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GENERAL DYNAMICS

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Report No. 8926-126

Material - Aluminum - 2024-T4 Extrusions

Effect of Stretching on Mechanical and Fatigue
Properties

R. J. Haney, G D Lindeneau, W. E. Wise

25 June 1958

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Abstract:

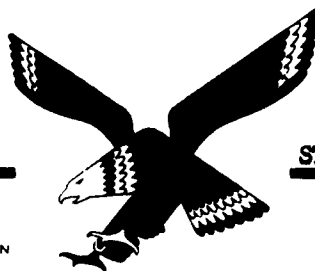
A large extruded Tee-section made from 2024 aluminum alloy was subjected to fifteen variations in degree of stretch, solution heat treatment and natural aging sequences. The various processing sequences approximated various manufacturing steps, and the mechanical and fatigue properties resulting therefrom were desired for comparison with minimum design allowable strengths already established for unstretched extrusions. In all cases the processed extrusion mechanical and fatigue properties exceeded design minima for unstretched extrusions. In general the strengths were higher than established minima, and the elongations approached minimum values.

Reference: Haney, R. J., Lindeneau, G. D., Wise, W. E., "2024 Extrusions #E-801903 - Effects of Stretching on Tensile Yield, Ultimate & Elongation - Compression Yield - Fatigue Properties - Thickness," General Dynamics/Convair MP 57-997, San Diego, California, 25 June 1958 (Reference attached).

CONVAIR

A DIVISION OF GENERAL DYNAMICS CORPORATION

SAN DIEGO



STRUCTURES & MATERIALS LABORATORIES

REPORT 57-997

DATE 25 June 1958

MODEL 22

TEST NO. 57-997
58-049

TITLE

REPORT NO. 57-997

2024 EXTRUSION #E-801903
EFFECTS OF STRETCHING ON;
TENSILE YIELD, ULTIMATE & ELONGATION -
COMPRESSION YIELD - FATIGUE PROPERTIES
- THICKNESS

MODEL 22

PREPARED BY R. J. Haney

R. J. Haney

G. D. Lindeneau

G. D. Lindeneau

GROUP STRUCTURES LABORATORIES

REFERENCE _____

CHECKED BY W. E. Wise

W. E. Wise

APPROVED BY E. F. Strong

E. F. Strong
Chief, Test Laboratories

WITNESS:

NO. OF PAGES 35

NO. OF DIAGRAMS 33

R. A. Miller, Structures

REVISIONS

NO.	DATE	BY	CHANGE	PAGES AFFECTED
A	8-12-58	Haney	Added paragraph #3 to Test Specimen description	1

ANALYSIS

PREPARED BY R. J. Haney

CHECKED BY W. E. Wise

REVISED BY

CONVAIR

A DIVISION OF GENERAL DYNAMICS CORPORATION
SAN DIEGO

PAGE 1

REPORT NO. 57-997

MODEL 22

DATE 25 June 1958

INTRODUCTION:

Many 2024 extruded sections used in the Model 22 are stretch-formed to obtain the desired contours. Stretch forming causes a reduction in thickness of the part being formed and can produce a substantial change in some mechanical properties, depending on the temper at the time of forming. It is necessary, therefore, to establish a permissible range of stretching, and a temper condition which will produce maximum strength, minimum reduction in thickness, and yet be compatible with production requirements.

OBJECT:

To compare the strengths and reduction in thickness produced by stretching a 2024 extrusion various amounts when in different temper conditions.

TEST SPECIMEN:

The extruded section used for this evaluation is identified by Convair Drawing No. E 801903, and is shown in Figure 1. The extrusion was produced by the Harvey Aluminum Company in the 2024 alloy and delivered to Convair in the "o" condition (2024-0).

The material for this test was cut into sections each six feet long. These lengths were then processed using production facilities and specifications to give test coupon material for the following nominal conditions:

1. No Stretch-Solution Heat Treat
2. Stretch 3% - Solution Heat Treat
3. Stretch 6% - Solution Heat Treat
4. Stretch 10% - Solution Heat Treat
5. Stretch 6% - Solution Heat Treat Stretch 2% in W Condition (after quench)
6. Stretch 6% - Solution Heat Treat Stretch 3% in W Condition (after quench)
7. Stretch 6% - Solution Heat Treat Stretch 4% in W Condition (after quench)
8. Stretch 6% - Solution Heat Treat Stretch 6% in W Condition (3 days)
9. Stretch 6% - Solution Heat Treat Stretch 8% in W Condition (after quench)
10. Stretch 6% - Solution Heat Treat Stretch 10% in W Condition (3 days)
11. Stretch 6% - Solution Heat Treat Stretch 4% after room temperature age.
12. Stretch 6% - Solution Heat Treat - Stretch 6% after room temperature age.
13. Solution Heat Treat - Stretch 0% in W Condition (after quench)
14. Solution Heat Treat - Stretch 3% in W Condition (after quench)
15. Solution Heat Treat - Stretch 6% in W Condition (after quench)
16. Solution Heat Treat - Stretch 10% in W Condition (after quench)

In these cases where the required stretch was 8% or greater, the extrusion web was separated from the flanges for stretching. This was done because the load required for the full cross section exceeded the capacity of the machine.

ANALYSIS**PREPARED BY R. J. Haney****CHECKED BY W. E. Wise****REVISED BY****CONVAIR**

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The following types of test coupons were machined from each of the processed extrusions, and are shown in the indicated figures:

1. Standard longitudinal tensile - Figure 2.
2. Sub size longtransverse tensile - Figure 3.
3. Compression Specimen - Figure 4.
4. Unnotched axial fatigue specimen - Figure 5.
5. Unnotched bending fatigue specimen - Figure 6.

The compression, axial fatigue and bending fatigue specimens were also obtained from both the longitudinal and transverse grain directions. In all cases the material was naturally aged for at least four days prior to testing.

Some specimens were taken from the vertical leg of the extrusion. These are identified as "web" specimens, the others as "flange" specimens.

TEST LOADS AND PROCEDURE:

Tension and compression tests were performed in a Tinius-Olsen Electro-Matic Universal testing machine using the automatic strain rate controller to give .005 in./in./minute strain rate to yield, and .2 inch/minute crosshead speed from yield to ultimate. Percent elongation was measured over a 2 inch gage length.

Fatigue tests were performed in a Sonntag SF-1U fatigue machine as shown in Figures 7 and 8. The axial fatigue specimens were tested at four or more stress levels to produce an S-N diagram for each of the test conditions. The stress ratio for the axial fatigue tests was +.05. The bending fatigue specimens were all tested at $\pm 35,000$ PSI, a stress ratio of -1.0.

Thickness measurements were taken at six locations on each leg of the extrusions prior to stretching and after each stretch operation, to provide change in thickness data.

RESULTS AND DISCUSSION OF RESULTS:

The tension and compression test results are given in Tables I and II. Tensile properties are plotted in Figure 14.

ANALYSIS**PREPARED BY R. J. Haney****CHECKED BY W. E. Wise****REVISED BY****CONVAIR**A DIVISION OF GENERAL DYNAMICS CORPORATION
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The axial fatigue test results are given in Tables III to X, and are plotted in Figure 9 and 10 as envelope type S-N diagrams. In Figures 11 and 12, the axial fatigue results are plotted against the stretching and temper conditions for each of the test stress levels. In this type of data presentation, trends are indicated by the slope of the average result curve. If the curve slopes to the right, it indicates relative improvement in fatigue life as a result of the processing. A vertical line indicates no change in fatigue life, and a slope to the left represents a loss in life. A trend is significant only if observed at each stress level. Quantative evaluation of results is obtained by comparing the life of the point in question with the life plotted on the abscissa for heat treated but unstretched material.

The reversed bending fatigue results are given in Tables XI to XVIII and are plotted in Figure 13.

The change in material thickness resulting from stretching is given in Table XIX.

CONCLUSIONS:

In all cases the extrusion properties equalled or exceeded the requirements for 2024-T42 material given in ANC-5. In general, the ultimate strengths were considerably higher than 2024-T42 minimums, and elongation values were close to 2024-T42 minimums.

It is important to note that the extrusion used for this evaluation can not be stretched 8% in the full cross section, because the load required exceeds the capacity of the stretching machine.

NOTE: The test Data from which this report was prepared are recorded in Structures Test Laboratory Data Book No. 389, Pages 62 to 89.

