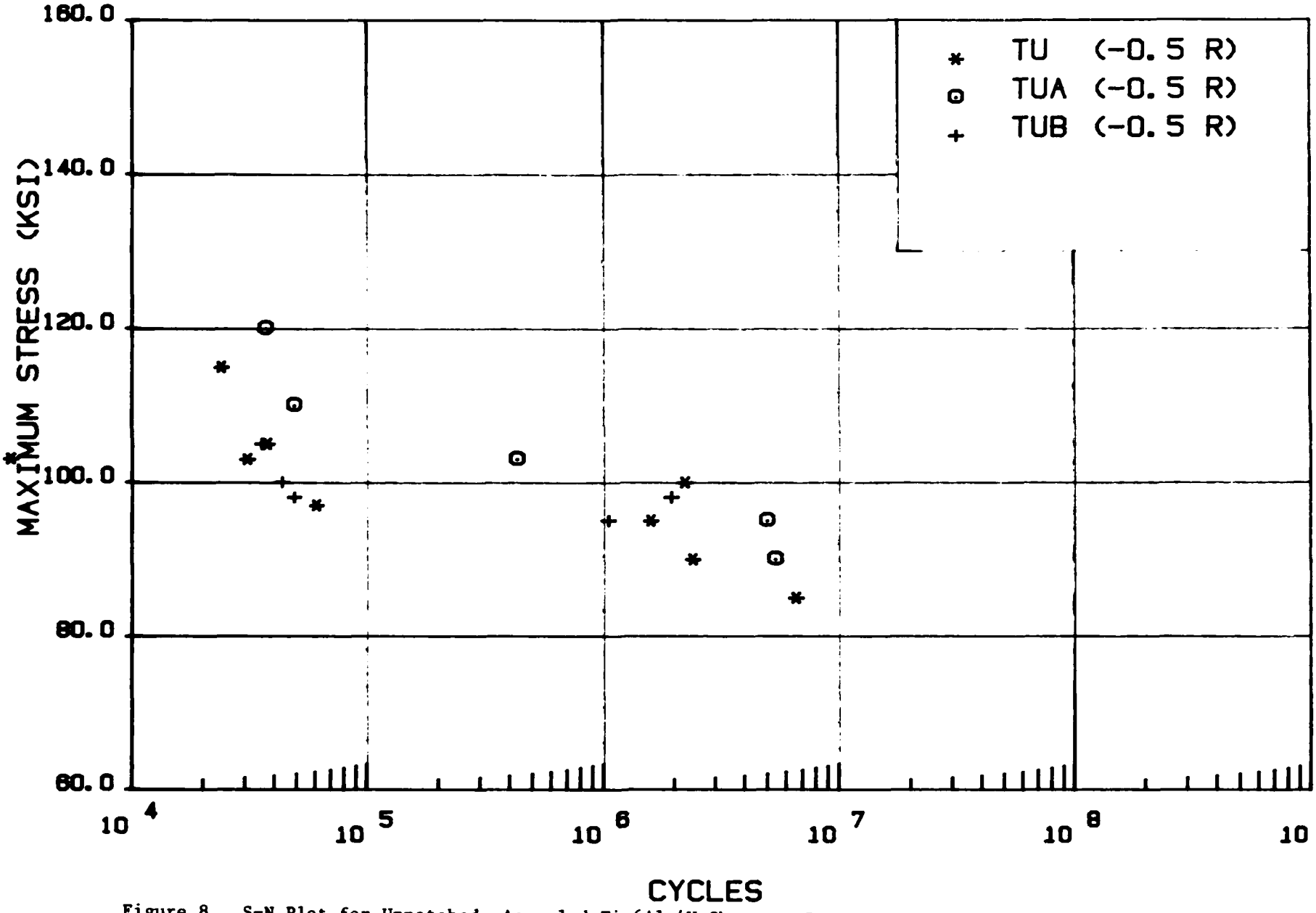

Figure 8. S-N Plot for Unnotched, Annealed Ti-6Al-4V Sheet at Room Temperature, Transverse Orientation, R-Ratio = -0.5.

