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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

TECHNICAL NOTE 3866

FATIGUE TESTS ON NOTCHED AND UNNOTCHED SHEET SPECIMENS OF 2024-T3 AND 7075-T6 ALUMINUM ALLOYS AND OF SAE 4130 STEEL WITH SPECIAL CONSIDERATION OF THE LIFE RANGE FROM 2 TO 10,000 CYCLES

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SUMMARY

Fatigue tests were performed on notched and unnotched sheet specimens made of 2024-T3 and 7075-T6 aluminum alloys and of SAE 4130 steel. The steel was tested in two conditions: normalized and heat-treated to a tensile strength of 180 ksi. The notched specimens had theoretical stress-concentration factors of 2.0 and 4.0 and the mean loads were 0 and 20 or 50 ksi. Emphasis is placed on the life range from 2 to 10,000 cycles. Some previously published data are included to extend the data to lifetimes up to 10^8 cycles. It was found that repeated applications of stresses in the vicinity of the ultimate strength on notched and unnotched specimens produced failures in much smaller numbers of cycles than might be inferred from previously published data. Ratios of fatigue strengths of unnotched specimens to those of notched specimens are given.

INTRODUCTION

The main objectives of past fatigue investigations have been to establish the endurance limits and the fatigue lives at stresses which produced failures in much more than 10,000 cycles. A limited amount of data has been published for fatigue tests which produced failures in less than 10,000 cycles (refs. 1, 2, and 3). Reference 1 gives only a few data for short lives with load ratio equal to zero for steel. Data for repeated applications of a chosen natural strain that produces failures in 1 to 7 cycles on 2024-T3 aluminum-alloy bars are given in reference 2. The results of axial-load fatigue tests on notched and unnotched aluminum-alloy and steel specimens in which no failures occurred between 1 and 100, 1,000, or 10,000 cycles for stress-concentration factors of 1.0, 2.0, and 4.0, respectively, appear in reference 3.

The present investigation was undertaken to extend available fatigue data to include the range between 2 and 10,000 cycles for 2024-T3 and 7075-T6 aluminum alloys and for SAE 4130 steel. The steel was tested in two conditions: normalized and heat-treated to a tensile strength of 180 ksi. The results of fatigue tests of similar specimens made from the same lot of material and tested at Battelle Memorial Institute are included (refs. 4, 5, and 6). Also included are all data from reference 7.

SYMBOLS

K_F ratio of maximum nominal stress in unnotched specimen at given lifetime to that in notched specimen at same lifetime (stress-concentration factor effective in fatigue)

K_T theoretical stress-concentration factor

N number of cycles to failure

R ratio of minimum nominal stress to maximum nominal stress, load ratio

S_m mean nominal stress

S_{max} maximum nominal stress

S_{ult} ultimate tensile strength

SPECIMENS

Details of specimen configurations are given in figure 1. The average tensile properties of the four materials appear in table I. The materials were obtained from special stocks of commercial 0.090-inch-thick 2024-T3 and 7075-T6 aluminum-alloy sheets and 0.075-inch-thick SAE 4130 steel sheets retained at the Langley Aeronautical Laboratory for fatigue-test purposes. The sheet layouts are shown in figures 1 and 2 of reference 4. One-half of the SAE 4130 specimen blanks were hardened by being heated to 1,575° F and quenched in warm oil. They were then clamped, six at a time, to a heavy flat bar and drawn at 850° F to a hardness of Rockwell C 40. This heat-treated material will be referred to as "hardened steel" in the rest of this paper.

In fabricating the notched specimens, the blanks were first clamped in stacks and machined along their longitudinal edges. Then they were individually mounted in a milling machine on a combination turntable and cross-slide support and the notches were cut with a milling tool rotated about an axis normal to the plane of the specimen. Notches with theoretical stress-concentration factors K_T of 2.0 and 4.0 were made with helical-edged milling tools having 0.188-inch and 0.100-inch diameters, respectively. The cutter speeds used for both notch configurations were 1,500 rpm for the 2024-T3 aluminum alloy, 1,000 rpm for the 7075-T6 aluminum alloy, 1,000 rpm for the SAE 4130 normalized steel, and 675 rpm for the SAE 4130 hardened steel. Machining cuts were made successively lighter, and the last few cuts were about 0.0005 inch deep. The burrs at the notches were removed with fine crocus cloth. The cloth was moved with light finger pressure in a longitudinal direction along the specimen face at the base of the notch. The unnotched specimens were mounted on the headstock of a lathe to cut the 12-inch-radius curve.

All the notched hardened-steel specimens were practically undistorted by heat treatment and machining; but, despite precautions taken to maintain flatness, the unnotched hardened-steel specimens were warped to a degree varying between virtual flatness and 0.25 inch out of a plane. The bending stress introduced by straightening a specimen assumed to have a circular curvature of the specimen face with 0.25 inch as the rise of the arc is 7.5 ksi.

All the notched specimens tested at the Langley Laboratory were unpolished. Most of the unnotched specimens were electropolished as were all the notched and unnotched specimens tested at Battelle Memorial Institute. (See refs. 4, 5, and 6.)

EQUIPMENT

Two types of fatigue testing machines were used in this series of tests. One was a subresonant machine which operates at 1,800 cpm. (See ref. 5.) The natural frequency of the system was adjusted to about 1,900 cpm by varying the mass of the loading unit which was excited by a rotating eccentric.

A photograph of the second type of testing machine, a double-acting hydraulic jack, is presented as figure 2. The principal parts of this machine are: a constant-discharge pump, a rate-control valve, a four-way valve to direct the hydraulic pressure, a double-acting hydraulic ram, and a null-method air-operated weighing system. The machine operates in a manner similar to that of other hydraulic testing machines. This machine was modified by the addition of an electric weighing system and an air servo for operating the four-way valve. Contacts on the electric load indicator were adjusted to actuate the air servo whenever the load on the specimen reached the desired value. The hydraulic pressure was thus directed to the opposite side of the load piston to reverse the direction of load application. Special grips similar to those used in the subresonant machines were used to permit testing of sheet specimens. (See ref. 5.)

Guide plates similar to those described in reference 5 were used to prevent buckling of the specimens. A low-voltage current was passed continuously through the specimens to operate a relay which stopped the hydraulic pump when the specimen failed.

An electronic load-measuring device was used to monitor the applied loads in the automatically controlled tests. Monitoring was necessary because time delays in the automatic-control mechanism made it difficult to preset the limiting contacts on the electric weighing system with sufficient precision. The loads were measured with the electronic monitoring equipment with a maximum error of approximately ±1 percent.

TESTS AND TESTING PROCEDURE

Final load adjustments were necessary during the initial stages of each fatigue test. Since the high-stress tests terminated after a small number of cycles, a relatively slow acting machine (the hydraulic jack) was required in order to allow the adjustments to be made before a large percentage of the total life had elapsed. A faster machine (the subresonant type) was required to perform the low-stress tests within a reasonable length of time.

During those tests in the jack in which failure was expected to occur after 30 cycles, the rate-control valve was fully opened to allow maximum testing speed. Loads were controlled automatically by the electric controlling device described in the section entitled "Equipment". Cycling speed was dependent on the load range and varied from about 14 to 50 cpm; the higher load ranges corresponded to the lower frequencies.

Tests in which failure was expected to occur in less than about 30 cycles were manually controlled in the double-acting hydraulic jack. In these tests, the rate-control valve was used to decrease the loading rate when approaching the maximum and minimum loads for more precise load control. The frequency of manual cycling varied from 0.4 to 1.0 cpm. Load-time curves for the jack are illustrated in figure 3. The precipitous unloading was due to the sudden release of oil pressure which occurred while shifting between tension and compression. The curved portions resulted from manipulation of the rate-control valve.

The fatigue behaviors of four materials with various combinations of K_T and S_m were investigated by covering the life range from 1 to approximately 10^8 cycles for each combination shown in the following table:

Material	Mean stress, S_m, ksi, for -		
	$K_T = 1.0$	$K_T = 2.0$	$K_T = 4.0$
2024-T3 aluminum alloy	0	0 and 20	0 and 20
7075-T6 aluminum alloy	0	0 and 20	0 and 20
Normalized SAE 4130 steel	0	0 and 20	0 and 20
Hardened SAE 4130 steel	0 and 50	0 and 50	0 and 50

Most tests were run at stresses which caused failure in less than 10,000 cycles. A few tests in each group were run at lower stresses to afford comparison of the results with data obtained at Battelle Memorial Institute on similar specimens. (See refs. 4, 5, and 6.)

The effect of cycling speed on the fatigue strength was investigated in a limited way by testing identical specimens at the same stress conditions but at different cycling rates. For practical reasons these tests were limited to stress levels which were expected to cause failure in the neighborhood of 10,000 cycles. High-speed tests at shorter lives were almost impossible to perform and low-speed tests at longer lives would have been extremely time consuming.

The greatest errors in load application were less than 5 percent and occurred during the first few cycles of the automatically controlled tests while final adjustments were being made.

RESULTS AND DISCUSSION

The results of the fatigue tests are given in tables II to V and are presented in figures 4 to 15 as maximum nominal stress plotted against the number of cycles to failure (designated herein as S-N curves). The scatter in the results of the tests in the short-life range was remarkably small, whereas the tests at long lifetimes indicated considerably more scatter in the results.

Of the unnotched hardened-steel specimens, 19 were appreciably warped after heat treatment. During these tests the guide plates, which were employed to prevent buckling, straightened the specimens and necessarily introduced bending stresses, with the maximum stresses probably occurring at the minimum cross section. The fatigue cracks in 13 of the 19 warped specimens were initiated on the concave face (the face that probably contained tensile bending stresses due to straightening). However, the scatter in the S-N curves for the unnotched hardened-steel specimens (fig. 13) was not extreme and indicated that these bending stresses played a minor role in determining the fatigue life.

The minimum number of cycles to failure, greater than 1, for all the S-N curves regardless of the value of mean stress fell between 2 and 58. Minimum lives for those groups subjected to completely reversed loading only (R = -1) were less than 16 cycles. These minimum lives differed from those published in reference 3 which showed that, for $R = 0$, fatigue failures at stresses near the ultimate tensile strength did not occur in less than roughly 10^4, 10^3, and 10^2 cycles for specimens having values of K_T equal to 1.0, 2.0, and 4.0, respectively. The materials used in that investigation were 6061-T6 aluminum alloy and 347 and 403 stainless steels.

The present investigation resulted in S-N curves that are concave upward at the long-life end and have a reversal of curvature at a lifetime dependent on the stress-concentration factor and, to a lesser extent, on the mean stress. These inflection points occur at roughly 10^5, 10^3, and 10^2 cycles for stress-concentration factors of 1.0, 2.0, and 4.0, respectively, for all four materials. The S-N curves for mean stresses greater than 0 generally have the reversal at a somewhat greater number of cycles than the curves for mean stresses of 0.

Of practical interest to the aircraft designer is the fatigue behavior of specimens subjected to repeated stresses in the vicinity of two-thirds of the ultimate tensile strength. This stress corresponds to the limit design stress of a given aircraft part. Table VI gives the number of cycles to failure at this stress level for each material and type of specimen. The specimens with the highest stress-concentration factor K_T had the shortest lives at this loading with the aluminum alloys having the lowest values. The results of the tests on steels at $R = -1$ compared on this basis show that the hardened steel has a longer fatigue life than the normalized steel for unnotched specimens, whereas the reverse is true for the notched specimens with $K_T = 2.0$ and 4.0.

If it is assumed that for $R = -1$ an unnotched specimen would fail in the same number of cycles as a notched specimen, provided the maximum local stresses are equal in both specimens, it follows that the effective stress-concentration factor of the notch would be equal to the ratio of the maximum nominal stresses in the two specimens. This ratio K_F of the nominal stresses at the same number of cycles is plotted against the maximum nominal stress of the notched specimens in figure 16.

In figure 16, the limits of the scatter bands are the ratios of the corresponding limits of the scatter of the S-N curves. The K_F curves extend to the ultimate tensile strengths of the notched specimens. The maximum values of K_F were generally smaller than K_T because size effect reduced the severity of the notch. (See ref. 8.) In general, K_F decreased with increased nominal stress because the maximum local stress entered the plastic range. The width of the scatter band for K_F also decreased with increased nominal stress.

It was found in previous investigations, such as those reported in references 3 and 9, that the tensile strength of notched specimens sometimes exceeded that of unnotched specimens made of the same material. In the present investigation, the notched 7075-T6 specimens had somewhat higher tensile strengths than the unnotched specimens; for $K_T = 2.0$ the increase was 9 percent and for $K_T = 4.0$ the increase was 4 percent. For notched 2024-T3 specimens, however, the reverse was true; that is, for $K_T = 2.0$ there was no static-strength change and for $K_T = 4.0$ a reduction of 8 percent was produced. The tensile strengths of the notched steel specimens, both normalized and hardened, were about 8 percent higher than those of the unnotched steel specimens.

No effect of polishing was found. Also, no definite difference in test results was found between specimens tested at 50 and 1,800 cpm; however, it should be noted that only a very small number of tests entered into this comparison.

CONCLUSIONS

Fatigue tests were performed in the life range from 2 to 10,000 cycles, and previously published data have been included to extend the data to lifetimes up to 10^8 cycles. Notched and unnotched sheet specimens made of 2024-T3 and 7075-T6 aluminum alloys and of SAE 4130 steel with theoretical stress-concentration factors of 1.0, 2.0, and 4.0 were used. The steel was tested in normalized and hardened conditions. The following conclusions can be drawn:

1. Repeated application of stresses in the vicinity of the ultimate strength on notched and unnotched specimens produced failures in much smaller numbers of cycles than might be inferred from previously published data.

2. The ratio K_F of the fatigue strength of unnotched specimens to that of notched specimens at the same lifetime decreased with increased

nominal stress. The scatter in these ratios also decreased with increased nominal stress.

3. The tensile strengths of notched specimens made of 7075-T6 aluminum alloy and SAE 4130 normalized and hardened steels were higher than those of unnotched specimens in the same materials. The reverse was true for 2024-T3 aluminum alloy.

4. There appeared to be no significant difference between the test results of polished and unpolished specimens or between the test results of specimens cycled at 50 and 1,800 cpm.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., September 5, 1956.