Prepared by: R. J. Mauer
 CORNELL
 SAN DIEGO

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TABLE I
 MECHANICAL PROPERTIES STRETCHED 2024 EXTRUSION

STRETCH PROCESSING				LONGITUDINAL MECHANICAL PROPERTIES				AVERAGES				INDIVIDUAL TESTS				MECHANICAL PROPERTIES				AVERAGES			
FILAMENT OF EXTRUSION BY CASE DESIGN NUMBER	DESIGN NO.	ACTUAL %	DESIGN %	Fty Psi	Fty Psi	Fty Psi	Fty Psi	Elong. %	Fty Psi	Fty Psi	Fty Psi	Fty Psi	Fty Psi	Fty Psi	Fty Psi	Elong. %	Fty Psi	Fty Psi	Fty Psi	Elong. %	Fty Psi	Fty Psi	Fty Psi
1	0	0	—	52,400	78,850	13.5	53,700	—	—	—	—	50,200	73,700	18.0	54,600	—	—	—	—	—	—	—	—
2	3	3.2	—	50,980	77,720	16.0	54,000	—	—	—	—	47,900	72,500	19.5	52,600	—	—	—	—	—	—	—	—
3	3	3.2	—	42,540	66,400	20.0	44,745	—	—	—	—	45,600	68,800	9.0	45,900	—	—	—	—	—	—	—	—
4	10	8.45	—	41,220	65,360	21.5	47,200	—	—	—	—	43,800	66,500	9.0	47,815	—	—	—	—	—	—	—	—
5	6	6.25	—	42,400	67,125	20.0	47,100	—	—	—	—	43,400	67,900	11.5	48,600	—	—	—	—	—	—	—	—
6	10	8.45	—	41,550	66,450	19.5	46,300	—	—	—	—	42,500	67,600	12.0	45,900	—	—	—	—	—	—	—	—
7	6	7.64	—	42,250	67,400	21.5	46,675	—	—	—	—	43,700	68,400	11.5	47,150	—	—	—	—	—	—	—	—
8	6	5.64	—	59,000	66,900	20.5	42,300	—	—	—	—	43,800	68,000	10.5	47,105	—	—	—	—	—	—	—	—
9	6	5.97	—	50,400	66,200	18.5	44,400	—	—	—	—	47,900	67,400	8.0	52,195	—	—	—	—	—	—	—	—
10	6	5.97	—	51,330	64,260	21.0	43,200	—	—	—	—	46,900	66,800	9.0	49,700	—	—	—	—	—	—	—	—
11	6	5.97	—	59,000	66,300	20.0	44,900	—	—	—	—	49,000	67,600	10.0	53,885	—	—	—	—	—	—	—	—
12	6	5.97	—	51,420	64,485	19.0	39,750	—	—	—	—	48,700	67,400	10.0	55,900	—	—	—	—	—	—	—	—
13	6	6.53	—	56,100	66,500	13.5	45,300	—	—	—	—	48,270	67,195	10.0	55,000	—	—	—	—	—	—	—	—
14	6	6.53	—	55,700	66,800	15.5	44,700	—	—	—	—	48,800	68,000	11.5	54,955	—	—	—	—	—	—	—	—
15	6	6.39	—	59,600	64,175	15.5	47,145	—	—	—	—	48,370	67,335	11.0	55,100	—	—	—	—	—	—	—	—
16	6	6.39	—	55,600	64,600	19.0	47,200	—	—	—	—	52,965	68,375	6.0	56,525	—	—	—	—	—	—	—	—
17	6	5.83	—	56,800	66,000	15.5	47,200	—	—	—	—	54,600	70,200	6.0	56,525	—	—	—	—	—	—	—	—
18	6	5.83	—	57,585	66,360	15.0	45,715	—	—	—	—	53,120	68,085	7.0	56,900	—	—	—	—	—	—	—	—
19	6	5.83	—	61,000	67,200	11.0	52,300	—	—	—	—	53,000	66,500	4.0	62,000	—	—	—	—	—	—	—	—
20	6	5.83	—	61,500	67,900	9.0	51,700	—	—	—	—	54,000	68,100	4.0	59,405	—	—	—	—	—	—	—	—
21	6	5.83	—	61,000	67,760	15.0	49,795	—	—	—	—	54,000	67,200	3.5	58,900	—	—	—	—	—	—	—	—
22	6	5.83	—	58,300	67,400	15.0	50,200	—	—	—	—	55,000	72,300	7.0	60,225	—	—	—	—	—	—	—	—
23	6	5.83	—	60,000	69,700	11.0	50,800	—	—	—	—	53,300	71,700	9.0	62,100	—	—	—	—	—	—	—	—
24	6	5.83	—	57,140	68,095	19.5	49,175	—	—	—	—	53,900	72,100	8.5	58,100	—	—	—	—	—	—	—	—
25	6	6.39	—	64,200	71,200	17.0	59,000	—	—	—	—	57,100	72,000	9.5	62,500	—	—	—	—	—	—	—	—
26	6	6.39	—	64,900	71,000	13.0	53,200	—	—	—	—	57,800	72,500	11.0	63,230	—	—	—	—	—	—	—	—
27	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
28	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
29	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
30	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
31	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
32	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
33	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
34	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
35	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
36	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
37	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
38	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
39	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
40	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
41	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
42	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
43	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
44	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
45	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
46	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
47	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
48	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
49	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
50	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
51	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
52	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
53	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
54	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
55	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
56	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
57	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
58	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—
59	6	6.39	—	63,715	69,645	16.0	50,380	—	—	—	—	56,000	73,200	10.0	60,600	—	—	—	—	—	—	—	—

TABLE II
MECHANICAL PROPERTIES STRETCHED 2024 EXTRUSION

[illegible]

Prepared by: R. J. Harvey
H. Henderson

TABLE III

AXIAL FATIGUE TEST RESULTS - STRETCHED 2024 EXTRUSIONS

SPEC. GROUP	PROCESSING	APPLIED TO EXTRUSION	HEAT TREAT	LOCATION	GRAIN	ROCKWELL C	MAX SURF IN L	MAX STRESS (PSI)	CYCLES TO FAILURE
1	NO STRETCH	SOLUTION	HEAT TREAT	F	T	101.4	16	55,000	42,000
"	"	"	"	F	T	102.9	14	50,000	67,000
"	"	"	"	F	T	100.6	16	45,000	217,000
"	"	"	"	W	T	98.8	10	42,500	300,000
"	"	"	"	F	T	99.5	12	40,000	1,613,000 U
"	"	"	"	F	L	102.0	27	55,000	27,000
"	"	"	"	F	L	97.5	17	50,000	111,000
"	"	"	"	W	L	101.0	9	45,000	302,000
"	"	"	"	F	L	99.6	17	42,500	80,000
"	"	"	"	F	L	101.2	14	40,000	454,000
"	"	"	"	W	L	100.3	9	37,500	6,825,000 U
2	STRETCHED 32% THEN SOL.	HEAT TREATED	"	F	T	102.5	18	55,000	15,000
"	"	"	"	F	T	101.6	20	50,000	23,000
"	"	"	"	F	T	101.9	24	45,000	126,000
"	"	"	"	W	T	98.3	12	42,500	153,000
"	"	"	"	F	T	100.9	9	40,000	6,585,000 U
"	"	"	"	F	L	99.5	10	55,000	28,000
"	"	"	"	F	L	100.0	15	50,000	38,000
"	"	"	"	F	L	100.8	13	45,000	59,000
"	"	"	"	F	L	100.4	16	40,000	212,000
"	"	"	"	W	L	100.5	12	37,500	544,000
"	"	"	"	W	L	101.3	7	35,000	1,997,000 U

① W=WEB F=FLANGE ② L=LONGITUDINAL, T=TRANSVERSE ③ R=1.05 ④ U=UNFATIGUED

Prepared by: R. J. Hancy
A. J. Hancy

TABLE IV
AXIAL FATIGUE TEST RESULTS - STRETCHED 2024 EXTRUSIONS

SPEC. GROUP	PROCESSING APPLIED TO EXTRUSION	LOCATION	GRAIN	ROCKWELL C ₄₅	MAX. SURF. FIN. (μm)	MAX. STRESS (PSI)	CYCLES TO FAILURE
3	STRETCHED 6.3% THEN SOL. H.T.	F	T	101.7	11	55,000	26,000
"	" " " " " "	F	T	101.0	11	50,000	85,000
"	" " " " " "	F	T	100.5	8	45,000	43,000
"	" " " " " "	W	T	101.0	11	45,000	53,000
"	" " " " " "	W	T	101.7	10	42,500	79,000
"	" " " " " "	F	T	101.4	11	40,000	1,437,000 U
"	" " " " " "	F	L	101.8	11	55,000	19,000
"	" " " " " "	F	L	100.6	14	50,000	51,000
"	" " " " " "	F	L	101.2	10	45,000	64,000
"	" " " " " "	W	L	100.1	10	42,500	92,000
"	" " " " " "	F	L	98.6	12	40,000	966,000
4	STRETCHED 9.5% THEN SOL. H.T.	F	T	102.6	12	55,000	23,000
"	" " " " " "	F	T	102.5	8	50,000	47,000
"	" " " " " "	F	T	102.5	13	45,000	75,000
"	" " " " " "	W	T	101.8	11	42,500	235,000
"	" " " " " "	F	T	101.0	13	40,000	1,035,000 U
"	" " " " " "	F	L	100.4	17	55,000	21,000
"	" " " " " "	F	L	99.9	10	50,000	39,000
"	" " " " " "	F	L	102.4	14	45,000	73,000
"	" " " " " "	W	L	101.3	15	42,500	67,000
"	" " " " " "	W	L	101.2	13	40,000	1,000
"	" " " " " "	F	L	100.1	21	40,000	1,471,000 U

① W=WEB, F=FLANGE ② L=LONGITUDINAL, T=TRANSVERSE ③ R=±0.5 ④ U=UNFAILED

Prepared by R. J. Handy
H. Gendreau

TABLE V

SPEC GROUP	AXIAL		LOCATION	GRAIN	ROCKWELL		MAX. STRESS (PSI)	CYCLES TO FAILURE
	PROCESSING	APPLIED TO EXTRUSION			"E"	"T"		
5	STR. 6% SOL. H.T. STRETCH 2.2% IN W' COND.							
"	"	"	F	T	101.5	11	55,000	12,000
"	"	"	F	T	99.9	35	50,000	41,000
"	"	"	F	T	101.0	11	45,000	115,000
"	"	"	F	T	100.1	35	40,000	147,000
"	"	"	W	T	100.5	10	37,500	1,844,000 U
"	"	"						
"	"	"	F	L	100.0	13	55,000	21,000
"	"	"	F	L	100.5	19	50,000	31,000
"	"	"	F	L	100.0	12	45,000	126,000
"	"	"	F	L	104.5	16	40,000	315,000
"	"	"	W	L	100.7	16	37,500	605,000
"	"	"	W	L	101.0	14	35,000	407,000
"	"	"						
6	STR. 3% SOL. H.T. STRETCH 3.2% IN W' COND.							
"	"	"	F	T	101.8	10	55,000	21,000
"	"	"	F	T	98.8	11	50,000	35,000
"	"	"	F	T	101.9	11	45,000	86,000
"	"	"	F	T	101.5	11	40,000	370,000
"	"	"	W	T	100.1	13	37,500	1,594,000 U
"	"	"						
"	"	"	F	L	102.0	15	55,000	17,000
"	"	"	F	L	103.3	13	50,000	38,000
"	"	"	F	L	102.0	17	45,000	219,000
"	"	"	F	L	103.0	16	40,000	252,000
"	"	"	W	L	101.3	15	37,500	2,382,000 U