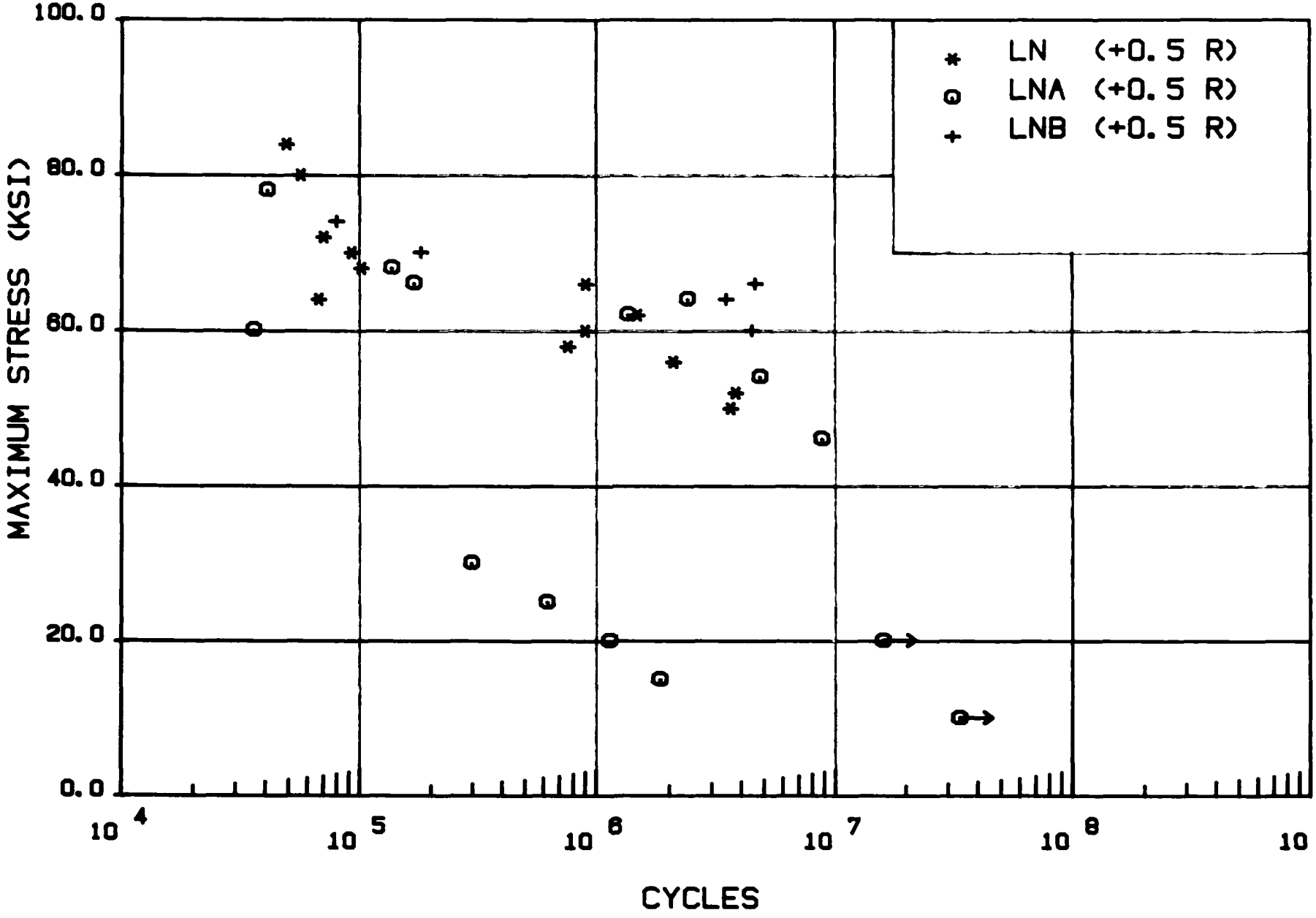

Figure 9. S-N Plot for Notched, Annealed Ti-6Al-4V Sheet at Room Temperature, Longitudinal Orientation, R-Ratio = +0.5.