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TABLE I.- TENSILE PROPERTIES OF MATERIALS TESTED

Material	Number of tests	Yield stress, (0.2 percent offset), ksi				Ultimate tensile strength, ksi				Total elongation, 2-inch gage length, percent				Young's modulus, ksi			
		Av.	Min.	Max.	σ (*)	Av.	Min.	Max.	σ (*)	Av.	Min.	Max.	σ (*)	Av.	Min.	Max.	σ (*)
2024-T3 aluminum alloy	148	52.1	46.9	59.3	1.7	72.1	70.3	73.4	0.9	20.3	15.0	25.0	1.89	10,500	10,150	10,750	134
7075-T6 aluminum alloy	152	75.5	70.7	79.8	1.4	83.0	79.8	84.5	1.1	12.3	7.0	15.0	1.27	10,200	10,000	10,550	104
Normalized SAE 4130 steel	149	93.9	87.4	102.2	2.1	115.9	111.4	124.6	1.8	15.2	12.0	18.0	1.06	29,400	28,200	31,500	660
Hardened SAE 4130 steel	9	174.0	168.0	178.0	---	180.0	178.0	183.0	---	8.3	8.0	9.0	----	29,900	29,200	30,800	---

*Standard deviation, $\sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{h}\left(x_i - \bar{x}\right)^2 f_i}$

where

n number of tests
h number of class intervals
x_i average value of ith class
$\bar{x}$ average value
f_i number of tests in ith class

TABLE II.- AXIAL-LOAD FATIGUE TEST RESULTS FOR 2024-T3 ALUMINUM-ALLOY SHEET SPECIMENS

(a) $K_T = 1.0$; $S_m = 0$

Specimen	Maximum stress, S_{max}, ksi	Fatigue life, N, cycles	Frequency, cpm	Remarks
A77 S1 2	75.7	-----------	-----	Static tensile test
A79 S1 6	73.6	-----------	-----	
A75 S1 5	73.1	-----------	-----	
--------	73.0	-----------	-----	Static tensile test and Battelle (ref. 4)
A79 S1 7	72.0	7	-----	Manually controlled
A78 S1 5	72.0	7	-----	
A76 S1 6	70.0	102	12	Automatically controlled
A76 S1 7	70.0	104	12	
A73 S1 5	70.0	131	12	
A115 M 2	65.0	342	30	Manually controlled and automatically controlled
A74 S1 6	65.0	663	15	Automatically controlled
A74 S1 8	65.0	967	15	
A103 M 2	55.0	3,000	1,800	Subresonant machines (ref. 5)
A105 M 2	55.0	6,000	1,800	
A104 M 2	55.0	8,000	1,800	
A77 S1 1	55.0	8,948	17	Automatically controlled
A68 S1 8	55.0	8,998	17	
A108 M 2	50.0	10,008	22	
A117 M 1	50.0	11,000	1,800	Subresonant machines (ref. 5)
A116 M 1	50.0	16,000	1,800	
A109 M 2	45.0	11,662	24	Automatically controlled
A77 S1 8	45.0	16,000	1,800	Subresonant machines (ref. 5)
A114 M 1	45.0	31,000	1,800	
A76 S1 8	45.0	36,000	1,800	
A102 M 1	45.0	51,000	1,800	
A114 M 2	40.0	37,000	1,800	
A119 M 2	40.0	39,000	1,800	
A121 M 1	40.0	60,000	1,800	
A111 M 1	40.0	68,000	1,800	
A108 M 3	40.0	70,000	1,800	
A100 M 1	40.0	87,000	1,800	
A111 M 2	35.0	40,000	1,800	
A107 M 3	35.0	66,000	1,800	
A109 M 1	35.0	109,000	1,800	
A99 M 1	35.0	161,000	1,800	
A113 M 2	30.0	119,000	1,800	
A105 M 3	30.0	185,000	1,800	
A118 M 2	30.0	241,000	1,800	
A98 M 1	30.0	277,000	1,800	
A107 M 1	30.0	283,000	1,800	
A119 M 1	30.0	339,000	1,800	
A107 M 2	25.0	205,000	1,800	
A112 M 2	25.0	349,000	1,800	
A134 M 2	25.0	1,197,000	1,800	
A108 M 1	25.0	1,483,000	1,800	
A103 M 3	23.0	645,000	1,800	
A111 M 1	23.0	1,404,000	1,800	
A103 M 1	23.0	2,070,000	1,800	
A112 M 1	23.0	3,330,000	1,800	
A133 M 2	20.0	305,000	1,800	
A126 M 2	20.0	555,000	1,800	
A124 M 2	20.0	880,000	1,800	
A127 M 2	20.0	3,504,000	1,800	
A78 S1 2	20.0	4,515,000	1,800	
A117 M 2	20.0	6,441,000	1,800	
A123 M 2	20.0	11,831,000	1,800	
A113 M 1	20.0	13,196,000	1,800	
A116 M 2	20.0	23,001,000	1,800	
A106 M 1	20.0	84,875,000	1,800	
A129 M 2	18.0	868,000	1,800	
A79 S1 3	18.0	>25,863,000	1,800	
A105 M 1	18.0	101,109,000	1,800	

TABLE II.- AXIAL-LOAD FATIGUE TEST RESULTS FOR 2024-T3 ALUMINUM ALLOY SHEET SPECIMENS - Continued

(b) $K_T = 2.0$

Specimen	Maximum stress, S_{max}, ksi	Fatigue life, N, cycles	Frequency, cpm	Remarks
		$S_m = 0$		
---------	74.5	-----------	-----	Static tensile test and Battelle (ref. 6)
A55 S1 1	73.0	-----------	-----	Static tensile test
A55 S1 7	72.8	-----------	-----	
A54 S1 1	71.5	4	-----	Manually controlled
A53 S1 8	71.5	6	-----	
A55 S1 9	70.0	6	-----	
A55 S1 3	70.0	7	-----	
A55 S1 6	70.0	7	-----	
A53 S1 5	62.5	21	12	Automatically controlled
A53 S1 3	62.5	39	14	
A53 S1 9	62.5	41	-----	Manually controlled
A54 S1 5	55.0	122	15	Automatically controlled
A54 S1 2	55.0	138	15	
A54 S1 10	55.0	139	15	
A55 S1 2	40.0	936	20	
A54 S1 7	40.0	1,027	21	
A54 S1 6	40.0	1,049	21	
A79 S2 B	35.0	3,400	1,100	Battelle (ref. 6)
A84 S2 B	35.0	3,500	1,100	
A58 S1 3	34.0	2,960	28	Automatically controlled
A73 S3 B	30.0	6,500	1,100	Battelle (ref. 6)
A80 S3 B	30.0	7,700	1,100	
A57 S1 6	28.0	10,000	1,800	Subresonant machines
A58 S1 6	28.0	11,643	30	Automatically controlled
---------	25.0	2,108	-----	
A88 S2 B	25.0	17,400	1,100	Battelle (ref. 6)
A29 S2 B	20.0	70,000	1,100	
A35 S2 B	15.0	160,000	1,100	
A57 S1 8	15.0	207,000	1,800	Subresonant machines
A40 S2 B	15.0	210,000	1,100	Battelle (ref. 6)
A73 S2 B	15.0	754,000	1,100	
A1 S2 B	13.5	287,000	1,100	
A57 S1 9	13.0	3,239,000	1,800	Subresonant machines
A74 S3 B	11.0	>10,586,000	1,100	Battelle (ref. 6)
		$S_m = 20$		
A58 S1 8	76.5	-----------	-----	Static tensile test
A58 S1 5	73.5	131	-----	Manually controlled
A58 S1 1	73.0	76	-----	
A58 S1 9	72.0	109	-----	
A56 S1 1	71.5	103	-----	
A56 S1 3	70.0	58	16	Automatically controlled
A56 S1 4	70.0	59	16	
A56 S1 5	70.0	86	16	
A53 S1 4	70.0	106	-----	Manually controlled
A56 S1 6	65.0	249	19	Automatically controlled
A57 S1 1	65.0	283	19	
A53 S1 6	60.0	606	21	
A53 S1 2	60.0	740	21	
A53 S1 10	60.0	814	21	
A84 S2 B	52.5	3,100	1,100	Battelle (ref. 6)
A57 S1 7	49.0	3,641	29	Automatically controlled
A57 S1 4	49.0	5,430	29	
A70 S2 B	49.0	6,000	1,100	Battelle (ref. 6)
A85 S3 B	49.0	9,300	1,100	
A42 S2 B	45.0	21,800	1,100	
A91 S2 B	45.0	25,300	1,100	
A58 S1 10	40.0	5,723	20	Automatically controlled
A57 S1 5	40.0	20,000	1,800	Subresonant machines
A58 S1 2	40.0	33,853	42	Automatically controlled
A80 S2 B	35.0	66,500	1,100	Battelle (ref. 6)
A93 S2 B	35.0	82,200	1,100	
A90 S2 B	31.0	28,200	1,100	
A82 S2 B	31.0	128,500	1,100	
A85 S2 B	31.0	218,700	1,100	
A78 S2 B	30.0	48,300	1,100	
A57 S1 10	29.5	132,000	1,800	Subresonant machines
A58 S1 4	29.5	191,000	1,800	
A71 S2 B	29.5	>13,114,700	1,100	Battelle (ref. 6)
A89 S2 B	27.5	>15,671,300	1,100	
A58 S1 7	25.0	>57,058,000	1,800	Subresonant machines

TABLE II.- AXIAL-LOAD FATIGUE TEST RESULTS FOR 2024-T3 ALUMINUM ALLOY SHEET SPECIMENS - Concluded

(c) $K_T = 4.0$

Specimen	Maximum stress, S_{max}, ksi	Fatigue life, N, cycles	Frequency, cpm	Remarks
		$S_m = 0$		
A34 S1 2	68.6	-----------	-------	Static tensile test
A30 S1 4	67.8	-----------	-------	
A33 S1 8	66.0	2	0.5	Manually controlled
A33 S1 6	66.0	3	.4	
--------	65.4	-----------	-------	Static tensile test and Battelle (ref. 6)
A30 S1 3	63.0	4	.7	Manually controlled
A33 S1 1	63.0	5	.6	
A30 S1 5	62.0	5	.5	
A30 S1 2	62.0	5	1	
A32 S1 9	60.0	9	.6	
A32 S1 8	60.0	9	.8	
A32 S1 6	60.0	12	1	
A32 S1 2	55.0	12	1	
A35 S1 8	55.0	13	1	
A33 S1 5	46.2	34	24	Automatically controlled
A35 S1 7	44.0	37	19	
A35 S1 5	39.4	70	19	
A35 S1 3	39.4	77	19	
A35 S1 9	34.5	131	24	
A35 S1 10	34.5	174	25	
A32 S1 5	34.5	176	14	
A34 S1 7	34.5	181	20	
A35 S1 4	29.6	422	26	
A32 S1 10	29.6	432	25	
A35 S1 2	27.6	711	30	
A31 S1 10	24.5	1,390	40	
A32 S1 1	24.5	1,580	35	
A34 S1 1	22.5	2,586	39	
A10 S3 B	22.5	3,200	1,100	Battelle (ref. 6)
A30 S1 1	17.5	9,514	48	Automatically controlled
A34 S1 3	17.5	10,000	1,800	Subresonant machines
A47 S3 B	17.5	10,000	1,100	Battelle (ref. 6)
A9 S3 B	12.5	53,400	1,100	
A5 S3 B	10.0	121,500	1,100	
A34 S1 4	10.0	498,000	1,800	Subresonant machines
A33 S1 3	8.0	354,000	1,800	
A43 S3 B	8.0	944,400	1,100	Battelle (ref. 6)
A34 S3 B	7.5	1,256,700	1,100	
A44 S3 B	7.0	6,309,100	1,100	
A30 S1 7	7.0	7,725,000	1,800	Subresonant machines
A50 S3 B	5.0	>10,969,000	1,100	Battelle (ref. 6)
		$S_m = 20$		
A32 S1 4	67.5	5	0.8	Manually controlled
A31 S1 1	67.0	5	1.2	
A33 S1 7	67.0	6	1.3	
A31 S1 3	66.0	15	1.1	
A34 S1 10	64.0	17	-------	
A31 S1 4	64.0	22	-------	
A33 S1 4	63.0	23	-------	
A34 S1 6	63.0	26	-------	
A31 S1 8	57.5	62	22	Automatically controlled
A35 S1 1	57.5	65	22	
A35 S1 6	47.5	316	29	
A31 S1 5	47.5	377	29	
A34 S1 5	40.0	1,587	37	
A30 S1 10	37.4	1,643	37	
A12 S3 B	35.0	3,700	1,100	Battelle (ref. 6)
A31 S1 7	35.0	6,313	51	Automatically controlled
A29 S3 B	32.5	9,000	1,100	Battelle (ref. 6)
A44 S1 4	30.0	22,000	1,800	Subresonant machines
A49 S3 B	30.0	26,600	1,100	Battelle (ref. 6)
A16 S3 B	27.5	39,400	1,100	
A38 S1 3	27.5	49,000	1,800	Subresonant machines
A37 S3 B	25.0	1,343,000	1,100	Battelle (ref. 6)
A13 S3 B	22.5	>10,321,500	1,100	

TABLE III.- AXIAL-LOAD FATIGUE TEST RESULTS FOR 7075-T6 ALUMINUM-ALLOY SHEET SPECIMENS

(a) $K_T = 1.0$; $S_m = 0$

Specimen	Maximum stress, S_{max}, ksi	Fatigue life, N, cycles	Frequency, cpm	Remarks
B33 S1 8	82.6	-----------	-----	Static tensile test
---------	82.5	-----------	-----	Static tensile test and Battelle (ref. 4)
B134 M 1	82.0	15	-----	Manually controlled
B45 S1 6	82.0	18	-----	
B34 S1 1	81.9	-----------	-----	Static tensile test and Battelle (ref. 4)
B39 S1 4	81.0	46	-----	Manually controlled
B40 S1 6	80.0	50	-----	
B37 S1 3	75.0	107	-----	Automatically controlled
B44 S1 7	75.0	143	12	
B35 S1 5	70.0	228	14	
---------	70.0	320	13	
B35 S1 3	60.0	1,667	20	
B34 S1 3	60.0	1,688	16	
B42 S1 1	50.0	5,182	19	
B41 S1 7	50.0	8,132	20	
B118 S1 6	50.0	18,000	1,800	Subresonant machines (ref. 5)
B43 S1 1	50.0	19,000	1,800	
B37 S1 4	50.0	27,000	1,800	
B101 M 1	50.0	33,000	1,800	
B132 M 2	50.0	36,000	1,800	
B117 M 1	40.0	40,000	1,800	
B131 M 2	40.0	64,000	1,800	
B113 S1 2	40.0	68,000	1,800	
B102 M 1	40.0	104,000	1,800	
B109 M 1	30.0	95,000	1,800	
B113 S1 1	30.0	147,000	1,800	
B130 M2 1	30.0	149,000	1,800	
B103 M 1	30.0	437,000	1,800	
B43 S1 3	27.0	152,000	1,800	
B37 S1 2	25.0	248,000	1,800	
B111 M 1	25.0	262,000	1,800	
B110 M 1	25.0	295,000	1,800	
B41 S1 6	25.0	303,000	1,800	
B43 S1 2	25.0	324,000	1,800	
B127 M 2	25.0	549,000	1,800	
B106 M 1	25.0	718,000	1,800	
B104 M 1	25.0	758,000	1,800	
B115 M 1	20.0	573,000	1,800	
B114 M 1	20.0	646,000	1,800	
B112 M 1	20.0	656,000	1,800	
B113 M 1	20.0	660,000	1,800	
B130 M 1	20.0	704,000	1,800	
B34 S1 5	20.0	771,500	1,800	
B135 M 2	20.0	1,148,000	1,800	
B98 M 1	20.0	1,992,000	1,800	
B45 S1 8	20.0	41,524,000	1,800	
B132 M 1	18.0	1,049,000	1,800	
B128 M 1	18.0	1,220,000	1,800	
B118 M 1	18.0	3,137,000	1,800	
B116 M 1	18.0	3,857,000	1,800	
B129 M 1	18.0	8,956,000	1,800	
B123 M 1	18.0	37,770,000	1,800	
B99 M 1	18.0	>52,017,000	1,800	
B100 M 1	18.0	>52,513,000	1,800	
B38 S1 3	18.0	59,795,000	1,800	
B119 M 1	18.0	>97,856,000	1,800	
B125 M 1	17.0	1,842,000	1,800	
B122 M 1	17.0	10,856,000	1,800	
B127 M 1	17.0	>85,621,000	1,800	
B126 M 1	16.5	55,815,000	1,800	