(1) W=WEB, F=FLANGE (2) L=LONGITUDINAL, T=TRANSVERSE (3) K=KOS (4) U=UNFAILED

Prepared by, R. J. Hanger
A. J. Hanger

TABLE VI

AXIAL FATIGUE TEST RESULTS - STRETCHED 2024 EXTRUSIONS

STRETCH GROUP	PROCESSING	APPLIED TO EXTRUSION	LOCATION	GRAIN	ROTTWELL E ²	MAX SURFACE L	T	MAX STRESS (PSI)	CYCLES TO FAILURE
7	STRETCH 6% SOL. H.T.	STRETCH 4.7% IN W/END	F	T	102.1	14	25	55,000	19,000
"	"	"	F	T	100.5	25.5	72.5	50,000	56,000
"	"	"	F	T	101.9	12	24	45,000	108,000
"	"	"	F	T	101.5	12	68	40,000	298,000
"	"	"	W	T	103.0	15	24	35,000	1,293,000 U
"	"	"	F	L	103.3	12	22	55,000	20,000
"	"	"	F	L	102.5	13	28	59,000	6,000
"	"	"	F	L	102.7	12	24	45,000	117,000
"	"	"	W	L	102.8	15	25	42,500	800,000
"	"	"	F	L	103.4	16	35	40,000	1,484,000
11	STRETCH 6% SOL. H.T.	STRETCH 4% AFTER PLATE	F	T	102.7	14	24	55,000	23,000
"	"	"	F	T	104.3	16	24	50,000	65,000
"	"	"	F	T	103.0	13	24	45,000	129,000
"	"	"	F	T	104.0	20	22	42,500	459,000
"	"	"	F	T	104.5	15	21	40,000	1,517,000
"	"	"	F	L	105.9	20	28	55,000	14,000
"	"	"	F	L	102.7	14	23	50,000	65,000
"	"	"	F	L	105.5	10	24	45,000	139,000
"	"	39%	W	L	104.1	13	24	42,500	737,000
"	"	4%	F	L	103.8	13	23	40,000	1,162,000 U

① W=WEB, F=FLANGE ② L=LONGITUDINAL, T=TRANSVERSE ③ K=1.05 ④ U=UNFAILED

10-19-69
 J. J. Hinkley

TABLE VII
 AXIAL FATIGUE TEST RESULTS - STRETCHED 2024 EXTRUSIONS

SPEC. GROUP	PROCESSING APPLIED TO EXTRUSION	LOCATION	GRAIN	REDUCED MAX. SUBST. ENCL. (IN)	MAX. STRESS (PSI)	CYCLES TO FAILURE
8	STRETCH 6% SOL. H.T. STRECH 6% W'W' COND.	F	T	102.2	55,000	1,000
"	" " " " " " " "	W	T	101.8	55,000	40,000
"	" " " " " " " "	F	T	101.5	50,000	44,000
"	" " " " " " " "	F	T	102.1	45,000	75,000
"	" " " " " " " "	W	T	101.8	42,500	1,557,000
"	" " " " " " " "	F	T	101.3	40,000	1,000,000 U
"	" " " " " " " "	F	L	102.1	55,000	1,000
"	" " " " " " " "	W	L	102.1	55,000	58,000
"	" " " " " " " "	F	L	103.0	50,000	55,000
"	" " " " " " " "	F	L	101.4	45,000	106,000
"	" " " " " " " "	W	L	101.4	42,500	346,000
"	" " " " " " " "	F	L	102.5	40,000	1,079,000 U
12	STRETCH 6% SOL. H.T. STRECH 6.4% AFTER RT AGE	F	T	105.5	55,000	55,000
"	" " " " " " " "	F	T	104.7	50,000	68,000
"	" " " " " " " "	F	T	104.2	45,000	157,000
"	" " " " " " " "	F	T	104.5	45,000	169,000
"	" " " " " " " "	F	T	104.3	42,500	1,164,000 U
"	" " " " " " " "	F	T	102.9	40,000	1,019,000 U
"	" " " " " " " "	F	L	104.4	55,000	81,000
"	" " " " " " " "	F	L	105.3	50,000	127,000
"	" " " " " " " "	F	L	104.5	45,000	124,000
"	" " " " " " " "	W	L	103.5	42,500	348,000
"	" " " " " " " "	F	L	104.2	40,000	844,000
"	" " " " " " " "	W	L	103.6	37,500	1,962,000 U

① W=WEB, F=FLANGE, ② L=LONGITUDINAL, T=TRANSVERSE ③ K=1.05 ④ U=UNFRAILED

Prepared by R.D. Hardy
H. Anderson

TABLE VIII
AXIAL FATIGUE TEST RESULTS — STRETCHED 2024 EXTRUSIONS

SPEC. GROUP	PROCESSING APPLIED TO EXTRUSION	LOCATION	GRAIN	ROCKWELL "E"	MAX SURF FIN. IN. IN. L	MAX STRESS (PSI)	CYCLES TO FAILURE
9	STRETCH 6% SOL. HT. STRETCH 6.9% IN W COND	F	T	103.8	10	55,000	21,000
"	" " " " " " " "	F	T	101.9	13	50,000	43,000
"	" " " " " " " "	F	T	102.2	17	45,000	99,000
"	" " " " " " " "	F	T	100.9	8	40,000	220,000
"	" " " " " " " "	F	T	102.3	16	37,500	1,976,000
"	" " " " " " " "	F	L	102.3	14	55,000	12,000
"	" " " " " " " "	F	L	103.5	20	50,000	99,000
"	" " " " " " " "	F	L	102.4	16	45,000	229,000
"	" " " " " " " "	W	L	103.2	14	42,500	100,000
"	" " " " " " " "	W	L	103.6	14	42,500	784,000
"	" " " " " " " "	F	L	104.3	14	40,000	1,128,000 U
10	STRETCH 6% SOL. HT. STRETCH 10.3% IN W COND	F	T	103.7	13	55,000	17,000
"	" " " " " " " "	F	T	103.7	11	50,000	84,000
"	" " " " " " " "	F	T	104.5	13	45,000	237,000
"	" " " " " " " "	F	T	102.9	10	40,000	626,000
"	" " " " " " " "	F	T	103.8	15	37,500	1,104,000 U
"	" " " " " " " "	F	L	104.5	10	55,000	22,000
"	" " " " " " " "	F	L	104.7	14	50,000	69,000
"	" " " " " " " "	F	L	103.9	9	45,000	162,000
"	" " " " " " " "	F	L	104.9	12	40,000	622,000
"	" " " " " " " "	W	L	104.2	10	37,500	1,176,000 U

① W = WEB, F = FLANGE ② L = LONGITUDINAL, T = TRANSVERSE ③ R = 1.05 ④ U = UNFINISHED

Prepared by R. J. Henry
H. J. Henderson

TABLE II

ANAL FATIGUE TEST RESULTS - STRETCHED 2024 EXTRUSIONS

TEST NO.	PROCESSING	APPLIED TO EXTRUSIONS	LOCATION	GRAIN	BEVEL IN.	MAX. SURF. FINISH	MAX. STRESS (PSI)	CYCLES TO FAILURE
13	SOLUTION HT. NO STRETCH		F	T	99.3	14	55,000	48,000
"	"	"	F	T	101.5	14	50,000	92,000
"	"	"	F	T	100.8	13	45,000	152,000
"	"	"	F	T	100.5	12	42,500	1,083,000 U
"	"	"	F	T	101.5	15	40,000	1,083,000 U
"	"	"	F	L	102.0	14	55,000	19,000
"	"	"	F	L	100.0	16	50,000	34,000
"	"	"	F	L	101.0	13	SPECIMEN WARPED	
"	"	"	F	L	100.9	16	45,000	56,000
"	"	"	F	L	100.0	17	42,500	133,000
"	"	"	F	L	100.4	16	40,000	1,149,000 U
14	SOLUTION HT. THEN 30% STRETCH		F	T	102.0	14	55,000	24,000
"	"	"	F	T	102.5	13	50,000	82,000
"	"	"	F	T	102.4	13	45,000	260,000
"	"	"	F	T	102.5	10	42,500	187,000
"	"	"	F	T	104.0	14	40,000	1,018,000
"	"	"	F	L	101.0	14	55,000	24,000
"	"	"	F	L	101.9	14	50,000	88,000
"	"	"	F	L	101.6	13	45,000	133,000
"	"	"	F	L	101.1	12	41,400	249,000
"	"	"	F	L	101.5	14	40,000	470,000
"	"	"	F	L	102.1	12	40,000	534,000

① W=WEB, F=FLANGE, ② L=LONGITUDINAL, T=TRANSVERSE ③ R=1.05 ④ U=UNFAILED

Prepared by R. J. Hansen
A. J. Henderson

TABLE I

AXIAL FATIGUE TEST RESULTS — STRETCHED 2024 EXTRUSIONS

SPEC GROUP	PROCESSING	H.T. THEN	6% STRETCH	LOCATION	GRAIN	REVERSE L E"	MAX SURF FIN. (U IN)	MAX. STRESS (PSI)	CYCLES TO FAILURE
15	SOLUTION	H.T. THEN	6% STRETCH	F	T	103.5	12	55,000	61,000
"	"	"	"	F	T	104.7	14	50,000	181,000
"	"	"	"	F	T	103.8	12	45,000	334,000
"	"	"	"	F	T	104.0	10	42,500	459,000
"	"	"	"	F	T	104.3	10	40,000	6,460,000
"	"	"	"	F	L	103.0	12	55,000	52,000
"	"	"	"	F	L	103.8	13	50,000	135,000
"	"	"	"	F	L	104.2	13	45,000	67,000
"	"	"	"	F	L	103.2	15	40,000	121,000
"	"	"	"	F	L	104.0	18	40,000	321,000
"	"	"	"	F	L	104.0	15	37,500	198,000
16	SOLUTION	H.T. THEN	10% STRETCH	F	T	104.0	16	55,000	21,000
"	"	"	"	F	T	104.5	15	50,000	93,000
"	"	"	"	F	T	104.2	14	45,000	169,000
"	"	"	"	F	T	104.0	15	40,000	292,000
"	"	"	"	F	T	104.0	19	37,500	1,450,000 U
"	"	"	"	F	L	104.3	15	55,000	35,000
"	"	"	"	F	L	103.3	17	50,000	97,000
"	"	"	"	F	L	103.0	18	45,000	147,000
"	"	"	"	F	L	104.0	15	40,000	312,000
"	"	"	"	F	L	103.5	15	SPECIMEN WARPED	1,123,000
"	"	"	"	F	L	103.5	15	37,500	1,123,000

① W = WEB, F = FLANGE

② L = LONGITUDINAL, T = TRANSVERSE

③ R = ±0.5

④ U = UNFILED

Prepared by: R. J. King
H. G. Lenneman

TABLE 21
REVERSED BENDING FATIGUE TEST RESULTS
2024 EXTRUSION PROCESSED AS NOTED
MAX. STRESS $\pm$ 35,000 P.S.I. (R = -1)