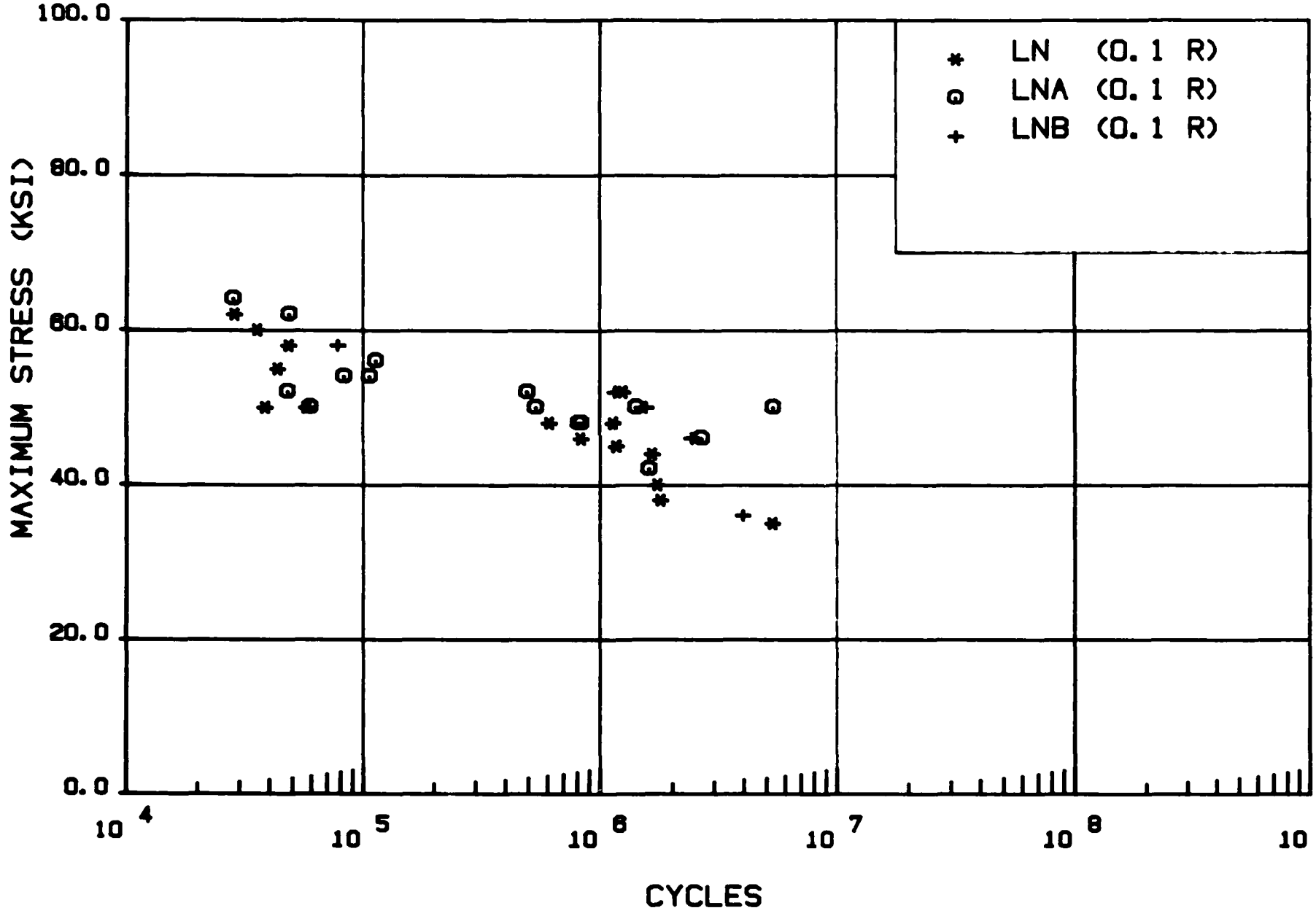

Figure 10. S-N Plot for Notched, Annealed Ti-6Al-4V Sheet at Room Temperature, Longitudinal Orientation, R-Ratio = +0.1.