TABLE III.- AXIAL-LOAD FATIGUE TEST RESULTS FOR 7075-T6 ALUMINUM-ALLOY SHEET SPECIMENS - Continued

(b) $K_T = 2.0$

Specimen	Maximum stress, S_{max}, ksi	Fatigue life, N, cycles	Frequency, cpm	Remarks
$S_m = 0$				
B98 S1 6	91.0	-----------	-------	Static tensile test
B98 S1 7	89.8	-----------	-------	
B88 S1 5	89.2	-----------	-------	
B96 S1 7	89.0	4	-------	Manually controlled
B99 S1 7	88.0	6	-------	
B98 S1 5	88.0	7	-------	
---------	87.5	-----------	-------	Static tensile test and Battelle (ref. 6)
B81 S1 8	87.0	7	-------	Manually controlled
B82 S1 5	87.0	8	-------	
B83 S1 8	87.0	10	-------	
B97 S1 7	75.0	43	11	Automatically controlled
B88 S1 7	75.0	46	10	
B81 S1 9	75.0	54	10	
B81 S1 6	65.0	114	-------	
B96 S1 6	65.0	117	-------	
B98 S1 8	65.0	140	-------	
B99 S1 10	55.0	258	-------	
B97 S1 8	55.0	302	-------	
B98 S1 10	55.0	330	15	
B97 S1 6	50.0	341	14	
B88 S1 6	40.0	1,124	20	
B85 S1 4	40.0	1,313	20	
B97 S1 1	40.0	1,454	20	
B85 S1 2	40.0	1,488	20	
B96 S1 9	34.0	3,170	27	
B50 S2 B	34.0	4,000	1,100	Battelle (ref. 6)
B95 S3 B	34.0	5,400	1,100	
B100 S3 B	34.0	5,500	1,100	
B83 S1 7	30.0	6,196	27	Automatically controlled
B96 S1 5	30.0	7,000	1,800	Subresonant machines
B97 S1 10	30.0	7,000	1,800	
B47 S2 B	30.0	11,400	1,100	Battelle (ref. 6)
B92 S3 B	30.0	12,000	1,100	
B44 S2 B	28.0	19,000	1,100	
B45 S3 B	24.0	23,700	1,100	
B82 S1 4	24.0	32,000	1,800	Subresonant machines
B85 S1 1	23.5	31,000	1,800	
B26 S2 B	21.0	89,000	1,100	Battelle (ref. 6)
B6 S2 B	18.0	213,000	1,100	
B17 S2 B	15.0	347,500	1,100	
B28 S2 B	15.0	579,000	1,100	
B10 S2 B	15.0	1,564,300	1,100	
B43 S2 B	12.5	>10,853,000	1,100	
$S_m = 20$				
B98 S1 3	90.7	-----------	-------	Static tensile test
B99 S1 2	90.7	-----------	-------	
B82 S1 6	89.8	4	1.0	Manually controlled
B83 S1 10	89.8	22	.9	
B82 S1 2	89.0	4	.8	
B96 S1 10	89.0	12	.8	
B99 S1 1	88.0	39	.8	
B85 S1 10	88.0	40	.7	
B98 S1 9	80.0	119	14	Automatically controlled
B98 S1 4	80.0	120	13	
B81 S1 4	70.0	392	17	
B88 S1 10	70.0	399	17	
B97 S1 5	70.0	482	17	
B83 S1 5	56.0	1,763	23	
B21 S2 B	56.0	2,100	1,100	Battelle (ref. 6)
B97 S3 B	54.0	3,200	1,100	
B97 S1 9	50.0	4,791	28	Automatically controlled
B3 S2 B	50.0	5,000	1,100	Battelle (ref. 6)
B81 S1 5	45.0	6,134	33	Automatically controlled
B14 S2 B	45.0	11,500	1,100	Battelle (ref. 6)
B82 S1 3	40.0	13,000	1,800	Subresonant machines
B40 S2 B	40.0	13,400	1,100	Battelle (ref. 6)
B11 S2 B	35.0	28,000	1,100	
B12 S2 B	32.5	76,800	1,100	
B27 S2 B	30.0	621,900	1,100	
B81 S1 2	30.0	4,862,000	1,800	Subresonant machines
B81 S1 1	30.0	10,546,000	1,800	
B23 S2 B	29.0	>284,000	1,100	Battelle (ref. 6)
B18 S2 B	28.0	>10,781,700	1,100	

TABLE III.- AXIAL-LOAD FATIGUE TEST RESULTS FOR 7075-T6 ALUMINUM-ALLOY SHEET SPECIMENS - Concluded

(c) $K_T = 4.0$

Specimen	Maximum stress, S_{max}, ksi	Fatigue life, N, cycles	Frequency, cpm	Remarks
		$S_m = 0$		
B48 S1 8	87.6	-----------	-------	Static tensile test
B50 S1 9	84.8	-----------	-------	
B48 S1 9	83.5	3	.4	Manually controlled
B51 S1 10	83.5	3	.6	
---------	82.5	-----------	-------	Static tensile test and Battelle (ref. 6)
B46 S1 10	82.0	4	.5	Manually controlled
B49 S1 10	82.0	5	-------	
B48 S1 3	80.0	5	.5	
B49 S1 3	80.0	5	.7	
B48 S1 10	70.0	10	.5	
B48 S1 4	70.0	10	.7	
B48 S1 7	62.5	14	.6	
B50 S1 8	62.5	15	.7	
B48 S1 1	62.5	17	.7	
B49 S1 9	55.0	24	14	Automatically controlled
B49 S1 2	55.0	24	-------	
B50 S1 5	47.5	50	1.0	Manually controlled
B48 S9 6	47.5	51	17	Automatically controlled
B49 S1 4	40.0	85	-------	
B49 S1 7	40.0	115	19	
B49 S1 5	32.5	329	23	
B49 S1 8	32.5	365	-------	
B99 S1 6	30.0	2,622	44	
B49 S1 1	25.0	2,228	28	
B47 S1 7	24.5	1,588	32	
B47 S1 5	20.0	5,261	48	
B45 S3 B	20.0	5,300	1,100	Battelle (ref. 6)
B10 S3 B	16.25	17,800	1,100	
B51 S1 2	15.0	30,000	1,800	Subresonant machines
B35 S3 B	12.5	70,000	1,100	Battelle (ref. 6)
B50 S1 6	10.0	274,000	1,800	Subresonant machines
B36 S3 B	9.25	339,200	1,100	Battelle (ref. 6)
B19 S3 B	8.5	969,200	1,100	
B51 S1 9	8.0	10,232,000	1,800	Subresonant machines
B28 S3 B	7.5	1,652,300	1,100	Battelle (ref. 6)
B20 S3 B	7.5	4,722,000	1,100	
B31 S3 B	5.5	>12,405,300	1,100	
B29 S3 B	4.0	>10,247,800	1,100	
		$S_m = 20$		
B46 S1 5	86.0	7	.9	Manually controlled
B46 S1 7	85.0	8	-------	
B46 S1 9	85.0	9	.9	
B47 S1 1	83.0	10	1.0	
B47 S1 10	83.0	11	1.2	
B46 S1 8	83.0	12	1.2	
B46 S1 3	80.0	13	1.0	
B47 S1 2	80.0	14	1.0	
B46 S1 2	75.0	23	1.1	
B46 S1 4	75.0	26	1.0	
B46 S1 1	65.0	47	19	Automatically controlled
B47 S1 9	65.0	49	18	
B47 S1 4	55.0	169	24	
B51 S1 1	55.0	170	23	
B51 S1 8	45.0	652	30	
B50 S1 2	45.0	756	30	
B21 S3 B	35.0	2,500	1,100	Battelle (ref. 6)
B46 S1 6	35.0	3,804	49	Automatically controlled
B25 S3 B	32.5	5,500	1,100	Battelle (ref. 6)
B98 S1 1	30.0	2,639	28	Automatically controlled
B97 S1 3	30	9,000	1,800	Subresonant machines
B51 S1 6	30.0	10,000	1,800	
B11 S3 B	30.0	10,500	1,100	Battelle (ref. 6)
B9 S3 B	30.0	10,700	1,100	
B98 S1 2	30.0	11,000	1,800	Subresonant machines
B37 S3 B	27.5	16,800	1,100	Battelle (ref. 6)
B48 S3 B	25.0	46,500	1,100	
B51 S1 7	25.0	85,000	1,800	Subresonant machines
B99 S1 9	25.0	140,000	1,800	
B50 S1 1	25.0	179,000	1,800	
B6 S3 B	22.5	566,500	1,100	Battelle (ref. 6)
B40 S3 B	22.5	>10,457,000	1,100	

TABLE IV.- AXIAL-LOAD FATIGUE TEST RESULTS FOR NORMALIZED

SAE 4130 STEEL SHEET SPECIMENS

(a) $K_T = 1.0$; $S_m = 0$

Specimen	Maximum stress, S_{max}, ksi	Fatigue life, N, cycles	Frequency, cpm	Remarks
C204 M 2	120.5	----------	--------	Static tensile test
C211 M 2	117.5	2	--------	Manually controlled
C214 M 2	117.5	4	1.1	
C212 M 2	115.0	8	0.8	
C212 M 1	115.0	9	1.0	
C209 M 2	112.0	10	--------	
C209 M 1	112.0	11	.6	
C210 M 1	112.0	14	1.0	
C211 M 1	112.0	16	--------	
C200 M 1	105.0	39	14.5	Automatically controlled
C199 M 2	105.0	92	18 to 13	
C201 M 2	105.0	114	--------	
C213 M 1	100.0	211	--------	Manually controlled
C208 M 2	100.0	265	20 to 14	Automatically controlled
C199 M 1	100.0	266	--------	
C208 M 1	100.0	350	20	
C207 M 2	80.0	3,553	28	
C205 M 2	80.0	4,392	--------	
C13 M 2	75.0	8,400	1,100	Battelle (ref. 4)
C253 M 2	70.0	17,000	1,800	Subresonant machines
C234 M 1	65.0	13,000	1,800	
C256 M 2	65.0	58,000	1,800	
C50 M 2	65.0	98,800	1,100	Battelle (ref. 4)
C250 M 1	60.0	36,000	1,800	Subresonant machines
C236 M 2	60.0	96,000	1,800	
C238 M 2	55.0	114,000	1,800	
C80 M 2	55.0	246,000	1,100	Battelle (ref. 4)
C235 M 2	55.0	601,000	1,800	Subresonant machines
C239 M 1	50.0	891,000	1,800	
C58 M 1	50.0	1,530,800	1,100	Battelle (ref. 4)
C231 M 1	50.0	1,984,000	1,800	Subresonant machines
C203 M 2	50.0	54,116,000	1,800	
C223 M 1	48.0	858,000	1,800	
C202 M 2	47.0	33,987,000	1,800	
C204 M 1	47.0	56,933,000	1,800	

TABLE IV.- AXIAL-LOAD FATIGUE TEST RESULTS FOR NORMALIZED

SAE 4130 STEEL SHEET SPECIMENS - Continued

(b) $K_T = 2.0$

Specimen	Maximum stress, S_{max}, ksi	Fatigue life, N, cycles	Frequency, cpm	Remarks
		$S_m = 0$		
C33 N1 6	130.2	-----------	-------	Static tensile test
C39 N1 6	130.0	-----------	-------	Manually controlled
C50 N1 3	125.0	6	-------	
C33 N1 1	125.0	8	.5	
C58 N1 7	120.0	14	-------	
C53 N1 3	120.0	15	.7	
C53 N1 1	120.0	19	-------	
---------	119.0	-----------	-------	Static tensile test and Battelle (ref. 6)
C63 N1 10	100.0	142	16	Automatically controlled
C42 N1 8	100.0	190	17	
C33 N1 7	100.0	205	17	
C45 N1 8	80.0	963	23	
C42 N1 7	80.0	1,075	22	
C67 N1 3	80.0	1,106	-------	
C39 N1 7	58.0	4,504	33	
C49 N1 3	58.0	5,779	32	
C42 N1 9	50.0	9,832	35	
C37 N1 2	50.0	9,970	37	
C39 N1 9	50.0	12,000	1,800	Subresonant machines
C51 S2 B	50.0	27,000	1,100	Battelle (ref. 6)
C197 S2 B	50.0	35,000	1,100	
C66 N1 8	50.0	39,000	1,800	Subresonant machines
C38 N1 4	45.0	30,000	1,800	
C82 B	45.0	43,000	1,100	Battelle (ref. 6)
C9 S2 B	45.0	45,700	1,100	
C13 S2 B	38.0	82,000	1,100	
C42 N1 5	32.0	182,000	1,800	Subresonant machines
C32 S2 B	32.0	635,000	1,100	Battelle (ref. 6)
C34 N1 10	32.0	>30,941,000	1,800	Subresonant machines
C14 S2 B	28.5	1,712,700	1,100	Battelle (ref. 6)
C47 S2 B	27.0	2,153,500	1,100	
C45 S2 B	25.0	>10,464,300	1,100	
C33 S2 B	25.0	>10,900,000	1,100	
		$S_m = 20$		
C61 N1 10	128.0	2	-------	Manually controlled
C46 N1 4	128.0	2	-------	
C67 N1 6	128.0	2	-------	
C63 N1 1	125.0	6	-------	
C66 N1 6	125.0	7	-------	
C42 N1 6	125.0	12	-------	
C34 N1 2	120.0	38	17	Automatically controlled
C67 N1 5	120.0	50	16	
C51 N1 1	120.0	58	16	
C35 N1 8	110.0	275	19	
C50 N1 2	110.0	297	19	
C66 N1 10	110.0	330	-------	
C34 N1 1	90.0	1,522	26	
C42 N1 10	90.0	1,855	25	
C67 N1 7	90.0	1,868	25	
C55 N1 2	90.0	1,954	25	
C57 N1 1	73.0	6,376	34	
C64 N1 3	73.0	7,350	-------	
C53 N1 5	72.5	6,832	35	
C199 S2 B	72.5	18,000	1,100	Battelle (ref. 6)
C189 S2 B	70.0	24,500	1,100	
C34 S2 B	70.0	28,000	1,100	
C67 N1 2	65.0	16,857	35	Automatically controlled
C53 N1 4	65.0	20,000	1,800	Subresonant machines
C60 N1 9	65.0	33,000	1,800	
C22 S2 B	65.0	39,700	1,100	Battelle (ref. 6)
C27 S2 B	60.0	70,900	1,100	
C20 S2 B	55.0	227,000	1,100	
C60 N1 6	50.0	195,000	1,800	Subresonant machines
C11 S2 B	50.0	535,900	1,100	Battelle (ref. 6)
C37 N1 1	47.5	290,000	1,800	Subresonant machines
C39 N1 8	47.5	464,000	1,800	
C36 S2 B	47.5	1,002,000	1,100	Battelle (ref. 6)
C12 S2 B	45.0	>1,528,000	1,100	
C7 S2 B	45.0	1,557,700	1,100	
C42 S2 B	42.5	>10,480,000	1,100	
C41 N1 8	40.0	>60,384,000	1,800	Subresonant machines