SPEC. GROUP	PROCESSING PRIOR TO TESTING	TEST SECTION OR GRAIN DIRECTION	ROCKWELL "E"	MAX SURFACE FINISH - U-I-N. LONG. TRANS.	CYCLES TO FAILURE	REMARKS
1	NO STRETCH - SOLUTION HEAT TREAT	TRANS.	99.9	12	136,000	
"	" " " "	"	99.1	13	118,000	
"	" " " "	"	99.7	11	115,000	
"	NO STRETCH - SOLUTION HEAT TREAT AVERAGE	TRANS.	99.1	10	129,000	
"			99.45	11.5	124,500	
"	NO STRETCH - SOLUTION HEAT TREAT	LONG.	102.2	10	134,000	
"	" " " "	"	102.2	14	76,000	
"	" " " "	"	101.4	15	140,000	
"	NO STRETCH - SOLUTION HEAT TREAT AVERAGE	LONG.	99.9	14	39,000	
"			101.4	13.25	97,250	
2	STRETCH 32% - SOLUTION HEAT TREAT	TRANS.	100.0	11	88,000	
"	" " " "	"	100.0	13	74,000	
"	" " " "	"	100.5	14	69,000	
"	STRETCH 32% - SOLUTION HEAT TREAT AVERAGE	TRANS.	99.8	14	89,000	GRIP FAILURE
"			100.1	13	80,000	
"	STRETCH 32% - SOLUTION HEAT TREAT	LONG.	100.4	11	79,000	
"	" " " "	"	101.9	12	78,000	
"	" " " "	"	99.8	11	231,000	GRIP FAILURE
"	STRETCH 32% - SOLUTION HEAT TREAT AVERAGE	LONG.	99.4	11	244,000	
"			100.4	11.25	158,000	

L = LONGITUDINAL
T = TRANSVERSE

ALL FAILURES OCCURRED IN TEST SECTION EXCEPT AS NOTED.

Prepared by: R. J. Hanes
H. Henderson

TABLE XVII
REVERSED BENDING FATIGUE TEST RESULTS
2024 EXTRUSION PROCESSED AS NOTED
MAX. STRESS $\pm 35,000$ P.S.I. (R = -1)

SPEC. GROUP	PROCESSING PRIOR TO TESTING	TEST SECTION GRAIN DIRECTION	ROCKWELL 'E'	MAX. SURFACE FINISH μ -IN. LONG. TRANS.	CYCLES TO FAILURE	REMARKS
3	STRETCH 63% - SOLUTION HEAT TREAT	TRANS.	101.4	14	43,000	
"	" " " " " "	"	99.8	11	110,000	
"	" " " " " "	"	100.0	16	65,000	
"	STRETCH 63% - SOLUTION HEAT TREAT AVER.	TRANS.	99.3	14	61,000	
"			100.1	13.75	69,750	
"	STRETCH 63% - SOLUTION HEAT TREAT	LONG.	101.4	12	149,000	GRIP FAILURE
"	" " " " " "	"	102.1	12	139,000	
"	" " " " " "	"	101.0	13	103,000	
"	STRETCH 63% - SOLUTION HEAT TREAT AVER.	LONG.	100.1	14	158,000	
"			101.15	12.75	137,250	
4	STRETCH 95% - SOLUTION HEAT TREAT	TRANS.	100.7	13	63,000	
"	" " " " " "	"	100.5	12	78,000	
"	" " " " " "	"	100.5	18	78,000	
"	STRETCH 95% - SOLUTION HEAT TREAT AVER.	TRANS.	101.3	13	86,000	
"			100.75	14	76,250	
"	STRETCH 95% - SOLUTION HEAT TREAT	LONG.	102.0	11	297,000	GRIP FAILURE
"	" " " " " "	"	101.5	9	255,000	
"	" " " " " "	"	99.7	12	87,000	
"	STRETCH 95% - SOLUTION HEAT TREAT AVER.	LONG.	100.8	13	82,000	
"			101.0	11.25	182,500	
L=LONGITUDINAL T=TRANSVERSE ALL FAILURES OCCURRED IN TEST SECTION EXCEPT AS NOTED.						

TABLE VIII

REVERSED BENDING FATIGUE TEST RESULTS
2024 EXTRUSION PROCESSED AS NOTED
MAX. STRESS $\pm 35,000$ PSI (R = -1)

Prepared By: R. J. Hines
H. J. Henderson

SPEC. GROUP	PROCESSING PRIOR TO TESTING	TEST SECTION SPRAIN DIRECTION	ROCKWELL 'E'	MAX. SURFACE FINISH μ -IN.	CYCLES TO FAILURE	REMARKS
5	STRETCH 6%-SOL. H.T.-STRETCH 22% IN W COND.	TRANS.	100.3	12	55	100,000
"	" " " " " " " "	"	101.5	12	19	74,000
"	" " " " " " " "	"	101.0	11	19	53,000
"	STRETCH 6%-SOL. H.T.-STRETCH 22% IN W COND.	TRANS.	100.0	14	26	69,000
	AVER.		100.7	12.25	29.75	74,000
"	STRETCH 6%-SOL. H.T.-STRETCH 22% IN W COND.	LONG.	102.3	9	18	71,000
"	" " " " " " " "	"	100.8	14	21	47,000
"	" " " " " " " "	"	101.0	13	35	48,000
"	STRETCH 6%-SOL. H.T.-STRETCH 22% IN W COND.	LONG.	100.5	11	21	43,000
	AVER.		101.15	11.75	23.75	52,250
6	STRETCH 6%-SOL. H.T.-STRETCH 32% IN W COND.	TRANS.	102.2	12	20	50,000
"	" " " " " " " "	"	102.2	15	23	88,000
"	" " " " " " " "	"	102.3	13	26	65,000
"	STRETCH 6%-SOL. H.T.-STRETCH 32% IN W COND.	TRANS.	103.0	11	23	76,000
	AVER.		102.4	12.75	23	69,750
"	STRETCH 6%-SOL. H.T.-STRETCH 32% IN W COND.	LONG.	101.5	15	25	330,000
"	" " " " " " " "	"	105.0	13	26	104,000
"	" " " " " " " "	"	102.7	14	25	55,000
"	STRETCH 6%-SOL. H.T.-STRETCH 32% IN W COND.	LONG.	102.3	15	25	80,000
	AVER.		102.9	14.25	25.25	79,670
TRANS= TRANSVERSE LONG= LONGITUDINAL ALL FAILURES OCCURRED IN TEST SECTION EXCEPT AS NOTED.						

TABLE VII

REVERSED BENDING FATIGUE TEST RESULTS
2024 EXTRUSION PROCESSED AS NOTED
MAX. STRESS $\pm 35,000$ P.S.I. (R = -1)

SPEC. GROUP	PROCESSING PRIOR TO TESTING	TEST SECTION GRAIN DIRECTION	ROCKWELL "E"	MAX. SURFACE FINISH μ -IN.	CYCLES TO FAILURE	REMARKS
7	STRETCH 6% - SOL. H.T. - STRETCH 4% IN W/COND	TRANS.	100.7	LONG. 12	65,000	
"	" " " " " " " "	"	101.3	20	80,000	
"	" " " " " " " "	"	101.1	28	64,000	
"	STRETCH 6% - SOL. H.T. - STRETCH 4% IN W/COND AVER.	TRANS.	101.6	25	51,000	
"	" " " " " " " "	"	101.2	23.50	65,000	
"	STRETCH 6% - SOL. H.T. - STRETCH 4% IN W/COND	LONG.	102.8	21	89,000	
"	" " " " " " " "	"	103.1	19	52,000	
"	" " " " " " " "	"	101.1	28	86,000	
"	STRETCH 6% - SOL. H.T. - STRETCH 4% IN W/COND AVER.	LONG	101.2	21	85,000	
"	" " " " " " " "	"	102.05	22.25	78,000	
//	STRETCH 6% - SOL. H.T. - STRETCH 4% AFTER ROOM TEMP. AVER.	TRANS.	102.0	17	20,000	GRIP FAILURE
"	" " " " " " " "	"	106.0	18	—	OVERLOADED
"	" " " " " " " "	"	103.1	28	84,000	GRIP FAILURE
"	STRETCH 6% - SOL. H.T. - STRETCH 4% AFTER ROOM TEMP. AVER.	TRANS.	102.7	27	55,000	
"	" " " " " " " "	"	102.95	22.5	53,000	
"	STRETCH 6% - SOL. H.T. - STRETCH 4% AFTER ROOM TEMP. AVER.	LONG	103.5	19	99,000	
"	" " " " " " " "	"	104.0	20	121,000	
"	" " " " " " " "	"	102.2	23	54,000	
"	STRETCH 6% - SOL. H.T. - STRETCH 4% AFTER ROOM TEMP. AVER.	LONG	102.1	27	82,000	
"	" " " " " " " "	"	102.95	22.25	89,000	
TRANS = TRANSVERSE LONG = LONGITUDINAL						
ALL FAILURES OCCURRED IN TEST SECTION EXCEPT AS NOTED.						

TABLE IV

REVERSED BENDING FATIGUE TEST RESULTS
2024 EXTRUSION PROCESSED AS NOTED
MAX. STRESS $\pm 35,000$ P.S.I. (R = -1)

SPEC.	PROCESSING PRIOR TO TESTING	TEST SECTION GRAIN DIRECTION	ROCKWELL 'E'	MAX. SURFACE FINISH U-IN.	CYCLES TO FAILURE	REMARKS
8	STRETCH 6%-SOL. H.T.-STRETCH 6% IN W COND.	TRANS.	102.4	13	21	75,000
"	" " " " " " " "	"	102.5	12	20	72,000
"	" " " " " " " "	"	101.6	12	23	74,000
"	STRETCH 6%-SOL. H.T.-STRETCH 6% IN W COND. AVER.	TRANS.	102.5	18	25	78,000
			102.25	13.75	22.25	74,750
"	STRETCH 6%-SOL. H.T.-STRETCH 6% IN W COND.	LONG.	102.1	13	23	100,000
"	" " " " " " " "	"	102.0	12	19	66,000
"	" " " " " " " "	"	102.2	12	21	36,000
"	STRETCH 6%-SOL. H.T.-STRETCH 6% IN W COND. AVER.	LONG.	101.9	14	22	59,000
			102.05	12.75	21.25	65,250
12	STRETCH 6%-SOL. H.T.-STRETCH 6% AFTER R.T. AGE	TRANS.	104.4	17	24	82,000
"	" " " " " " " "	"	104.0	9	23	63,000
"	" " " " " " " "	"	104.5	14	27	93,000
"	STRETCH 6%-SOL. H.T.-STRETCH 6% AFTER R.T. AGE AVER.	TRANS.	103.8	14	22	103,000
			104.18	13.5	24	85,250
"	STRETCH 6%-SOL. H.T.-STRETCH 6% AFTER R.T. AGE	LONG.	106.5	11	19	85,000
"	" " " " " " " "	"	104.3	14	22	67,000
"	" " " " " " " "	"	105.0	11	20	117,000
"	STRETCH 6%-SOL. H.T.-STRETCH 6% AFTER R.T. AGE AVER.	LONG.	104.4	12	21	119,000
			105.05	12	20.5	97,000
LONG. = LONGITUDINAL TRANS. = TRANSVERSE ALL FAILURES OCCURRED IN TEST SECTION EXCEPT AS NOTED.						