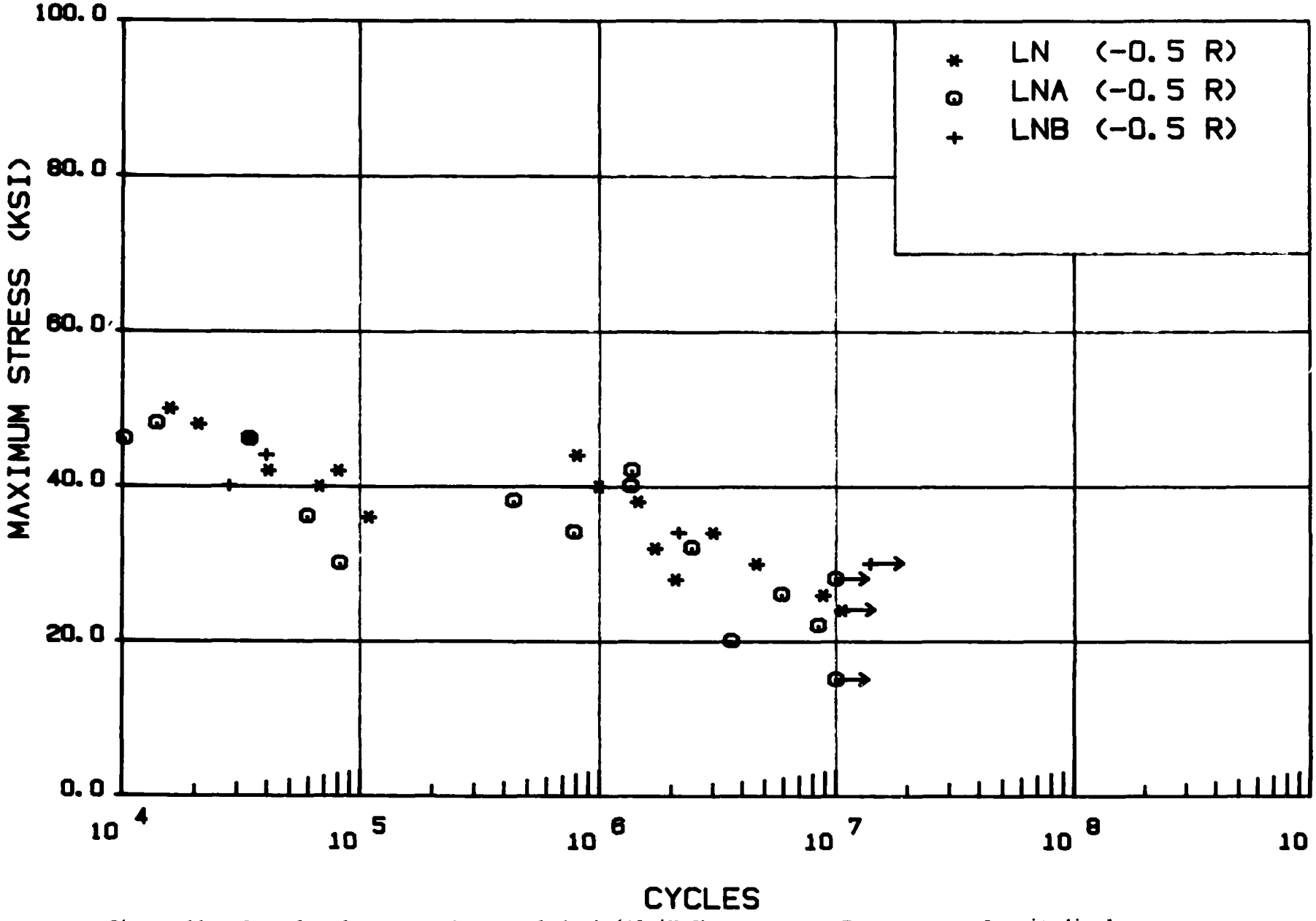

Figure 11. S-N Plot for Notched, Annealed Ti-6Al-4V Sheet at Room Temperature, Longitudinal Orientation, R-Ratio = -0.5.