TABLE IV.- AXIAL-LOAD FATIGUE TEST RESULTS FOR NORMALIZED

SAE 4130 STEEL SHEET SPECIMENS - Concluded

(c) $K_T = 4.0$

Specimen	Maximum stress, S_{max}, ksi	Fatigue life, N, cycles	Frequency, cpm	Remarks
		$S_m = 0$		
---------	129.0	-----------	-----	Static tensile test and Battelle (ref. 6)
C57 N1 2	128.0	-----------	-----	Static tensile test
C45 N1 9	128.0	-----------	-----	↓
C41 N1 7	124.0	4	-----	Manually controlled
C49 N1 5	124.0	4	-----	
C65 N1 1	120.0	5	-----	
C50 N1 10	120.0	6	-----	
C62 N1 5	110.0	13	-----	
C62 N1 10	110.0	14	-----	↓
C43 N1 2	90.0	104	19	Automatically controlled
C37 N1 10	90.0	106	-----	
C36 N1 5	65.0	589	-----	
C54 N1 6	65.0	682	28	
C56 N1 10	65.0	874	29	↓
C149 S2 B	42.5	5,400	1,100	Battelle (ref. 6)
C44 N1 5	42.5	8,440	43	Automatically controlled
C104 S2 B	42.5	14,800	1,100	Battelle (ref. 6)
C111 S2 B	37.5	19,700	1,100	
C144 S2 B	37.0	19,000	1,100	
C130 S2 B	32.5	30,500	1,100	↓
C50 N1 5	32.5	35,000	1,800	Subresonant machines
C125 S2 B	27.5	107,000	1,100	Battelle (ref. 6)
C38 S2 B	27.0	94,300	1,100	
C115 S2 B	22.5	269,000	1,100	↓
C38 N1 10	17.5	493,000	1,800	Subresonant machines
C122 S2 B	17.5	537,900	1,100	Battelle (ref. 6)
C142 S2 B	15.0	1,719,000	1,100	
C146 S2 B	12.5	>10,325,000	1,100	↓
		$S_m = 20$		
C48	126.5	-----------	-----	Static tensile test
C47 N1 3	125.0	5	-----	Manually controlled
C44 N1 4	125.0	5	-----	
C57 N1 6	125.0	7	-----	↓
C38 N1 3	100.0	116	-----	Automatically controlled
C37 N1 3	100.0	152	-----	
C61 N1 1	100.0	157	-----	
C43 N1 3	100.0	158	-----	
C51 N1 5	80.0	496	-----	
C46 N1 5	80.0	625	-----	
C47 N1 5	80.0	898	-----	
C51 N1 7	57.5	4,711	45	
C49 N1 10	57.5	5,847	48	
C38 N1 9	57.5	6,486	50	↓
C112 S2 B	57.5	11,400	1,100	Battelle (ref. 6)
C147 S2 B	55.0	18,000	1,100	
C135 S2 B	51.25	27,000	1,100	↓
C34 N1 6	51.0	12,451	53	Automatically controlled
C52 N1 2	51.0	16,000	1,800	Subresonant machines
C40 N1 1	51.0	19,000	1,800	↓
C129 S2 B	45.0	59,000	1,100	Battelle (ref. 6)
C137 S2 B	40.0	106,000	1,100	↓
C54 N1 1	40.0	121,000	1,800	Subresonant machines
C106 S2 B	37.5	134,000	1,100	Battelle (ref. 6)
C105 S2 B	35.0	164,000	1,100	
C150 S2 B	35.0	181,500	1,100	
C118 S2 B	35.0	202,000	1,100	
C132 S2 B	32.5	>10,000,000	1,100	
C103 S2 B	32.5	>10,287,000	1,100	↓

TABLE V.- AXIAL-LOAD FATIGUE TEST RESULTS FOR HARDENED SAE 4130 STEEL SHEET SPECIMENS

(a) $K_T = 1.0$

Specimen	Maximum stress, S_{max}, ksi	Fatigue life, N, cycles	Frequency, cpm	Remarks
$S_m = 0$				
C75 N1 1	182.8	-----------	-----	Static tensile test
C68 N1 8	182.5	-----------	-----	Manually controlled
C80 N1 4	180.0	2	-----	
C70 N1 5	180.0	4	-----	
C79 N1 8	178.0	8	-----	
C68 N1 7	178.0	9	-----	
C74 N1 1	176.0	71	-----	
C77 N1 1	160.0	74	11	Automatically controlled
C73 N1 7	160.0	129	14	
C78 N1 8	140.0	731	16	
C69 N1 6	140.0	1,112	16	
--------	139.0	2,000	1,800	Subresonant machines
C73 N1 8	120.0	3,329	-----	Automatically controlled
C71 N1 5	120.0	8,000	1,800	Subresonant machines
C71 N1 1	120.0	10,050	21	Automatically controlled
C74 N1 3	104.0	48,000	1,800	Subresonant machines
C73 N1 5	104.0	64,000	1,800	
C80 N1 7	103.8	80,000	1,800	
C72 N1 7	80.0	127,000	1,800	
C71 N1 2	80.0	220,000	1,800	
C74 N1 7	80.0	271,000	1,800	
C76 N1 4	72.0	486,000	1,800	
C69 N1 7	72.0	6,126,000	1,800	
C69 N1 4	65.0	200,000	1,800	
C68 N1 6	63.5	213,000	1,800	
C71 N1 6	62.0	1,023,000	1,800	
C78 N1 6	60.0	>5,238,000	1,800	
C76 N1 7	60.0	>8,213,000	1,800	
$S_m = 50$				
C69 N1 5	182.0	76	-----	Manually controlled
C75 N1 6	180.0	42	-----	Automatically controlled
C75 N1 7	180.0	71	-----	
C76 N1 1	170.0	280	-----	
C80 N1 1	170.0	432	18	
C72 N1 8	170.0	530	19	
C68 N1 3	170.0	1,020	18	
C73 N1 3	160.0	4,258	-----	
C79 N1 3	160.0	4,806	20	
C79 N1 4	150.0	11,517	22	
C79 N1 5	150.0	11,597	22	
C68 N1 1	120.0	27,940	-----	
C69 N1 3	120.0	32,275	34	
C78 N1 3	120.0	109,000	1,800	Subresonant machines
C69 N1 2	120.0	116,000	1,800	
C78 N1 7	110.0	143,000	1,800	
C73 N1 8	110.0	196,000	1,800	
C78 N1 5	105.0	207,000	1,800	
C70 N1 4	100.0	>12,897,000	1,800	
C80 N1 6	96.0	>4,930,000	1,800	

TABLE V.- AXIAL-LOAD FATIGUE TEST RESULTS FOR HARDENED SAE 4130 STEEL SHEET SPECIMENS - Continued

(b) $K_T = 2.0$

Specimen	Maximum stress, S_{max}, ksi	Fatigue life, N, cycles	Frequency, cpm	Remarks
		$S_m = 0$		
C61 N1 4	197.3	-----------	-----	Static tensile test
C57 N1 10	195.8	-----------	-----	
C66 N1 1	192.7	-----------	-----	
C40 N1 5	190.0	4	-----	Manually controlled
C41 N1 6	190.0	9	-----	
C49 N1 7	186.0	3	-----	
C45 N1 10	186.0	7	-----	
C34 N1 7	186.0	7	-----	
C55 N1 3	186.0	10	-----	
C41 N1 5	185.0	8	-----	
C40 N1 6	160.0	83	11	Automatically controlled
C64 N1 3	160.0	86	11	
C80 N1 3	160.0	93	-----	
C51 N1 2	160.0	111	-----	
C35 N1 1	140.0	183	13	
C38 N1 5	140.0	212	13	
C42 N1 4	140.0	240	14	
C44 N1 2	120.0	421	15	
C48 N1 4	120.0	449	15	
C41 N1 8	120.0	513	15	
C49 N1 8	100.0	916	18	
C63 N1 2	100.0	926	18	
C37 N1 8	100.0	1,048	18	
C38 N1 1	90.0	2,284	21	
C47 N1 6	80.0	2,908	22	
C52 N1 3	80.0	3,514	22	
C65 N1 6	60.0	12,551	33	
C60 N1 1	60.0	18,921	27	
C36 N1 6	60.0	31,000	1,800	Subresonant machines
C36 N1 7	40.0	695,000	1,800	
C44 N1 1	37.0	>18,514,000	1,800	
C44 N1 7	30.0	>7,056,000	1,800	
C67 N1 10	25.0	>5,158,000	1,800	
		$S_m = 50$		
C41 N1 3	193.0	12	-----	Manually controlled
C36 N1 9	193.0	15	-----	
C59 N1 1	193.0	23	-----	
C65 N1 3	186.0	58	-----	
C64 N1 9	180.0	161	-----	Automatically controlled
C43 N1 8	180.0	186	-----	
C38 N1 2	180.0	191	-----	
C36 N1 10	160.0	473	16	
C59 N1 7	160.0	479	16	
C35 N1 5	160.0	539	16	
C41 N1 1	130.0	1,727	-----	
C36 N1 2	130.0	1,843	-----	
C65 N1 5	130.0	2,133	24	
C61 N1 7	110.0	5,176	-----	
C54 N1 3	110.0	6,522	30	
C36 N1 4	90.0	15,964	41	
C55 N1 5	90.0	28,000	1,800	Subresonant machines
C44 N1 9	90.0	36,000	1,800	
C41 N1 10	80.0	40,085	-----	Automatically controlled
C55 N1 9	80.0	45,154	62	
C58 N1 8	80.0	88,000	1,800	Subresonant machines
C36 N1 8	70.0	464,000	1,800	
C61 N1 6	67.0	>7,579,000	1,800	
C44 N1 8	64.0	>7,983,000	1,800	

TABLE V.- AXIAL-LOAD FATIGUE TEST RESULTS FOR HARDENED SAE 4130 STEEL SHEET SPECIMENS - Concluded

(c) $K_T = 4.0$

Specimen	Maximum stress, S_{max}, ksi	Fatigue life, N, cycles	Frequency, cpm	Remarks
$S_m = 0$				
C67 N1 8	199.5	-----------	-----	Static tensile test
C43 N1 5	199.0	-----------	-----	↓
C51 N1 9	190.0	2	-----	Manually controlled
C49 N1 9	190.0	3	-----	↓
C61 N1 9	189.0	-----------	-----	Static tensile test
C66 N1 7	180.0	10	-----	Manually controlled
C46 N1 6	180.0	10	-----	
C46 N1 9	180.0	10	-----	
C40 N1 3	160.0	17	-----	
C44 N1 3	160.0	25	-----	
C62 N1 9	160.0	25	-----	↓
C65 N1 4	140.0	43	13	Automatically controlled
C65 N1 3	140.0	59	13	
C52 N1 9	140.0	60	13	
C34 N1 9	120.0	110	-----	
C67 N1 1	120.0	115	-----	
C66 N1 2	120.0	135	-----	
C42 N1 2	100.0	253	13	
C56 N1 9	100.0	296	18	
C65 N1 2	80.0	922	22	
C52 N1 6	80.0	1,300	23	
C63 N1 3	80.0	1,338	-----	
C40 N1 8	50.0	14,480	36	↓
C52 N1 5	50.0	18,000	1,800	Subresonant machines
C63 N1 5	40.0	45,000	1,800	
C54 N1 9	30.0	81,000	1,800	
C40 N1 9	30.0	104,000	1,800	
C52 N1 10	25.0	319,000	1,800	
C47 N1 7	20.0	606,000	1,800	
C56 N1 7	18.0	881,000	1,800	
C40 N1 7	15.0	>8,096,000	1,800	↓
$S_m = 50$				
C37 N1 6	185.0	13	-----	Manually controlled
C61 N1 3	185.0	21	-----	
C61 N1 5	185.0	25	-----	↓
C61 N1 8	160.0	91	17	Automatically controlled
C56 N1 8	160.0	99	17	
C53 N1 10	160.0	101	17	
C59 N1 2	140.0	242	20	
C64 N1 6	140.0	287	21	
C54 N1 4	140.0	319	21	
C48 N1 5	120.0	776	26	
C45 N1 5	120.0	811	26	
C45 N1 3	120.0	819	25	
C41 N1 2	100.0	2,440	37	
C51 N1 8	100.0	3,074	38	
C52 N1 6	100.0	3,303	-----	
C56 N1 5	80.0	15,659	63	↓
C57 N1 5	80.0	18,000	1,800	Subresonant machines
C58 N1 4	75.0	41,000	1,800	
C63 N1 7	70.0	70,000	1,800	
C67 N1 4	70.0	125,000	1,800	
C48 N1 3	64.0	206,000	1,800	
C43 N1 4	60.0	602,000	1,800	
C42 N1 1	56.0	>10,030,000	1,800	↓

TABLE VI.- FATIGUE LIFE RESULTING FROM MAXIMUM STRESS

EQUAL TO TWO-THIRDS ULTIMATE TENSILE STRESS

Material	S_m, ksi	Fatigue life, N, cycles, for -		
		K_T = 1.0	K_T = 2.0	K_T = 4.0
2024-T3 aluminum alloy	0	9,000	200	22
	20	-------	3,000	200
7075-T6 aluminum alloy	0	3,500	200	22
	20	-------	1,400	130
Normalized SAE 4130 steel	0	3,900	610	130
	20	-------	3,200	420
Hardened SAE 4130 steel	0	80,000	300	80
	50	105,000	1,900	500