Prepared By: R. J. Hagan
 & J. J. Hagan

TABLE XVI

REVERSED BENDING FATIGUE TEST RESULTS
 2024 EXTRUSION PROCESSED AS NOTED
 MAX. STRESS $\pm 35,000$ PSI. (R = -1)

SPEC. GROUP	PROCESSING	PRIOR TO TESTING	TEST SECTION DIRECTION	ROCKWELL "E"	MAX. SURFACE FINISH	W-IN	CYCLES TO FAILURE	REMARKS
9	STRETCH 6% - SOL.	H.T. - STRETCH 6% IN W/COND.	TRANS.	102.5	15	24	56,000	
"	"	"	"	103.0	10	21	74,000	
"	"	"	"	102.5	14	23	87,000	
"	STRETCH 6% - SOL.	H.T. - STRETCH 6% IN W/COND.	TRANS.	102.2	17	26	63,000	
"	"	"	AVER.	102.55	14	23.5	70,000	
"	STRETCH 6% - SOL.	H.T. - STRETCH 6% IN W/COND.	LONG.	103.0	15	23	96,000	
"	"	"	"	101.5	12	21	119,000	GRIP FAILURE
"	"	"	"	102.3	10	21	105,000	
"	STRETCH 6% - SOL.	H.T. - STRETCH 6% IN W/COND.	LONG.	102.0	10	19	144,000	
"	"	"	AVER.	102.2	11.75	21	116,000	
10	STRETCH 6% - SOL.	H.T. - STRETCH 10% IN W/COND.	TRANS.	103.6	10	19	39,000	
"	"	"	"	104.3	16	23	27,000	
"	"	"	"	104.6	12	19	70,000	GRIP FAILURE
"	STRETCH 6% - SOL.	H.T. - STRETCH 10% IN W/COND.	TRANS.	103.5	14	25	103,000	
"	"	"	AVER.	104.0	13	22	59,750	
"	STRETCH 6% - SOL.	H.T. - STRETCH 10% IN W/COND.	LONG.	106.0	9	19	84,000	
"	"	"	"	104.9	10	21	56,000	
"	"	"	"	104.5	12	23	69,000	
"	STRETCH 6% - SOL.	H.T. - STRETCH 10% IN W/COND.	LONG.	103.8	14	24	36,000	
"	"	"	AVER.	104.8	11.25	21.75	59,500	
"	TRANS. =	TRANS. VERSE						
"	LONG. =	LONG. TUDINAL						
"	ALL FAILURES OCCURRED IN TEST SECTION EXCEPT AS NOTED							

TABLE XVII

REVERSED BENDING FATIGUE TEST RESULTS
2024 EXTRUSION PROCESSED AS NOTED
MAX. STRESS $\pm 35,000$ P.S.I. (R = -1)

SPEC. GROUP	PROCESSING PRIOR TO TESTING	TEST SECTION GRAIN DIRECTION	ROCKWELL "E"	MAX FINISH "U"-IN.	CYCLES TO FAILURE	REMARKS
13	NO STRETCH-SOL.H.T. IN "W" CONDITION	TRANS	101.5	12	128,000	
"	" " " " " "	"	102.0	11	195,000	
"	" " " " " "	"	102.0	10	230,000	
"	NO STRETCH-SOL.H.T. IN "W" CONDITION AVERAGE	TRANS	101.0	13	217,000	
"	" " " " " "	"	101.6	11.5	192,500	
"	NO STRETCH-SOL.H.T. IN "W" CONDITION	LONG.	100.8	16	122,000	
"	" " " " " "	"	99.9	17	171,000	
"	" " " " " "	"	100.2	17	395,000	
"	NO STRETCH-SOL.H.T. IN "W" CONDITION AVERAGE	LONG.	100.0	16	144,000	
"	" " " " " "	"	100.2	16.5	216,000	
14	NO STRETCH-SOL.H.T. STRETCHED 3% IN "W" COND.	TRANS.	102.9	12	127,000	GRIP FAILURE
"	" " " " " "	"	101.9	14	129,000	"
"	" " " " " "	"	102.3	13	177,000	"
"	NO STRETCH-SOL.H.T. STRETCHED 3% IN "W" COND. AVERAGE	TRANS	102.0	14	188,000	"
"	" " " " " "	"	102.3	13.25	155,250	"
"	NO STRETCH-SOL.H.T. STRETCHED 3% IN "W" COND.	LONG.	102.0	17	104,000	
"	" " " " " "	"	101.5	16	159,000	
"	" " " " " "	"	101.0	14	151,000	
"	NO STRETCH-SOL.H.T. STRETCHED 3% IN "W" COND.	LONG.	101.0	13	92,000	
"	" " " " " "	"	101.4	15	128,250	

LONG. = LONGITUDINAL
TRANS. = TRANSVERSE
ALL FAILURES OCCURRED IN TEST SECTION EXCEPT AS NOTED.

Reported By R. J. Hanes
J. J. Henderson

TABLE XVIII
REVERSED BENDING FATIGUE TEST RESULTS
2024 EXTRUSION PROCESSED AS NOTED
MAX STRESS $\pm 35,000$ PSI. ($R = -1$)

SPEC. GROUP	PROCESSING PRIOR TO TESTING	TEST SECTION GRAIN DIRECTION	ROCKWELL "E"	MAX. SURFACE FINISH U-IN	CYCLES TO FAILURE	REMARKS
15	NO STRETCH-SOL.H.T. STRETCHED 6% IN W' COND.	TRANS	102.5	10	178,000	GRIP FAILURE
"	" " " " " "	"	103.0	12	302,000	
"	" " " " " "	"	103.0	11	408,000	
"	NO STRETCH-SOL.H.T. STRETCHED 6% IN W' COND. AVERAGE	TRANS	102.0	11	142,000	
			102.6	11	257,250	
"	NO STRETCH-SOL.H.T. STRETCHED 6% IN W' COND.	LONG	104.1	15	99,000	
"	" " " " " "	"	102.6	15	149,000	
"	" " " " " "	"	103.7	20	187,000	
"	NO STRETCH-SOL.H.T. STRETCHED 6% IN W' COND. AVERAGE	LONG	103.0	12	218,000	
			103.4	15.5	163,250	
16	NO STRETCH-SOL.H.T. STRETCHED 10% IN W' COND.	TRANS.	105.0	12	236,000	GRIP FAILURE
"	" " " " " "	"	105.0	12	232,000	
"	" " " " " "	"	105.0	11	116,000	
"	NO STRETCH-SOL.H.T. STRETCHED 10% IN W' COND. AVERAGE	TRANS.	104.5	11	57,000	
			104.9	11.5	160,250	
"	NO STRETCH-SOL.H.T. STRETCHED 10% IN W' COND.	LONG.	103.5	13	74,000	
"	" " " " " "	"	103.8	14	54,000	
"	" " " " " "	"	105.0	17	62,000	
"	NO STRETCH-SOL.H.T. STRETCHED 10% IN W' COND. AVERAGE	LONG.	103.5	21	47,000	
			104.0	16.25	53,250	
LONG. = LONGITUDINAL TRANS. = TRANSVERSE ALL FAILURES OCCURRED IN TEST SECTION EXCEPT AS NOTED.						

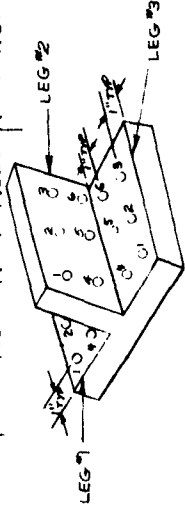
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Report No. 57-997
Model 22
Date 25 June 1958

Expanded by *Handwritten*

TABLE III

REDUCTION IN THICKNESS DUE TO STRETCHING - 2024 EXTRU 4 E 801903

ITEM	EXTENSION PROCESSING FIRST STRETCH OPERATION	STRETCH %	LEG #1						LEG #2 UPRIGHT						LEG #3					
			EDGE #1	EDGE #2	EDGE #3	EDGE #4	EDGE #5	EDGE #6	EDGE #1	EDGE #2	EDGE #3	EDGE #4	EDGE #5	EDGE #6	EDGE #1	EDGE #2	EDGE #3	EDGE #4	EDGE #5	EDGE #6
1	SOL.M.T. AFTER STRETCH	0	.010	.008	.008	.020	.020	.018	.005	.009	.008	.005	.009	.009	.007	.006	.006	.012	.011	.000
2	" " "	3.2	.011	.009	.009	.020	.020	.028	.014	.014	.015	.012	.013	.015	.012	.012	.013	.021	.018	.019
3	" " "	4.3	.013	.013	.012	.019	.018	.020	.015	.014	.014	.017	.018	.018	.011	.011	.012	.025	.028	.027
4	" " "	9.5	.014	.009	.009	.019	.018	.023	.016	.016	.016	.015	.012	.014	.010	.010	.010	.016	.016	.017
5	" " "	7.64	.004	.004	.004	.009	.011	.010	.011	.012	.013	.013	.015	.015	.007	.008	.008	.007	.008	.010
6	" " "	5.69	.004	.004	.005	.016	.014	.012	.016	.015	.013	.017	.013	.012	.005	.004	.004	.009	.008	.007
7	" " "	5.97	.004	.006	.003	.007	.010	.010	.010	.012	.011	.009	.011	.012	.003	.004	.005	.009	.010	.010
8	" " "	5.83	.004	.006	.004	.008	.011	.012	.011	.010	.010	.009	.008	.008	.006	.004	.005	.009	.009	.010
9	" " "	4.99	.004	.005	.005	.007	.008	.009	.009	.010	.010	.006	.007	.009	.006	.004	.005	.007	.009	.009
10	" " "	4.99	.003	.004	.003	.010	.010	.005	.005	.013	.010	.010	.009	.009	.003	.004	.005	.008	.009	.008
11	" " "	5.83	.006	.003	.006	.012	.010	.007	.012	.011	.010	.017	.011	.012	.007	.006	.006	.011	.011	.009
12	" " "																			
13	" " "																			
14	" " "																			
15	SECOND STRETCH	2.21	.008	.006	.006	.002	.005	.003	.002	.003	.002	.001	.007	.002	.003	.005	.002	.001	.002	.002
16	" " "	3.15	.004	.006	.006	.006	.005	.010	.006	.006	.006	.009	.005	.006	.000	.001	.003	.007	.008	.007
17	" " "	4.22	.007	.006	.006	.010	.014	.013	.006	.007	.008	.007	.008	.008	.005	.005	.005	.009	.005	.011
18	" " "	6.00	.003	.003	.003	.007	.007	.007	.007	.007	.009	.008	.008	.008	.004	.004	.003	.008	.006	.008
19	" " "	6.93	.010	.007	.008	.013	.013	.015	.009	.007	.009	.007	.006	.009	.012	.011	.013	.015	.015	.015
20	" " "	10.25	.014	.014	.014	.010	.012	.014	.012	.010	.015	.008	.011	.011	.005	.004	.008	.020	.019	.023
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NOTES:

- (1) TOLERANCES PER QQ-A-245
(EXCLUDING TABLE 24) UNLESS
NOTED.
- (2) DIE NO. 24324, VENDOR-HARVEY
- (3) AREA 4.40
- (4) DIMENSIONS SHOWN ARE THE
DIMENSIONS PRIOR TO
STRETCHING.