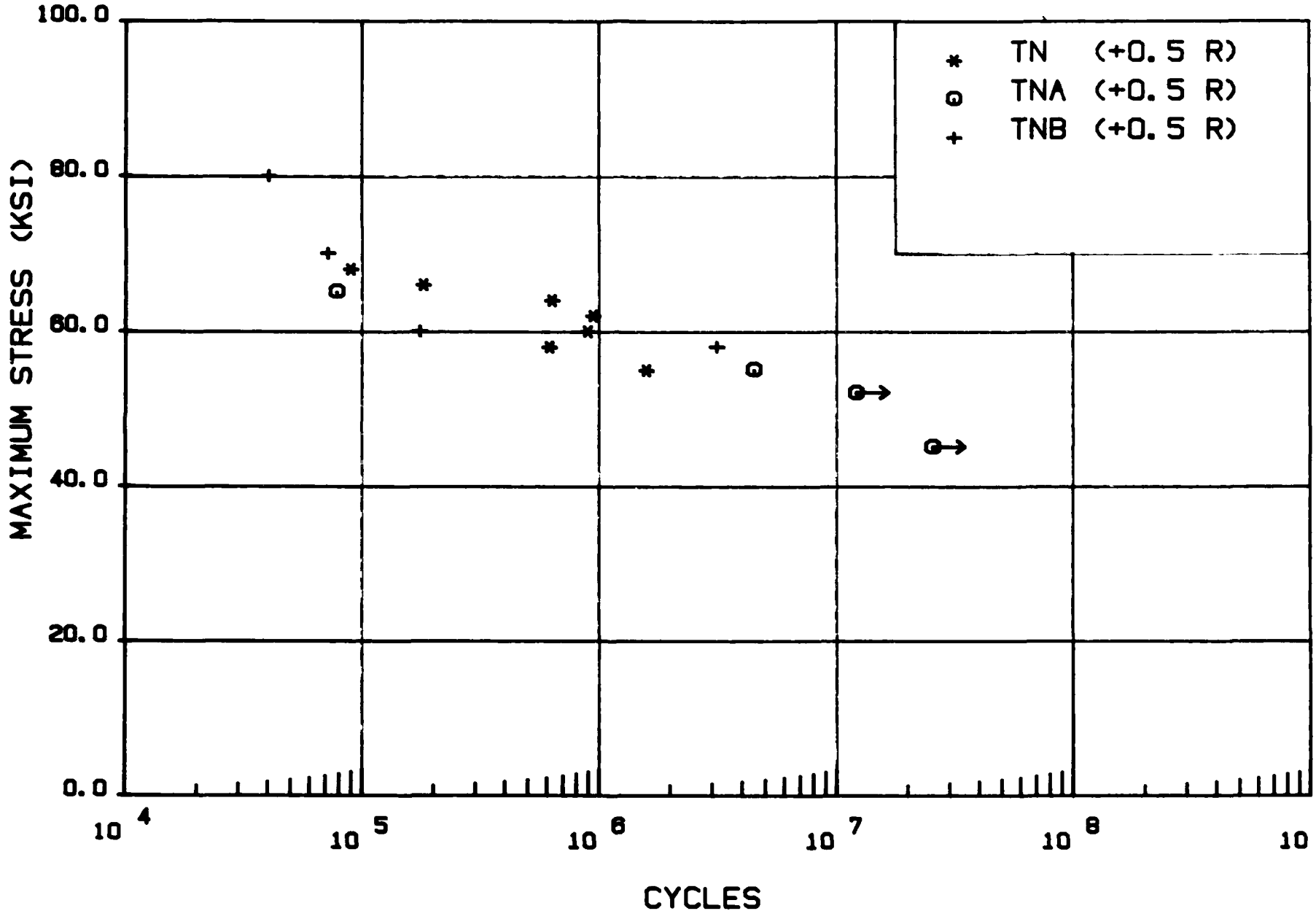

Figure 12. S-N Plot for Notched, Annealed Ti-6Al-4V Sheet at Room Temperature, Transverse Orientation, R-Ratio = +0.5.