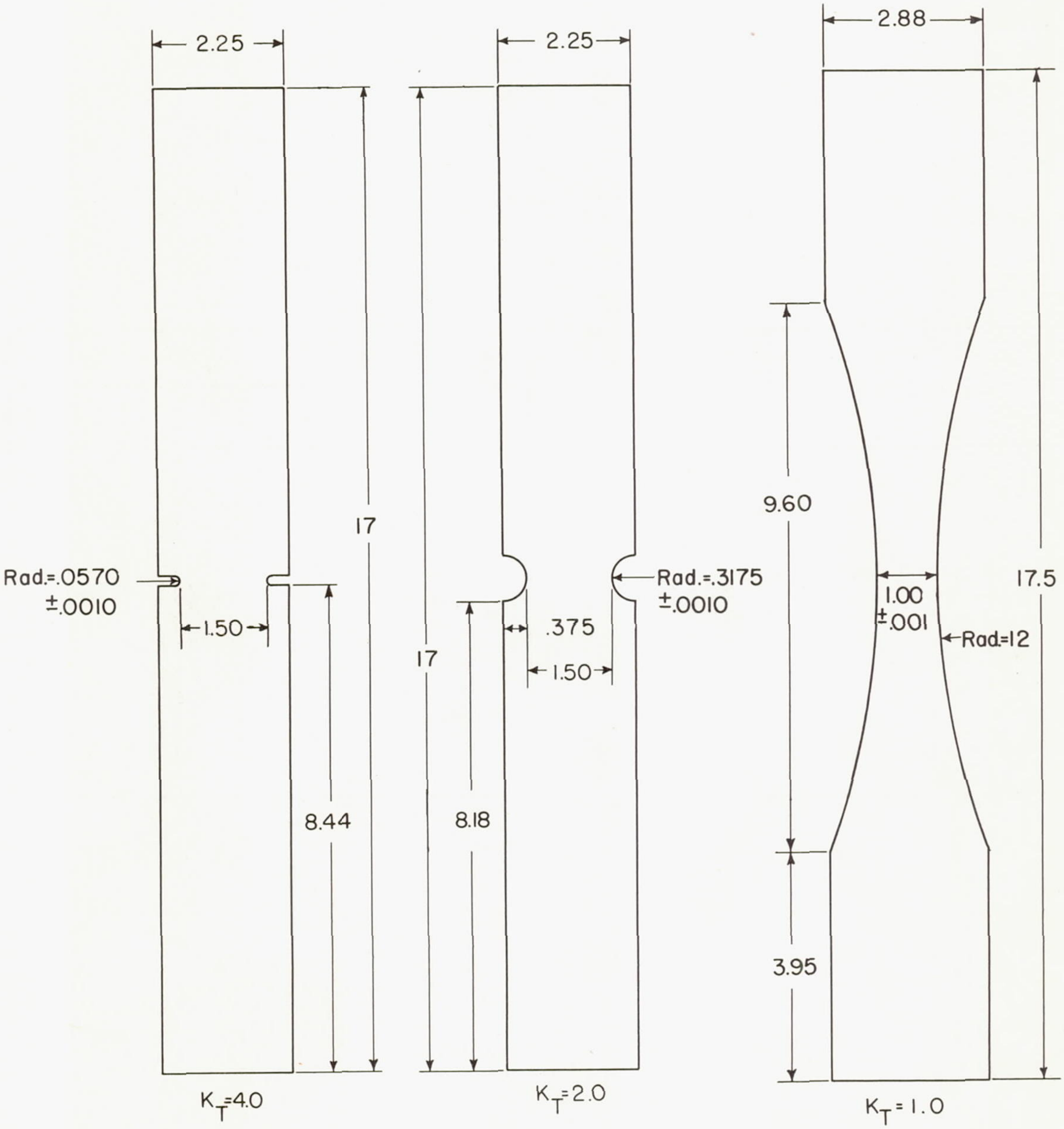
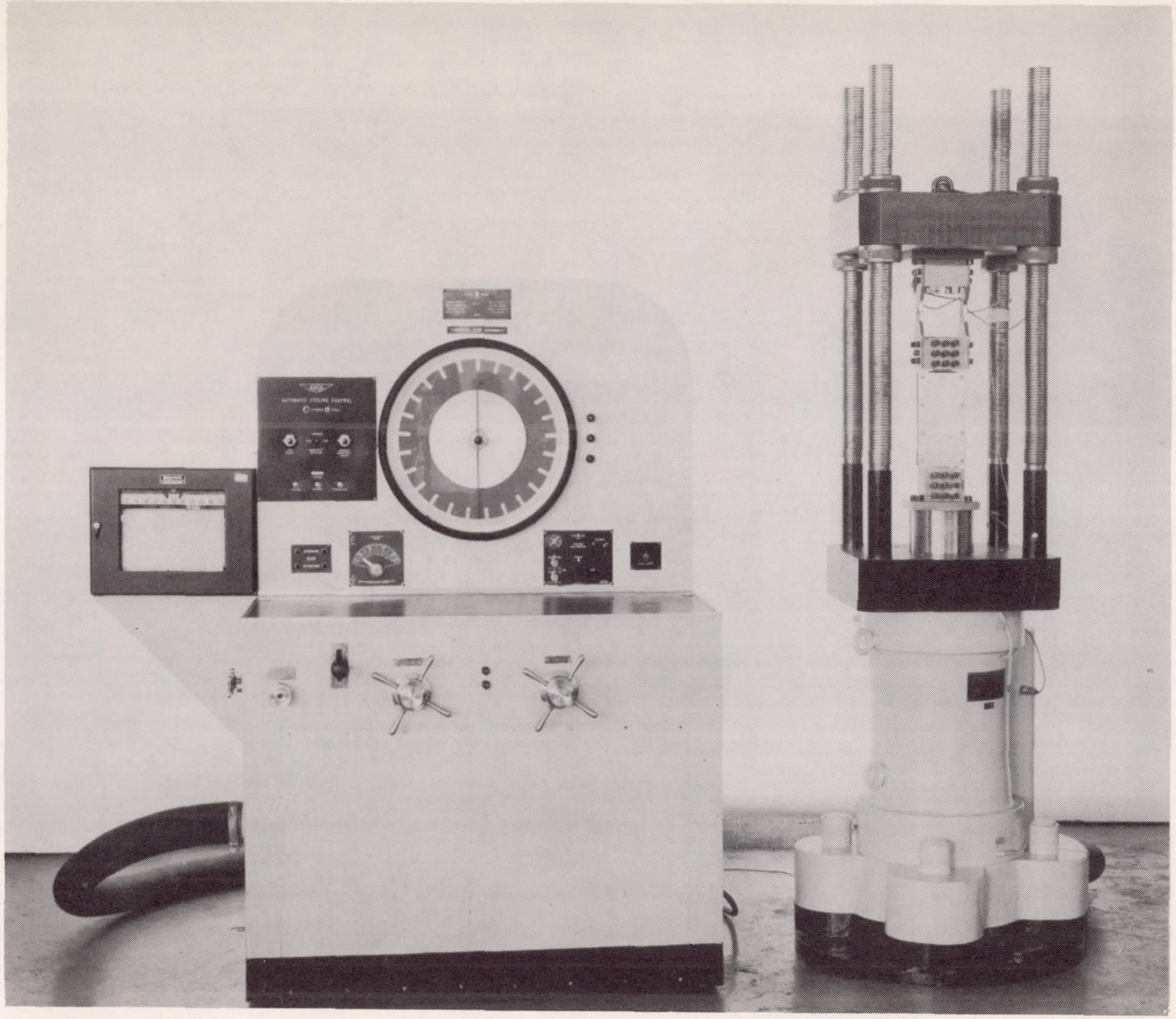
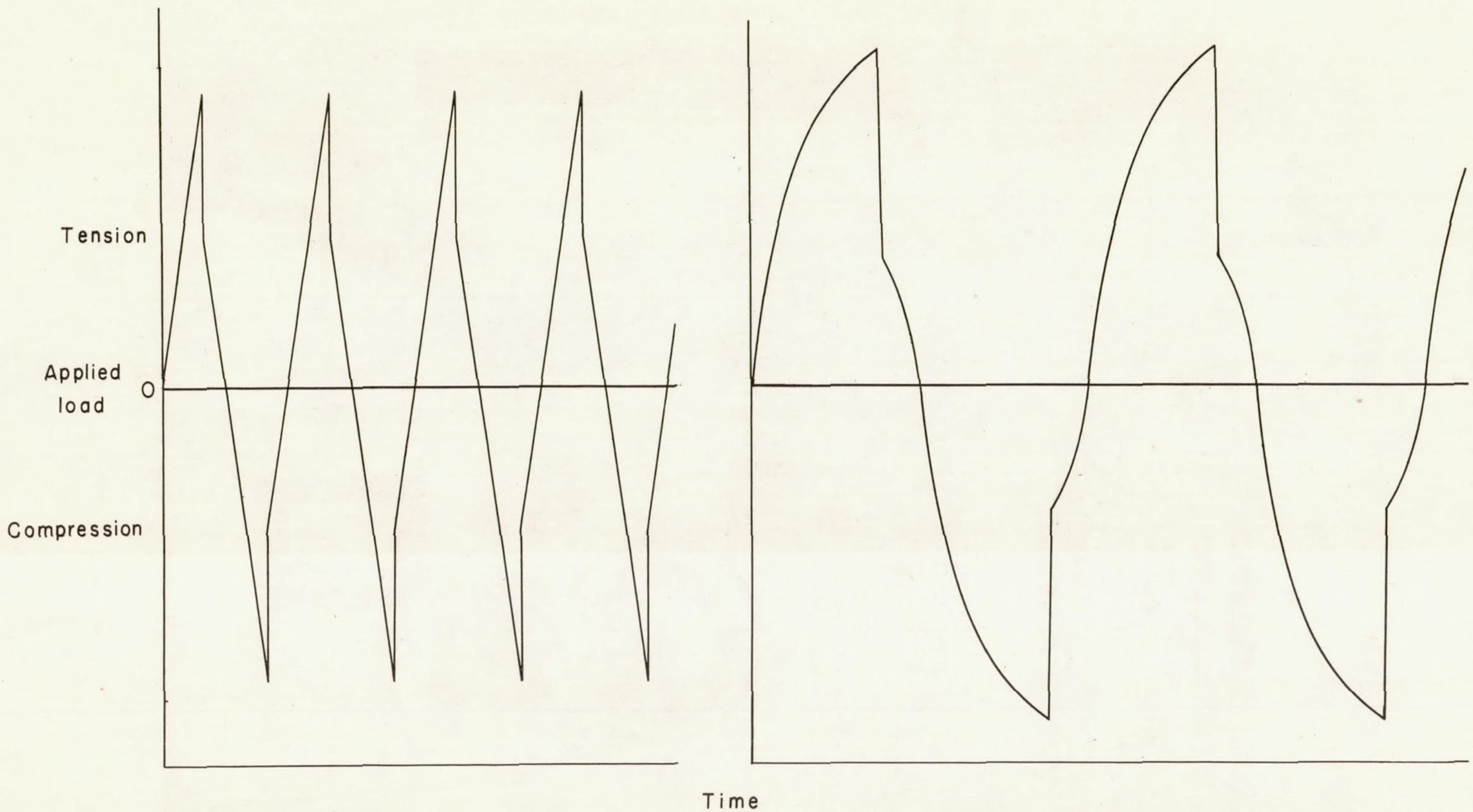


Figure 1.- Configurations of sheet specimens. Aluminum specimens, 0.090 inch thick; steel specimens, 0.075 inch thick.



L-80901.1

Figure 2.- Double-acting hydraulic jack with specimen in place.



(a) Automatically controlled.

(b) Manually controlled.

Figure 3.- Typical load-time curves for double-acting hydraulic jack.

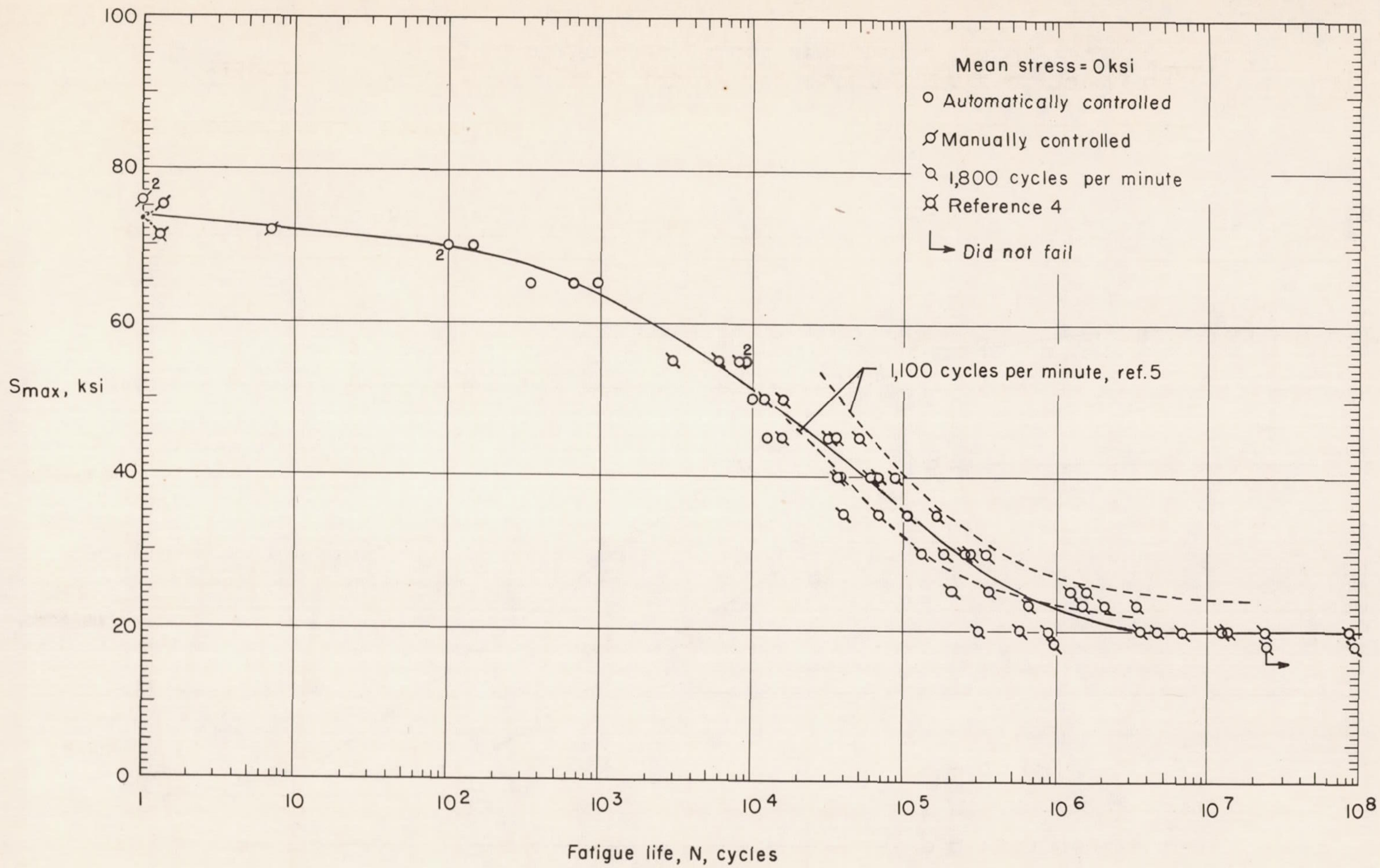


Figure 4.- Results of axial-load fatigue tests on unnotched 2024-T3 aluminum-alloy sheet specimens. $K_T = 1.0$.

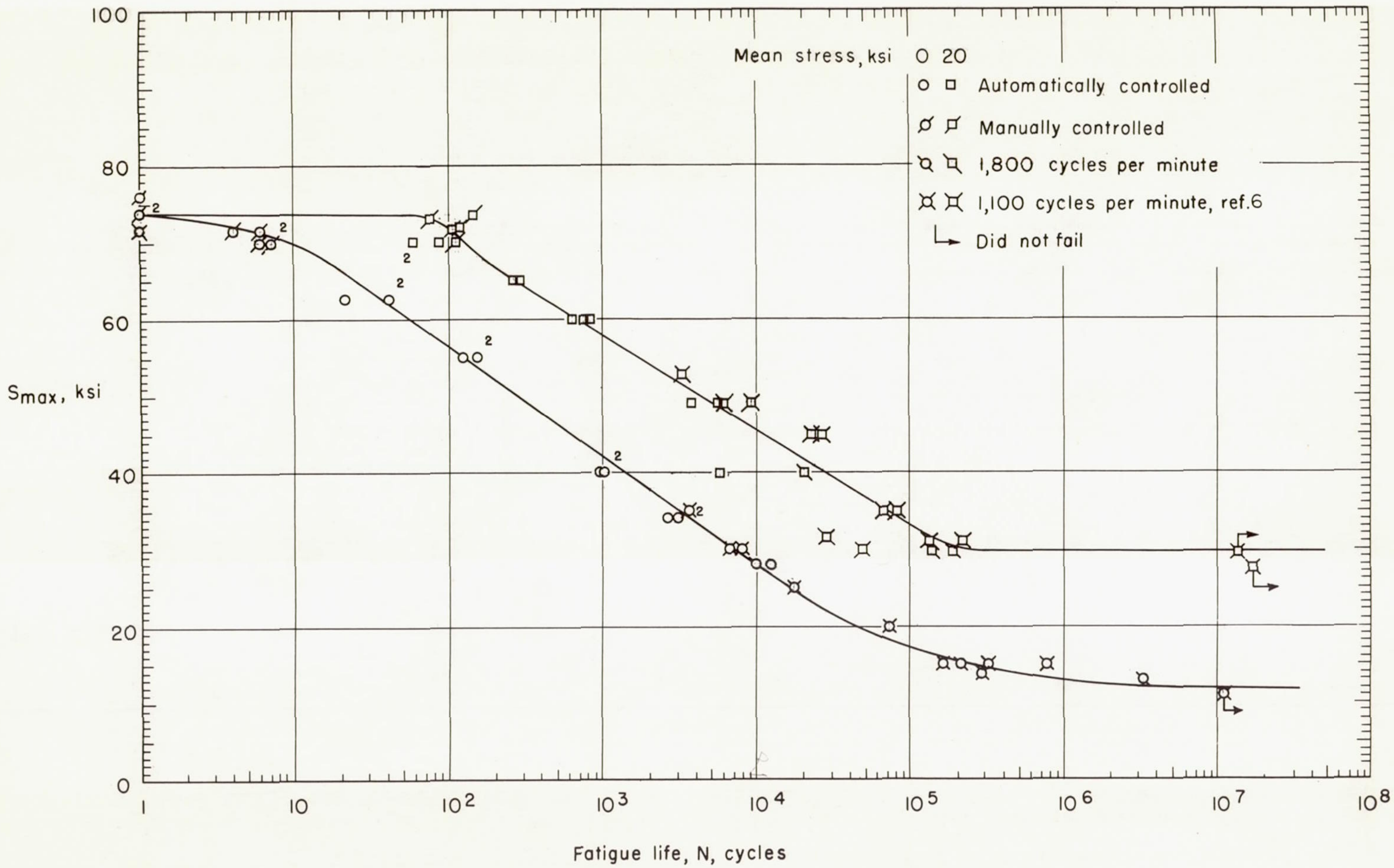


Figure 5.- Results of axial-load fatigue tests on notched 2024-T3 aluminum-alloy sheet specimens. $K_T = 2.0$.