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Date 25 June '58

STRUCTURAL TEST
CONVAIR - SAN DIEGO
A DIVISION OF GENERAL DYNAMICS

TITLE
TEE-EQUAL LEGS &
UNEQUAL ANGLES

MODEL SCALE DATE DRAWN BY
S.D. DRAWING NUMBER 2

E 801903

6-899

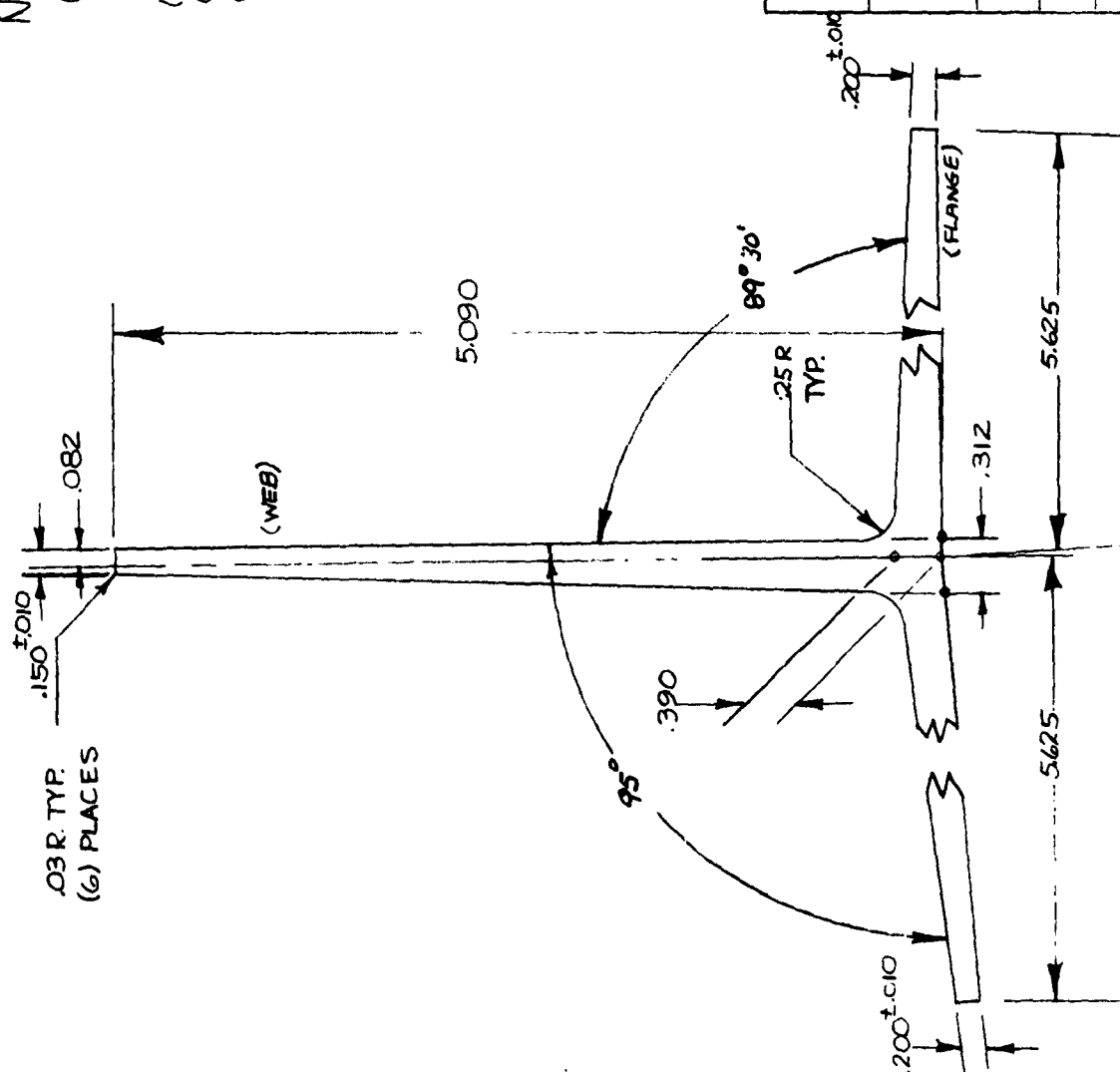
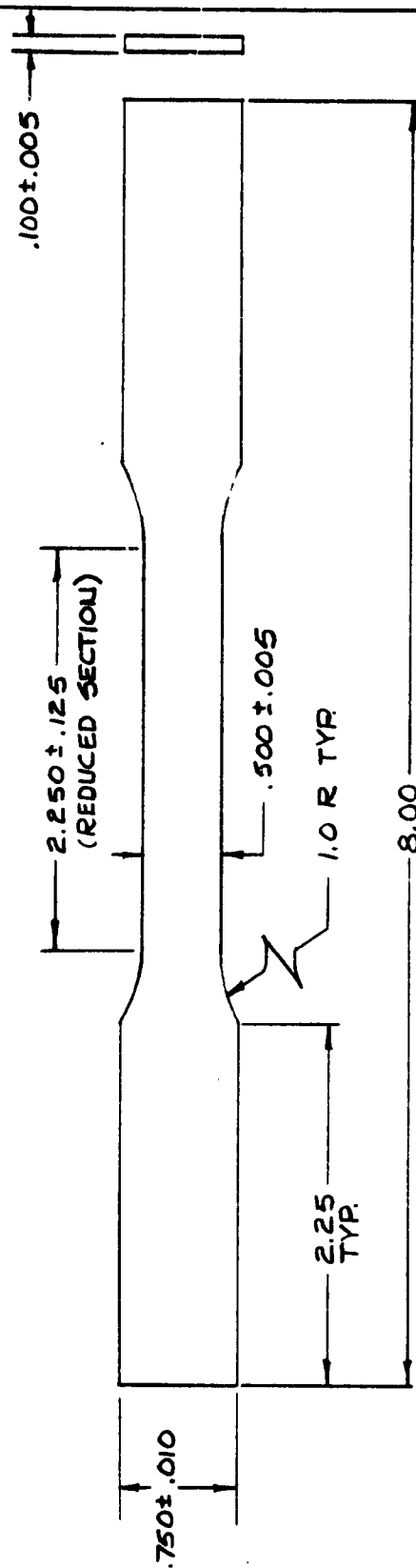


FIGURE 1



STRUCTURAL TEST
CONVAIR - SAN DIEGO
A DIVISION OF GENERAL DYNAMICS

TITLE

STANDARD TENSILE
LONGITUDINAL

MODEL	SCALE	DATE	DRAWN BY
	FULL	4-10-58	BRIGHT

DRAWING NUMBER

S.O.

W.O.

FIGURE 2

CEUTER REDUCED SECTION
TO EQUALIZE GRIP LENGTH.

2.250 $\pm$.125
 $\pm$.000

.750 $\pm$.010

1.062
TYP.

1.0 R TYR

.500 $\pm$.005

5.50 MIN.

RETAIN IDENT.
(MAY BE STAMPED)

XXX

STRUCTURAL TEST
CONVAIR - SAN DIEGO
A DIVISION OF GENERAL DYNAMICS

TITLE
SUB-SIZE TENSILE
LONG TRANSVERSE

MODEL	SCALE	DATE	DRAWN BY
	FULL	4-10-58	BRIGHT

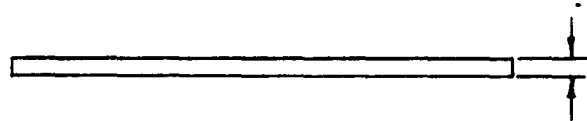
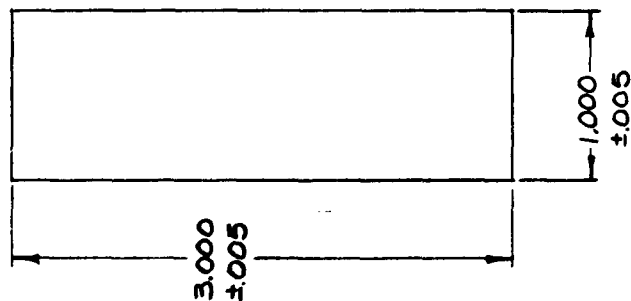
DRAWING NUMBER

S.O.

W.O.

CONVAIR SD - 321

FIGURE 3



SEE NOTE 2.