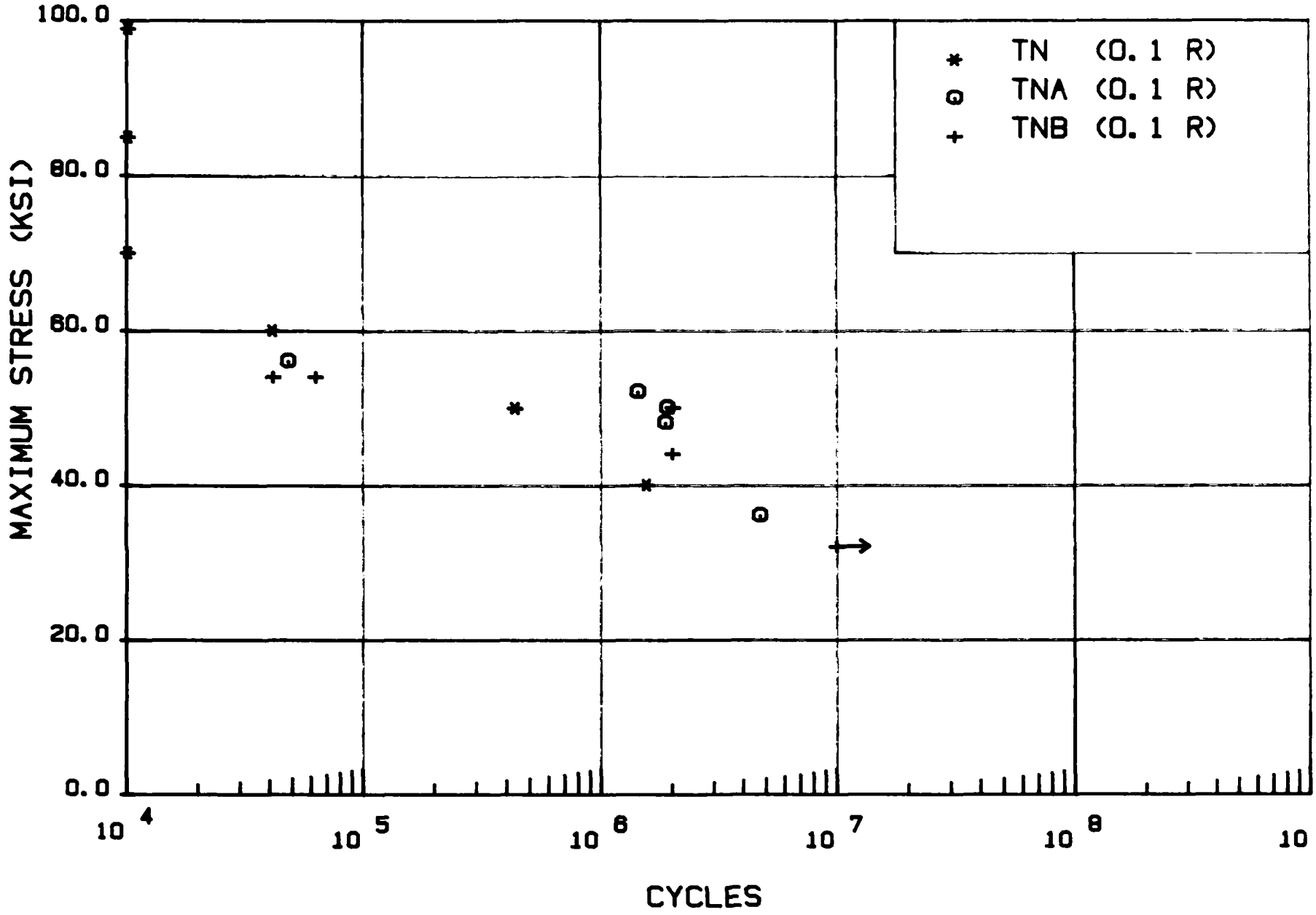

Figure 13. S-N Plot for Notched, Annealed Ti-6Al-4V Sheet at Room Temperature, Transverse Orientation, R-Ratio = +0.1.