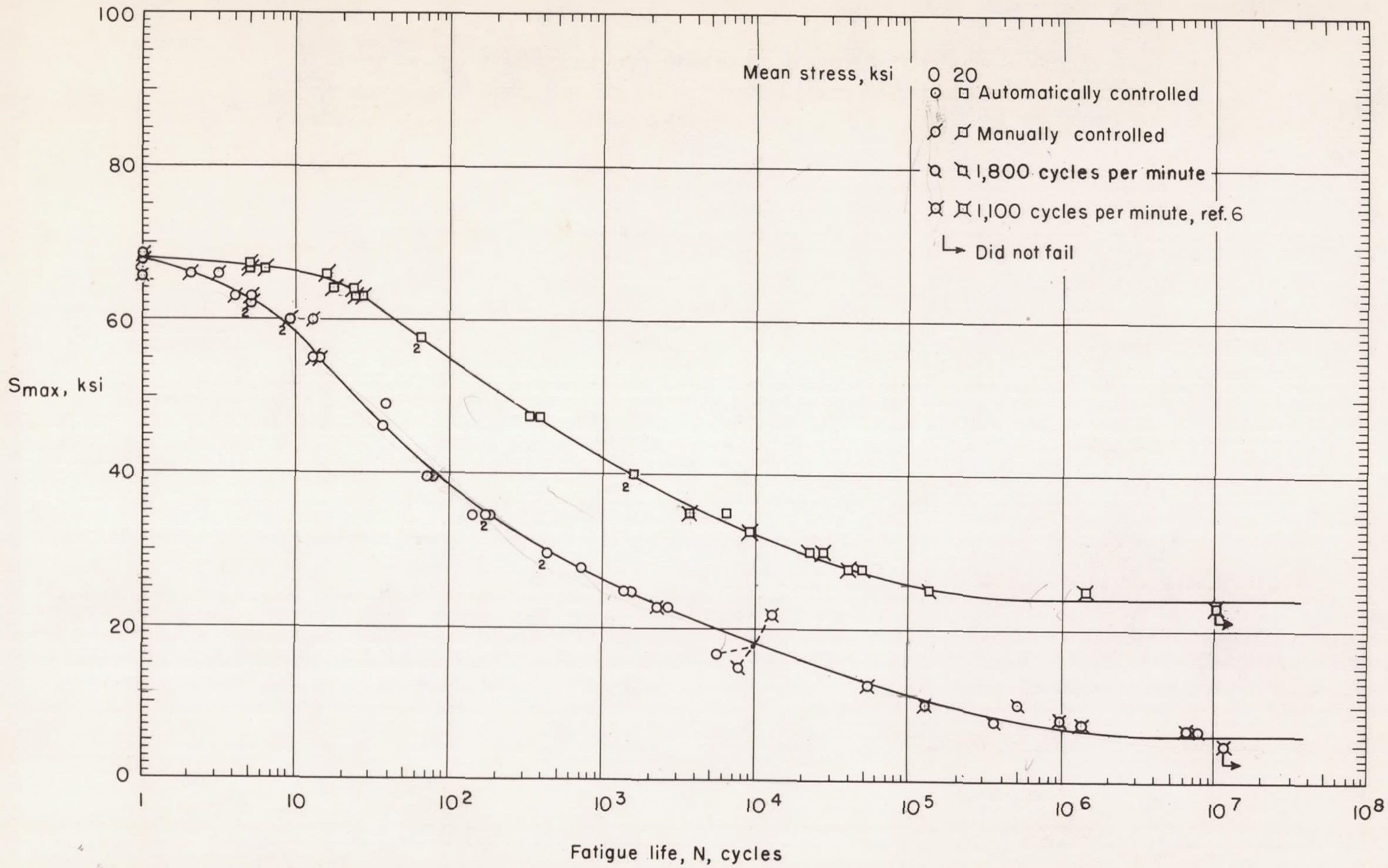


Figure 6.- Results of axial-load fatigue tests on notched 2024-T3 aluminum-alloy sheet specimens. $K_T = 4.0$.

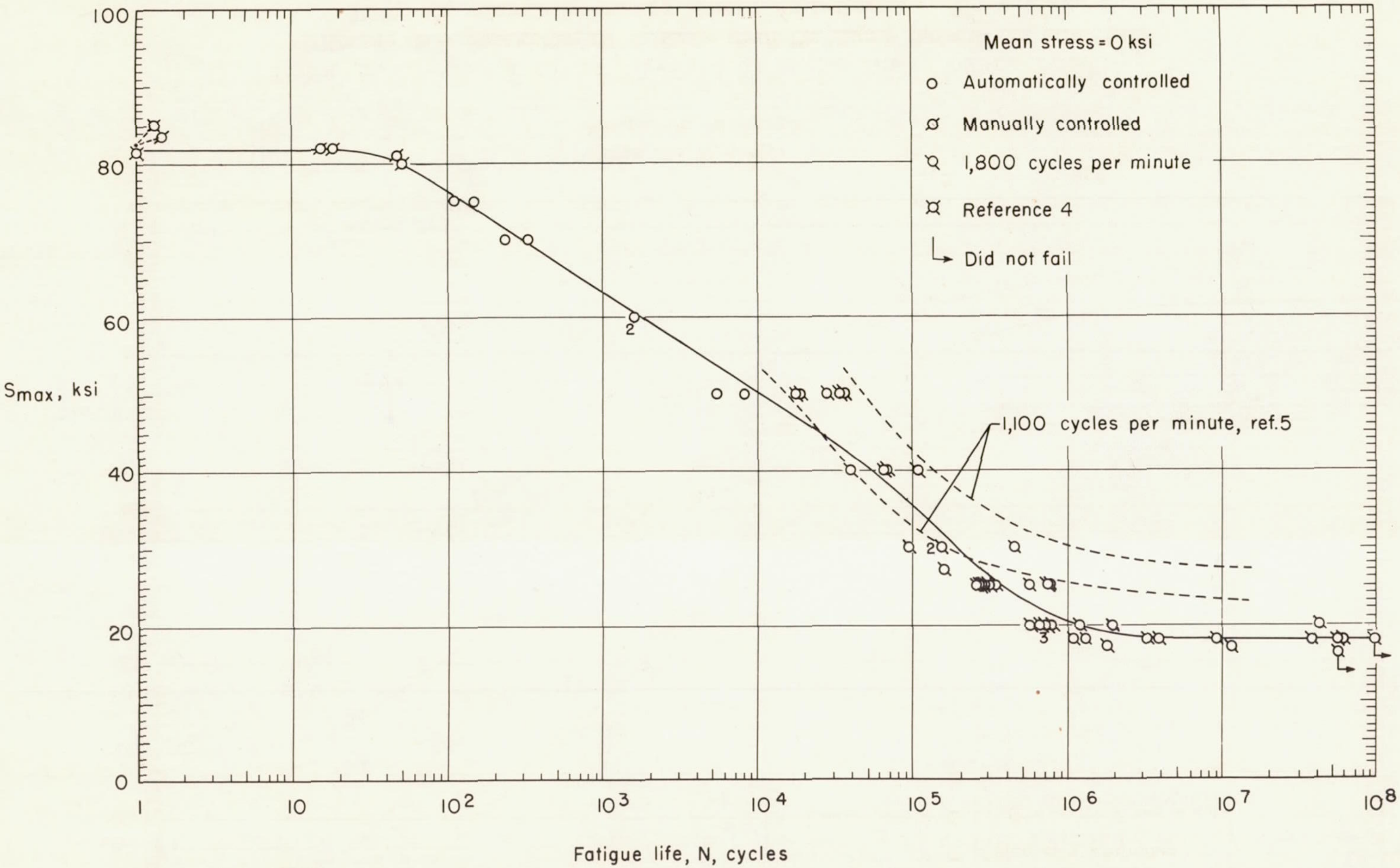


Figure 7.- Results of axial-load fatigue tests on unnotched 7075-T6 aluminum-alloy sheet specimens. $K_T = 1.0$.

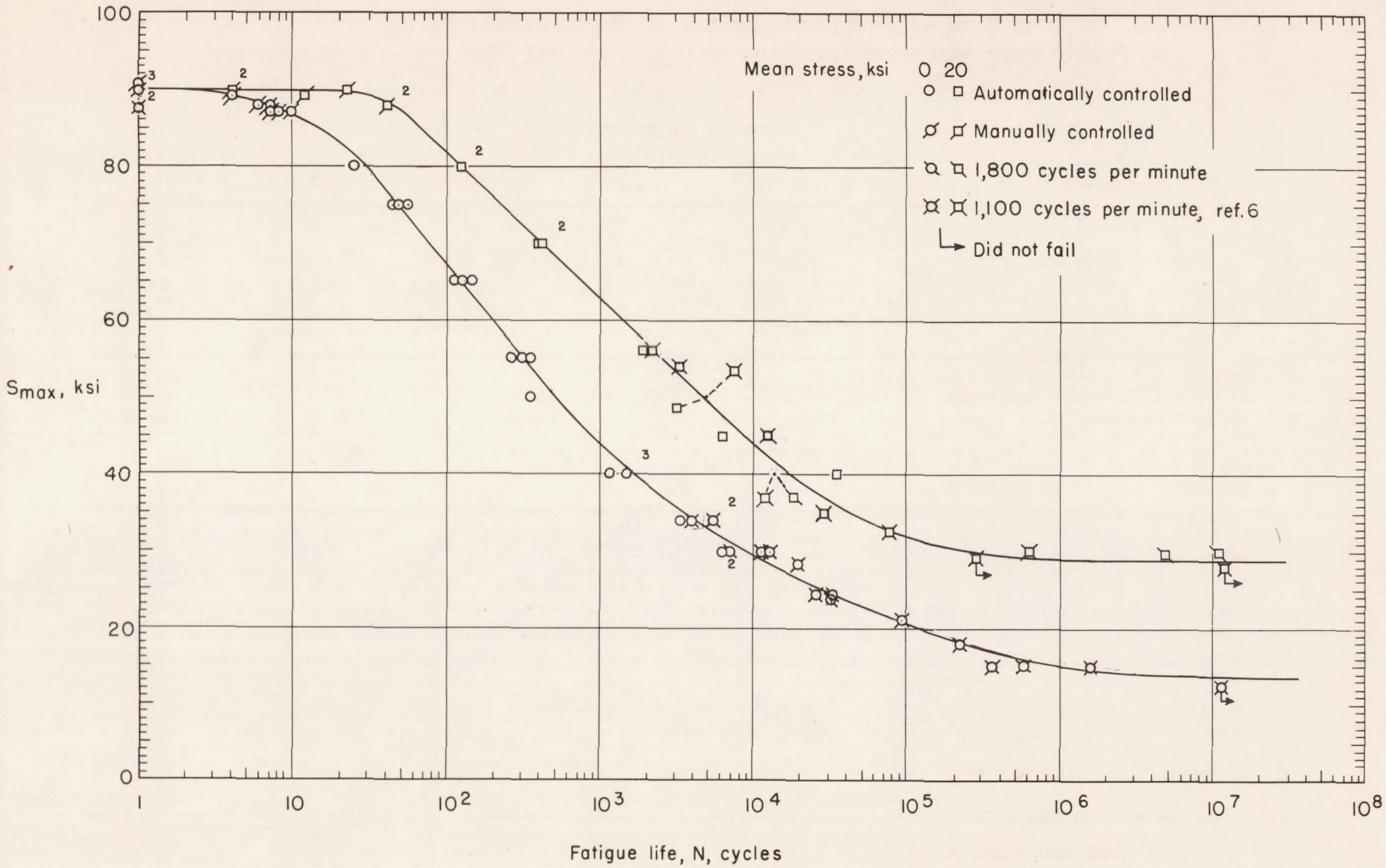


Figure 8.- Results of axial-load fatigue tests on notched 7075-T6 aluminum-alloy sheet specimens. $K_T = 2.0$.

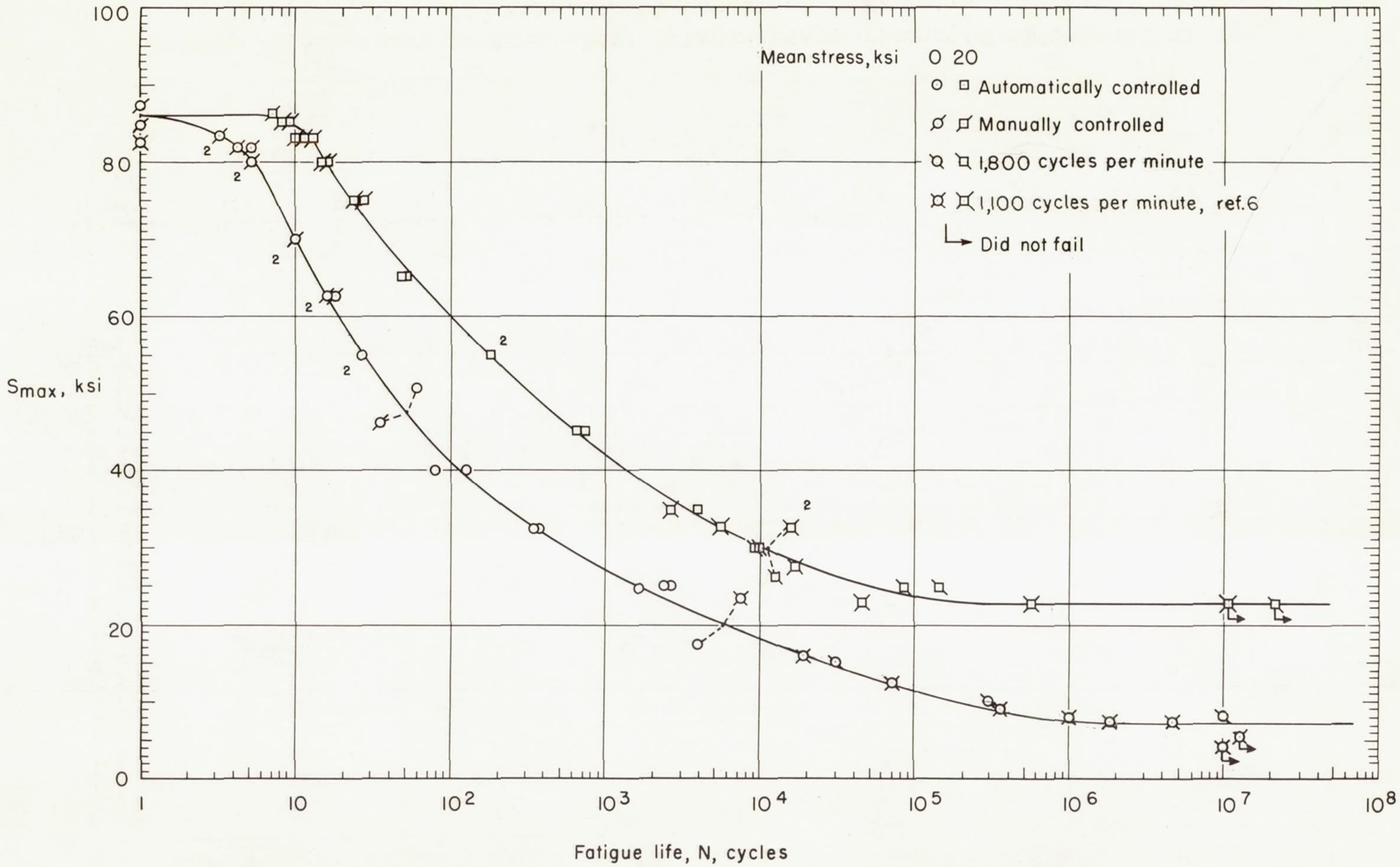


Figure 9.- Results of axial-load fatigue tests on notched 7075-T6 aluminum-alloy sheet specimens. $K_T = 4.0$.