NOTES:

1. RETAIN RED INK IDENTIFICATION.
DO NOT STEEL STAMP
2. MAX. TAPER .002 - .005 END TO END.
3. ENDS MUST BE FLAT AND PARALLEL. ° 15' PERMISSIBLE ANGULAR DEVIATION

STRUCTURAL TEST
CONVAIR - SAN DIEGO
A DIVISION OF GENERAL DYNAMICS

TITLE

COMPRESSION SPECIMEN
LONGIT. & LONG TRANSVERSE

MODEL SCALE DATE DRAWN BY

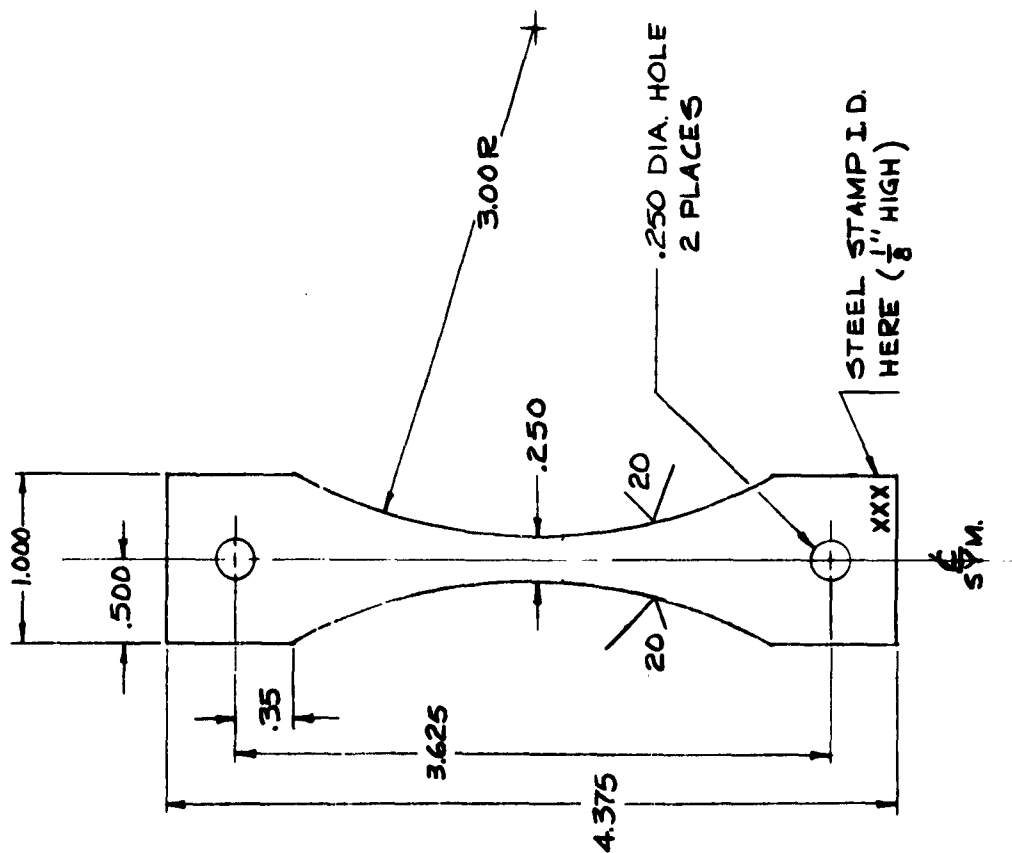
4-10-58 BRIGHT

S.O. W.O. DRAWING NUMBER

FIGURE 4

NOTES:

1. THERE ARE TO BE NO NICK, SCRATCHES OR UNDERCUTS IN TEST SECTION
2. $K_t = 1.025$
3. TOLERANCES:
 $XX \pm .030$
 $XXX \pm .010$



STRUCTURAL TEST
CONVAIR - SAN DIEGO
A DIVISION OF GENERAL DYNAMICS

TITLE
AXIAL FATIGUE SPECIMEN
UNNOTCHED

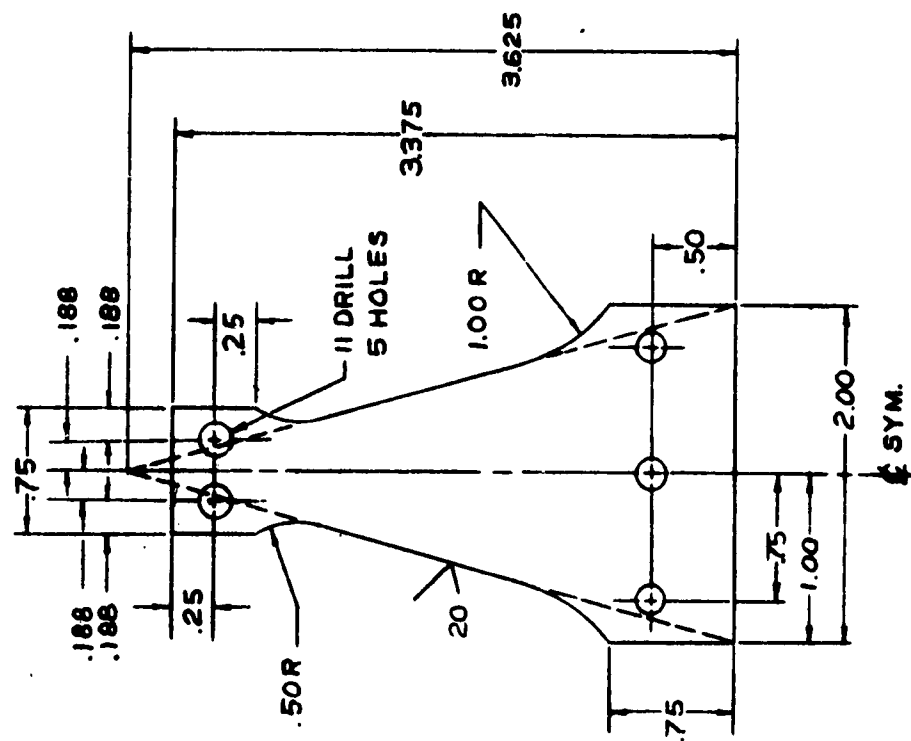
MODEL	SCALE	DATE	DRAWN BY
22	FULL	4-1-58	BRIGHT

DRAWING NUMBER

57-997-1

S.O.	4330
W.O.	30593

FIGURE 5



NOTES:

1. THERE ARE TO BE NO NICKS, SCRATCHES, OR UNDERCUTS IN TEST SECTION.
2. DO NOT GRIND

FIGURE 6

03001

55

CONVAIR 50 - 3213

ANALYSIS
PREPARED BY R. J. Haney
CHECKED BY W. E. Wise
REVISED BY

CONVAIR
A DIVISION OF GENERAL DYNAMICS CORPORATION
SAN DIEGO

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DATE 25 June 1958



Figure 7 AXIAL FATIGUE TEST SET-UP

ANALYSIS
PREPARED BY R. J. Haney
CHECKED BY W. E. Wise
REVISED BY

CONVAIR
A DIVISION OF GENERAL DYNAMICS CORPORATION
SAN DIEGO

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DATE 25 June 1958



Figure 8 BENDING FATIGUE TEST SET - UP

Prepared By: R. J. Flannery
H. J. Anderson

C O N V A I R
A Division of General Dynamics Corporation
Division

MATERIAL: 2024-VARIOUS %STRETCH #H.T. SEQUENCE

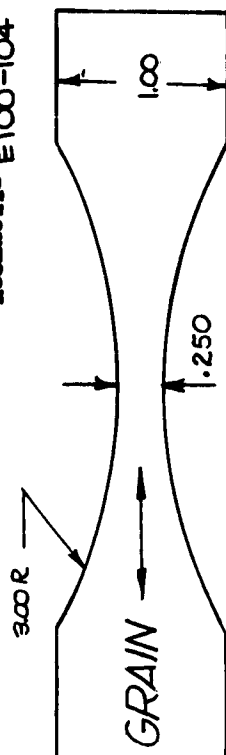
Mfr HARVEY
DIE #24324
F_{tu}

Ht. No. REF TABLES
F_{ty} = I & II

%El. = —

SPECIMEN (Sketch and Dimensions)

Surf. Fin. — 20AL-IN.
Rockwell — E100-104
OR BETTER



TEST SECTION CORRESPOND TO
AIA AXIAL TENSION SPEC. #17
TEST CONDITIONS: Machine SF-10

R = +05 Mean Stress =

Other

Speed 1800 C.P.M. Temp APPROX 70°F

Date: K_t (Net Section) = 1.025

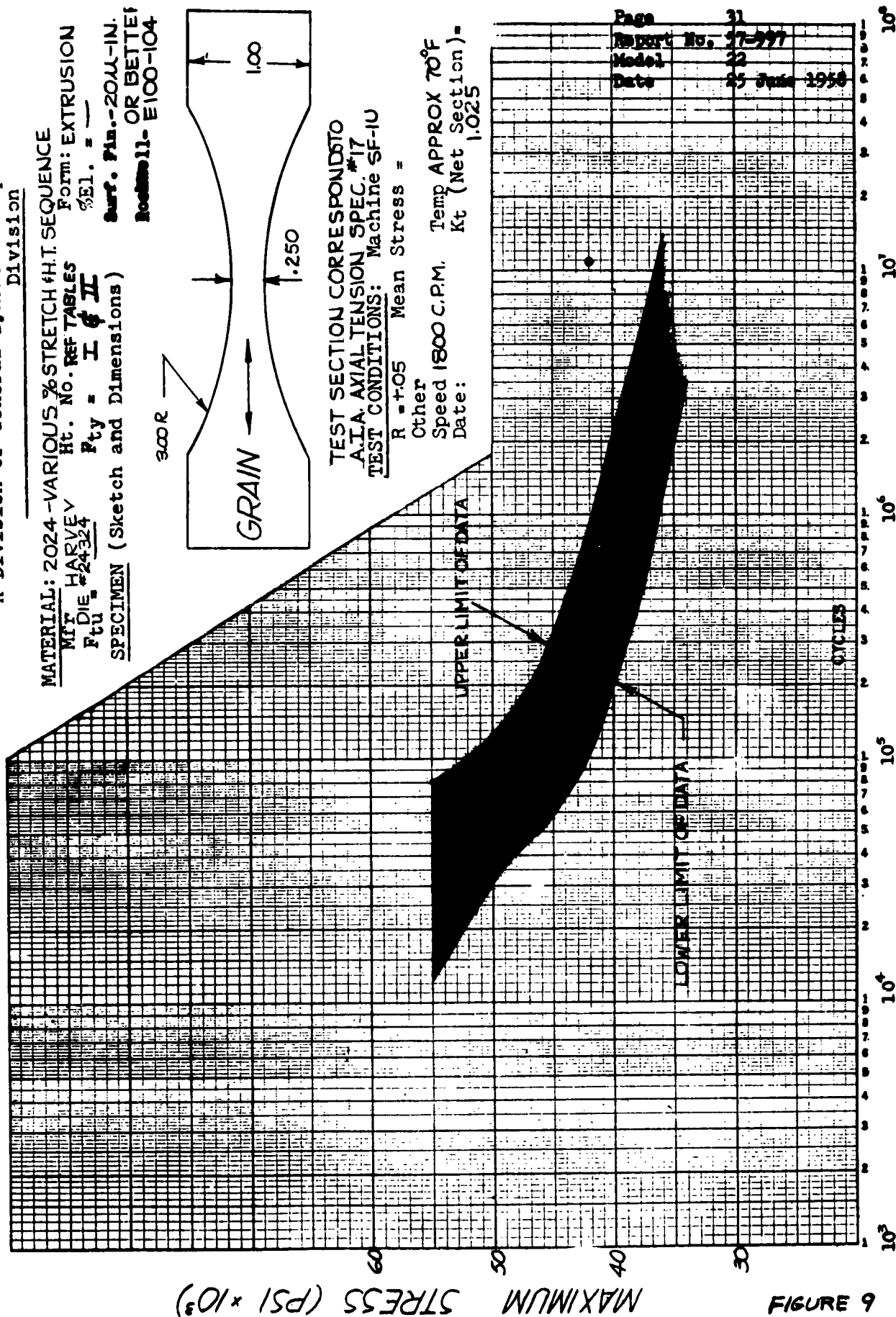
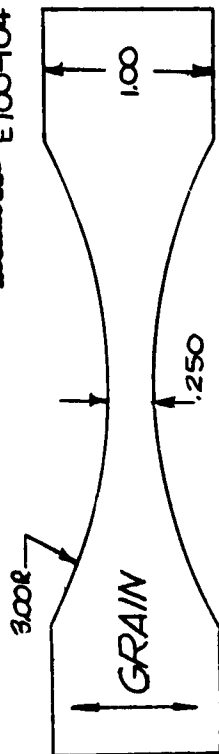