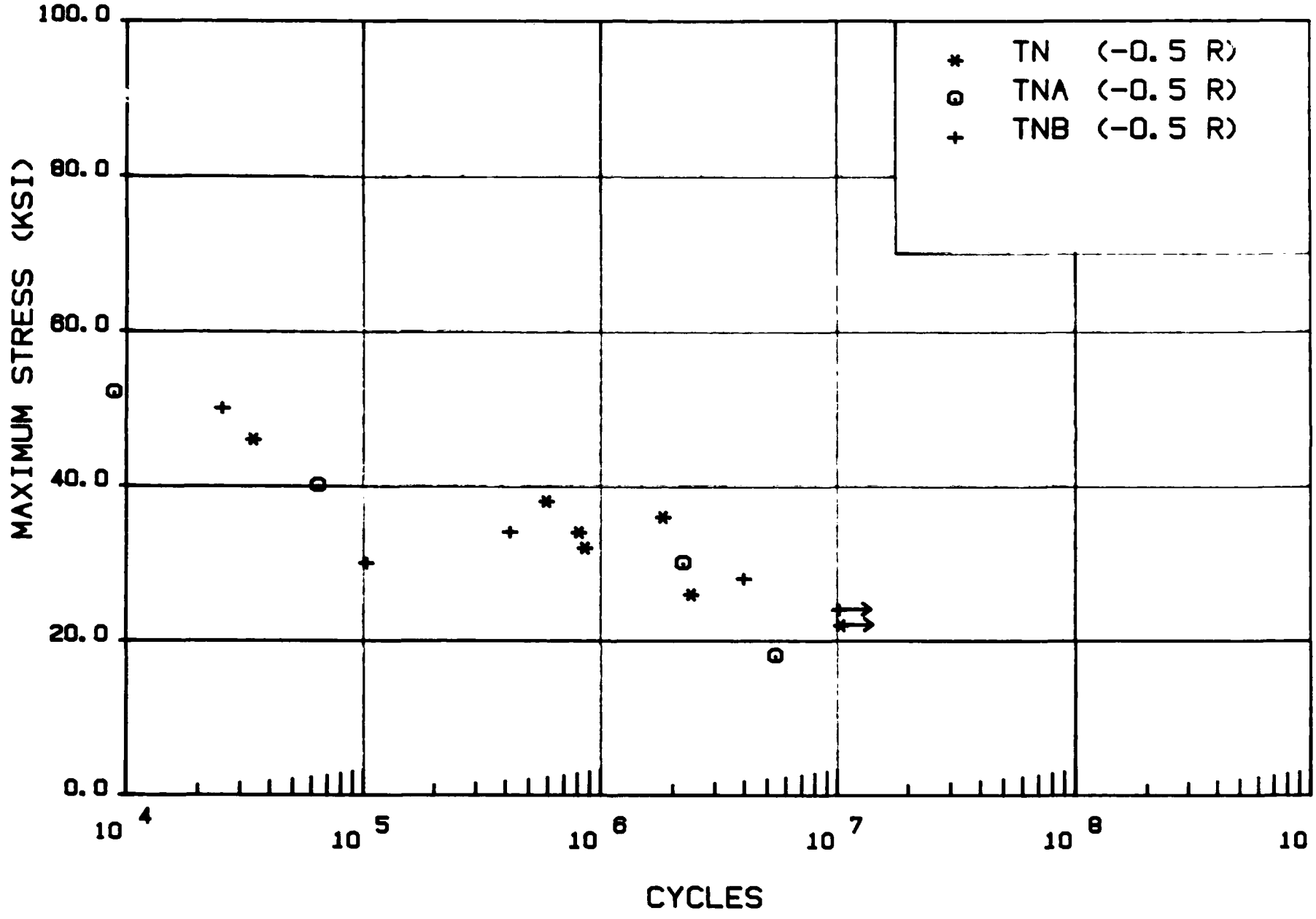

Figure 14. S-N Plot for Notched, Annealed Ti-6Al-4V Sheet at Room Temperature, Transverse Orientation, R-Ratio = -0.5.

TABLE 16 . RESIDUAL SURFACE STRESS IN ksi
vs. FATIGUE LIFE OF SELECTED SPECIMENS

SPEC. NO.	POS 1	POS 2	POS 3	GRIP A	GRIP B	R RATIO	MAX STRESS	CYCLES TO FAILURE
44LNA	-7	-35	-5	--	--	-0.5	32	2,452,100
45LNA	-1	-10	-7	--	--	-0.5	46	10,200
14TNA	-6	-51	-3	--	--	+0.5	55	4,492,300
15TNA	-6	-73*	-13	--	--	+0.5	45	25,583,400
14LNB	0	-5	-5	--	--	+0.5	60	4,452,200
15LNB	-7	-12	-12	--	--	+0.5	66	4,603,500
11TNB	-13	-8	-12	--	--	+0.5	52	12,123,400
12TNB	-6	-3	-7	--	--	+0.5	58	3,141,500
30LN	-5	-3	+1	+1	-12	-0.5	48	20,800
31LN	-6	-9	-7	+3	+2	-0.5	30	4,623,800
13TN	-20	-23*	-27*	+1	+1	+0.5	55	1,587,900
14TN	-7*	-22	-11	-1	+2	-0.5	46	34,100

*AVERAGE OF TWO MEASUREMENTS

*PSD SYSTEM, Cu RADIATION