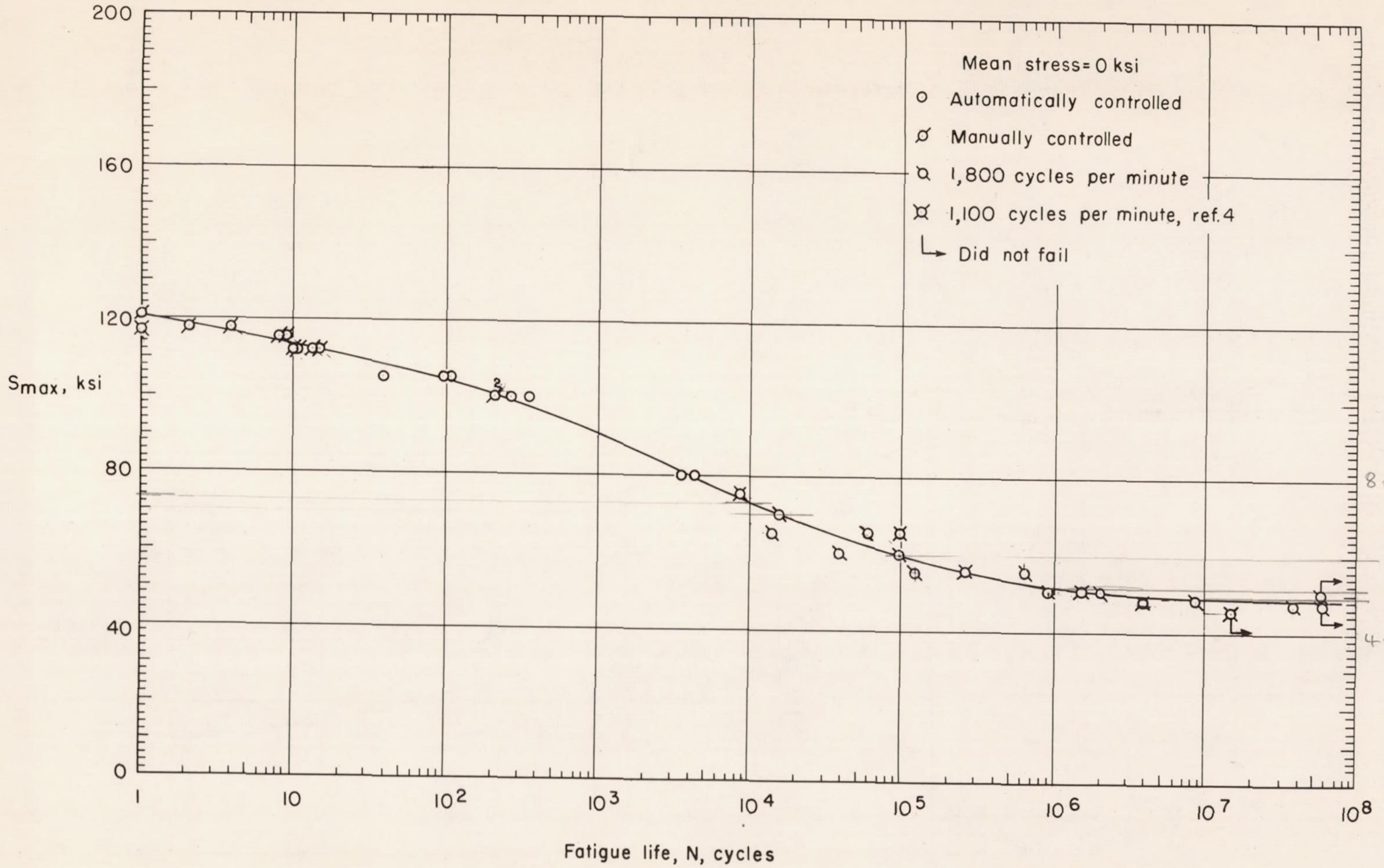


Figure 10.- Results of axial-load fatigue tests on unnotched normalized SAE 4130 steel sheet specimens. $K_T = 1.0$.

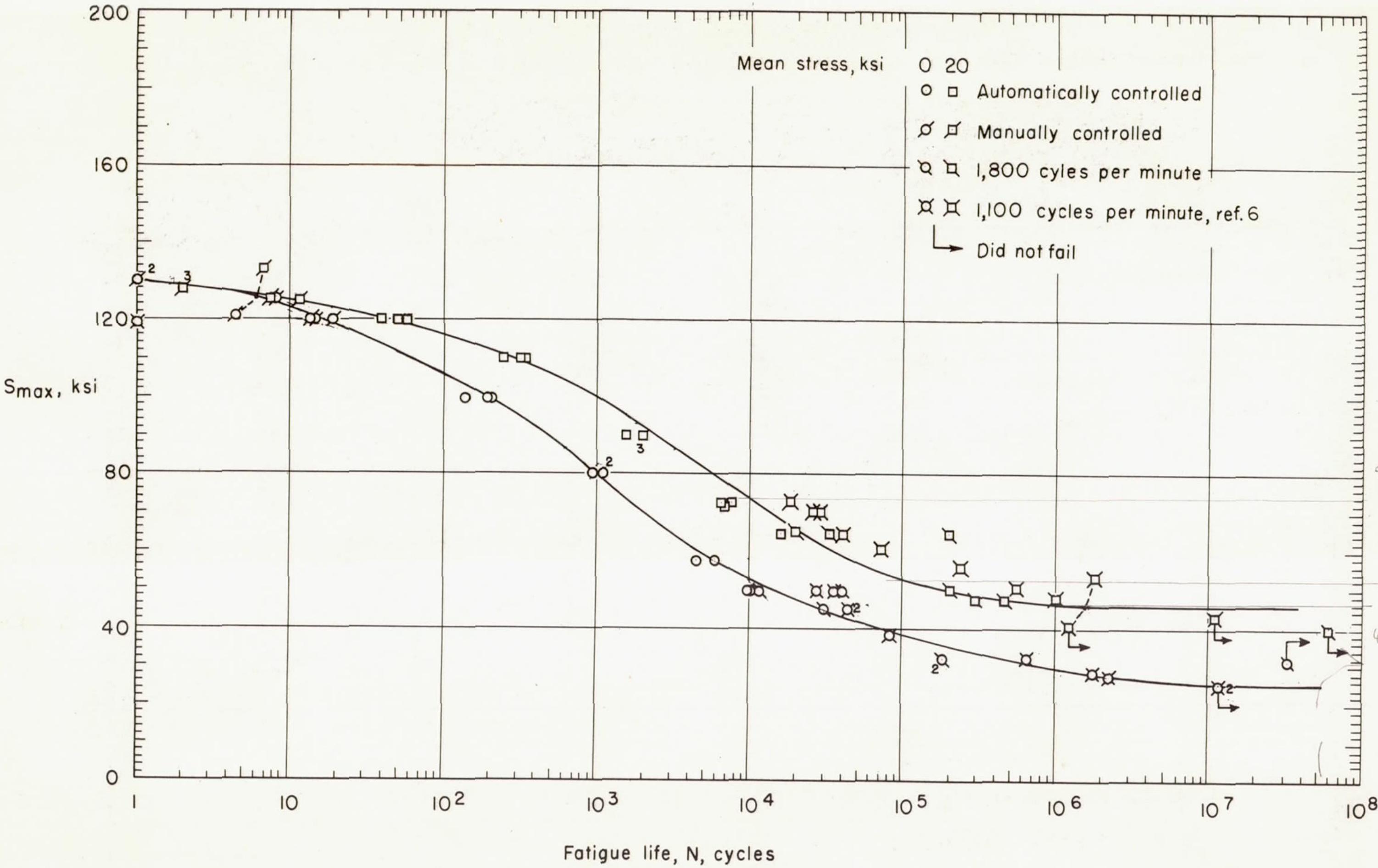


Figure 11.- Results of axial-load fatigue tests on notched normalized SAE 4130 steel sheet specimens. $K_T = 2.0$.

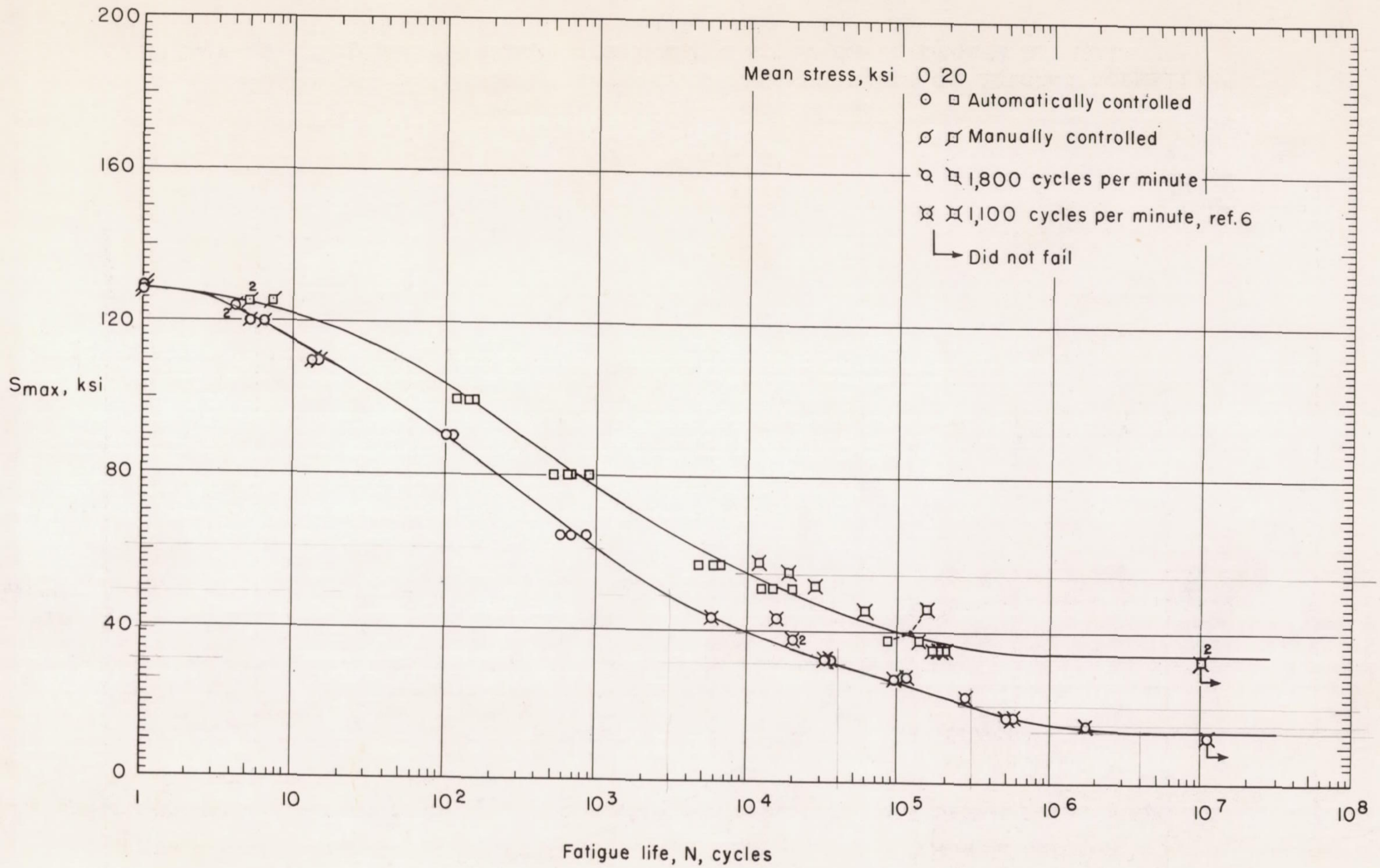


Figure 12.- Results of axial-load fatigue tests on notched normalized SAE 4130 steel sheet specimens. $K_T = 4.0$.

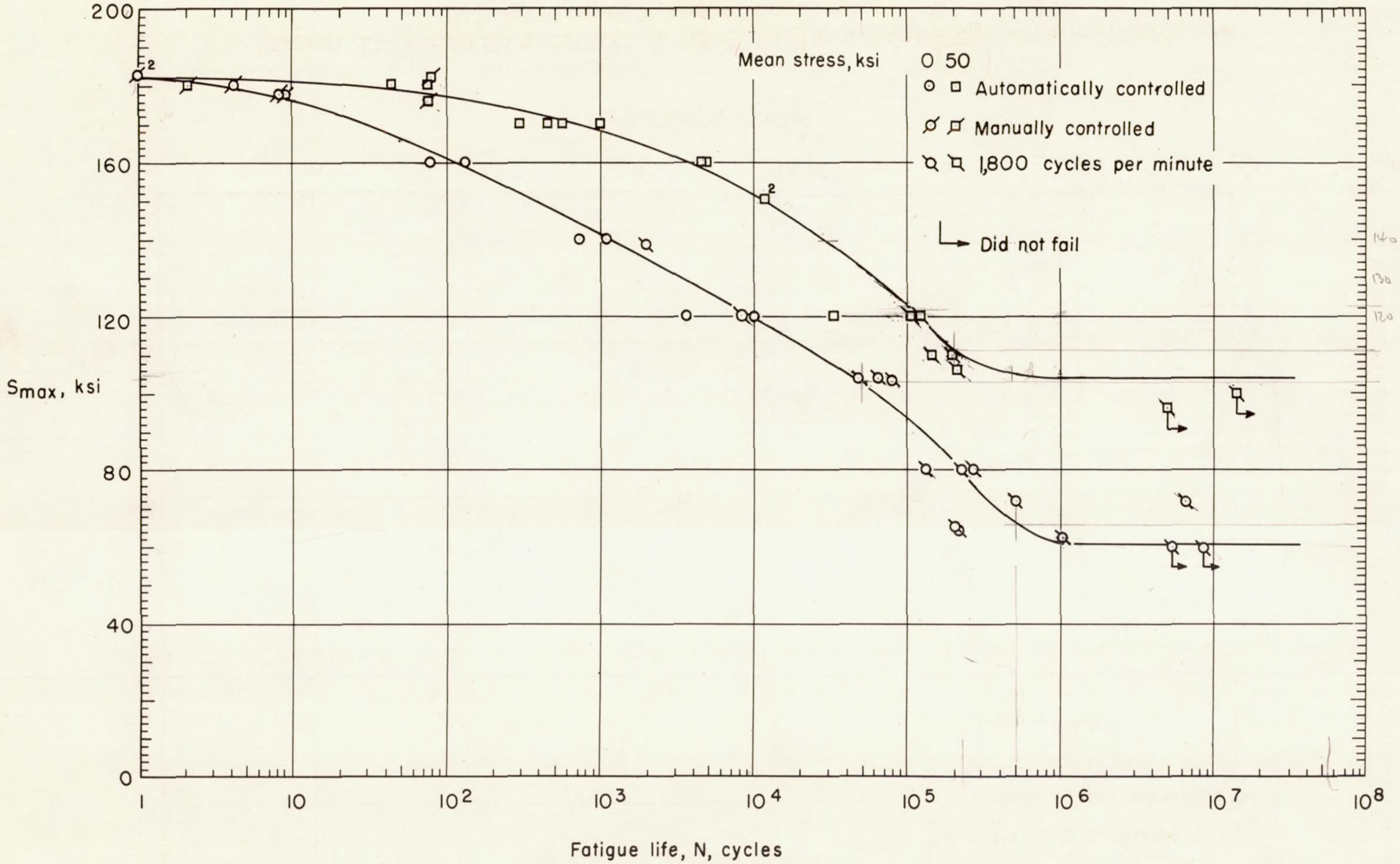


Figure 13.- Results of axial-load fatigue tests on unnotched hardened SAE 4130 steel sheet specimens. $K_T = 1.0$.

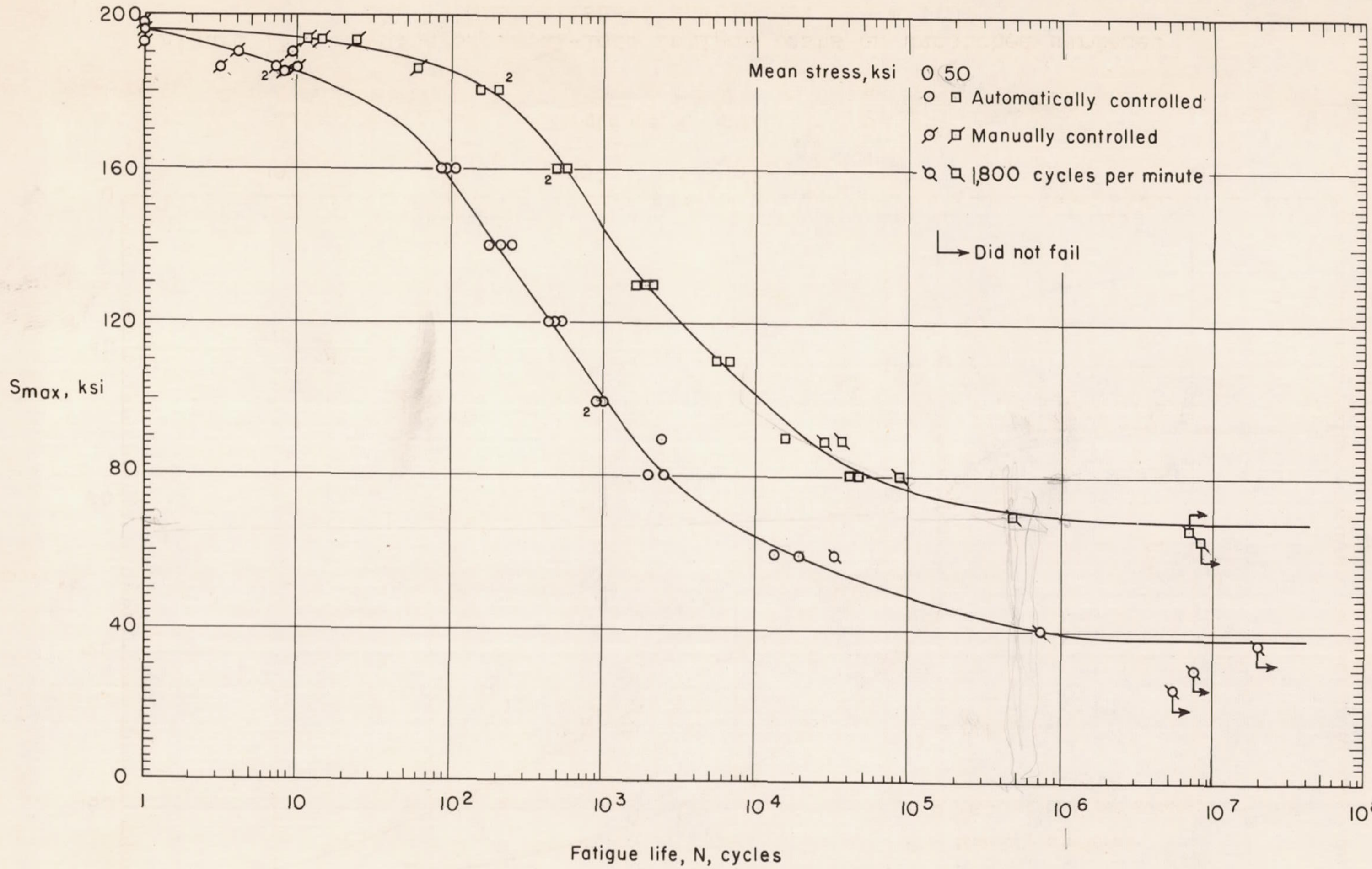


Figure 14.- Results of axial-load fatigue tests on notched hardened SAE 4130 steel sheet specimens. $K_T = 2.0$.

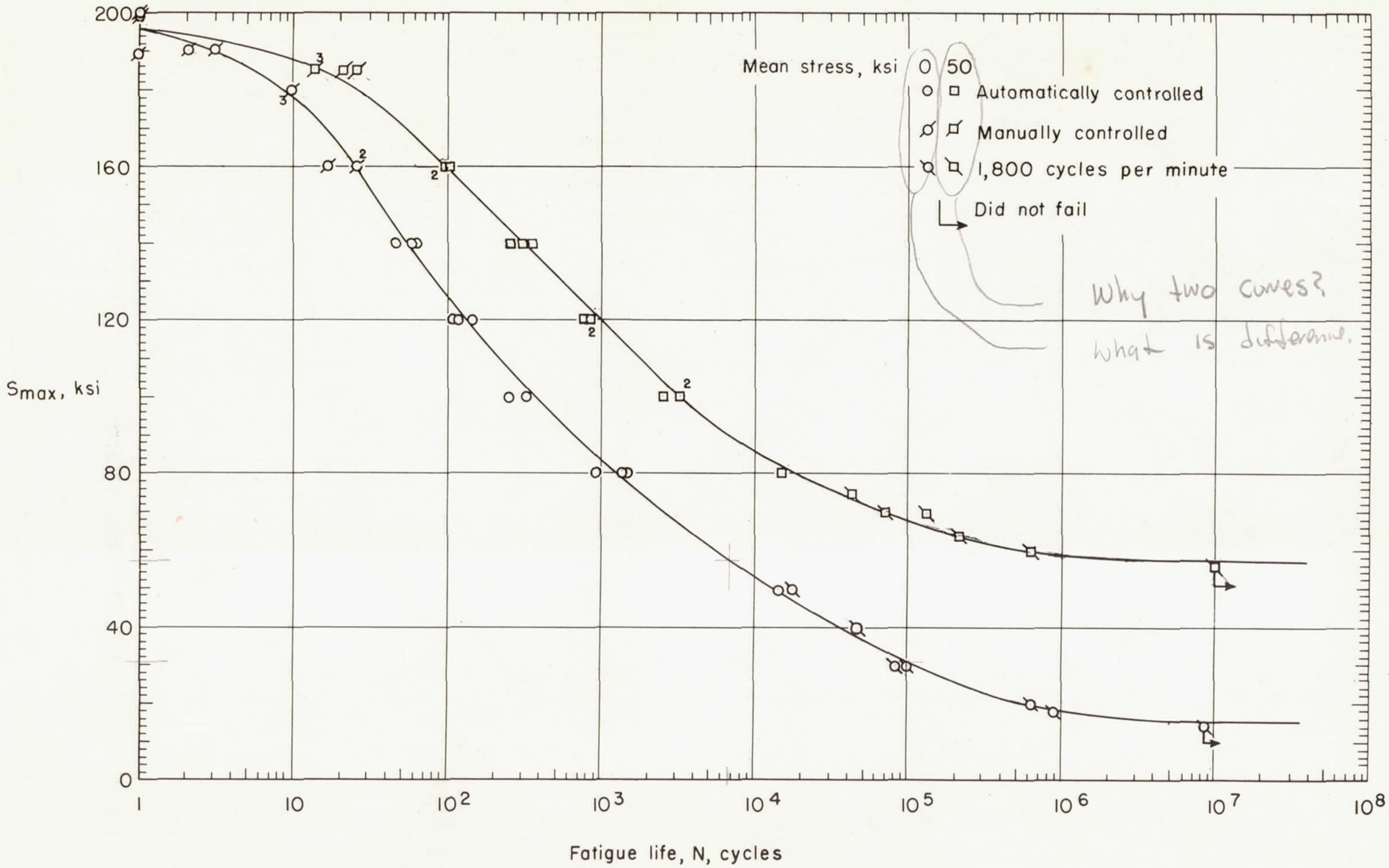
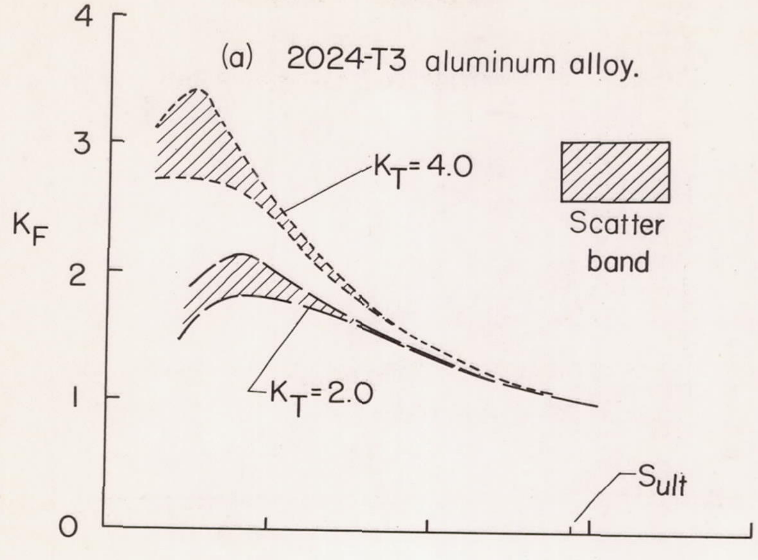


Figure 15.- Results of axial-load fatigue tests on notched hardened SAE 4130 steel sheet specimens. $K_T = 4.0$.



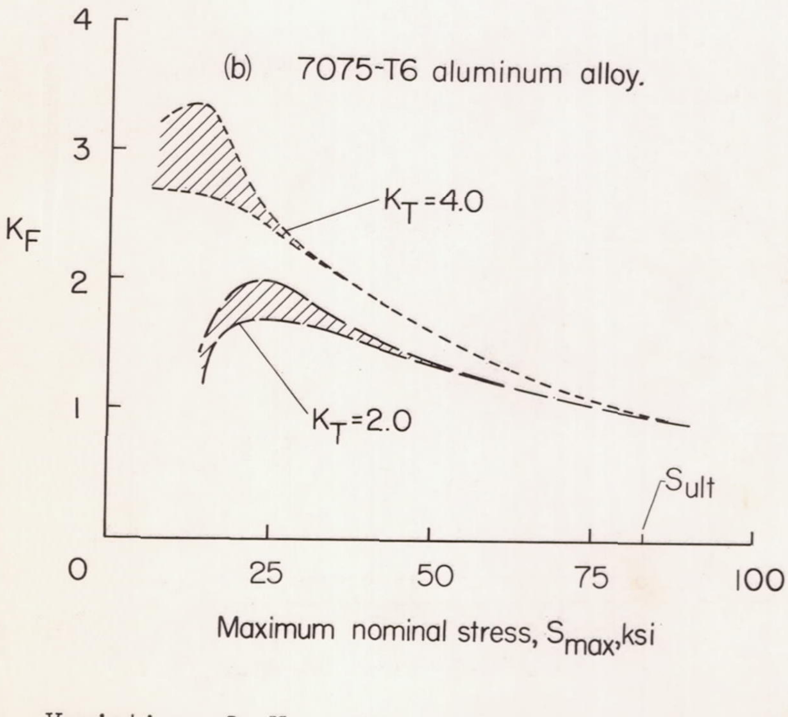
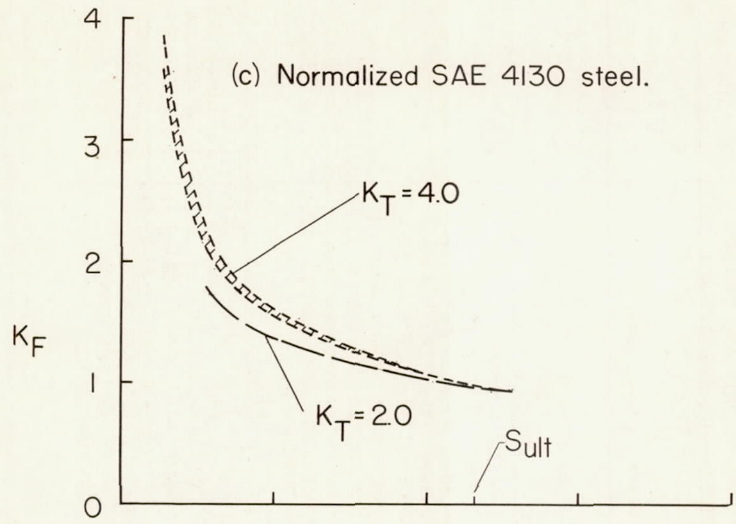


Figure 16.- Variation of K_F with maximum nominal stress of notched specimen. R = -1.



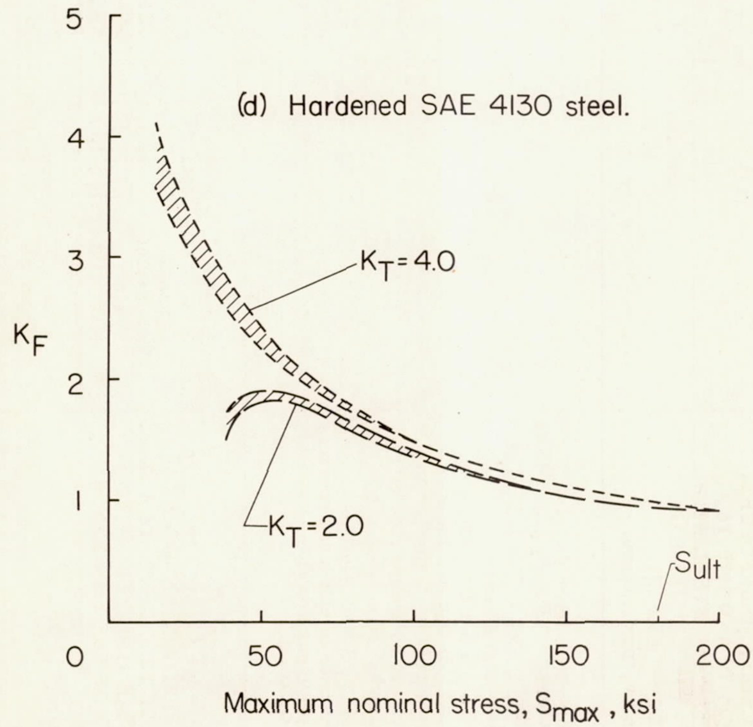


Figure 16.- Concluded.

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