FIGURE 9

Prepared By: R. J. Henry
J. P. Henderson

CONVAIR
A Division of General Dynamics Corporation
Division

MATERIAL: 2024-VARIOUS % STRETCH & H.T. SEQUENCE
Ht. No. REF TABLES Form: EXTRUSION
Fty = I & II %El. = —
SPECIMEN (Sketch and Dimensions)
Surf. Fin. — 2024-IN. OR BETTER
Machine — E100-104



TEST SECTION CORRESPONDS TO

ATA AXIAL TENSION SPEC #17

TEST CONDITIONS: Machine SF-1J

R = ±0.05 Mean Stress =

Other

Speed 1800 CPM

Temp APPROX 70°F

Date:

Kt (Net Section) =

1.025

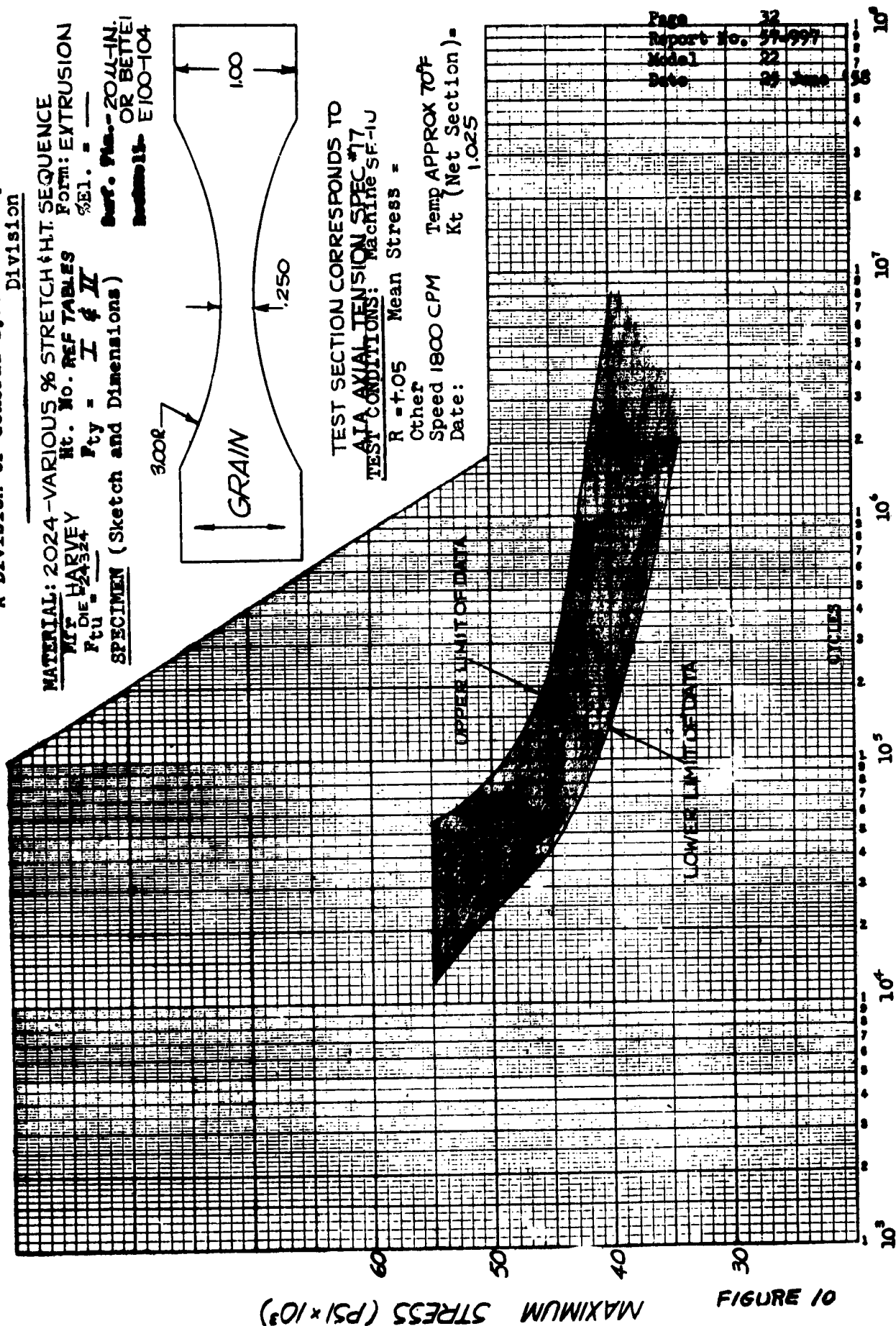


FIGURE 10

Prepared By: R. J. Davis
 NO. 10
 H. J. Henderson

AXIAL TENSION FATIGUE TEST RESULTS - STRAIN

TEST STRESS LEVEL

55,000

55,000

1

10⁴

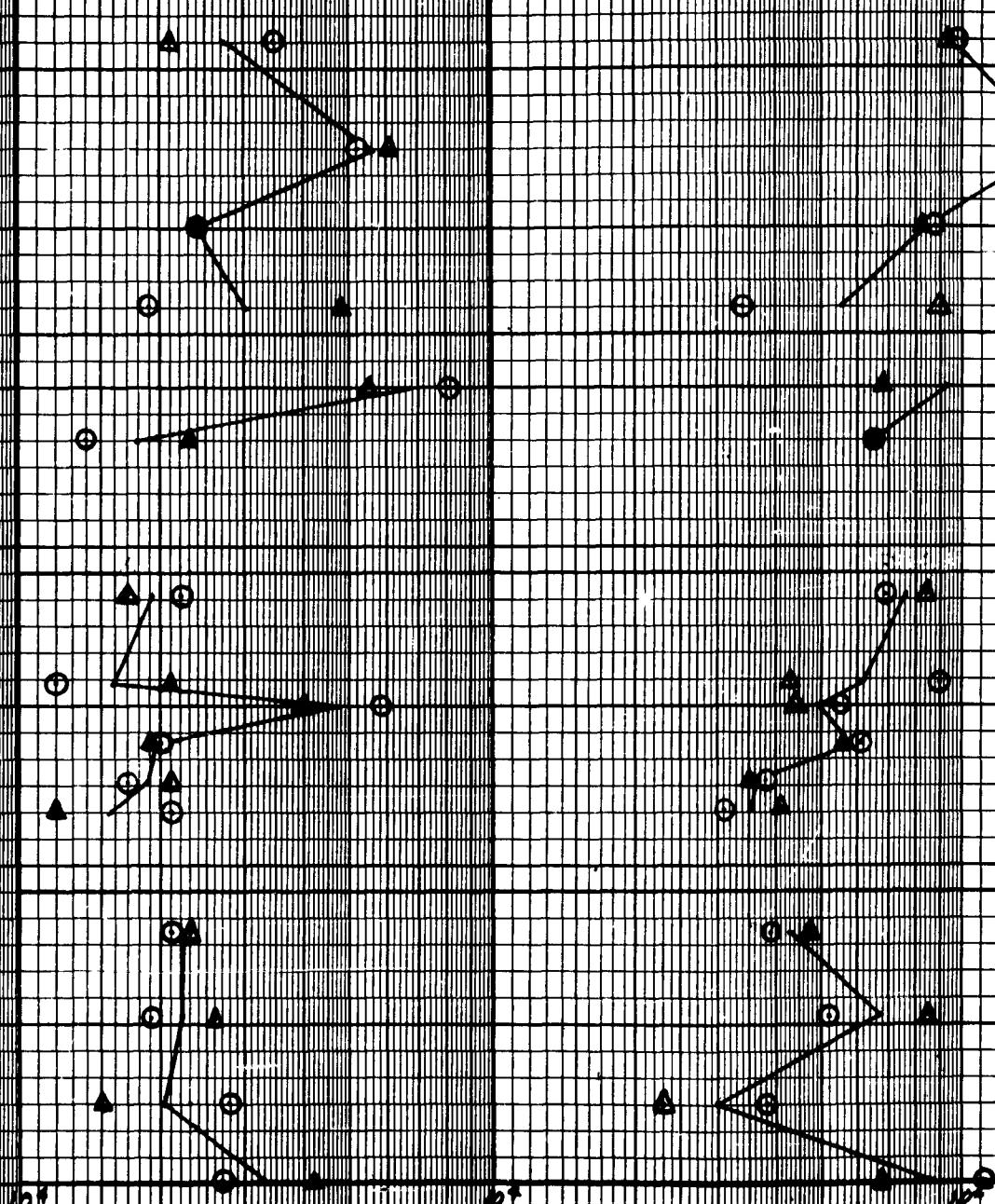
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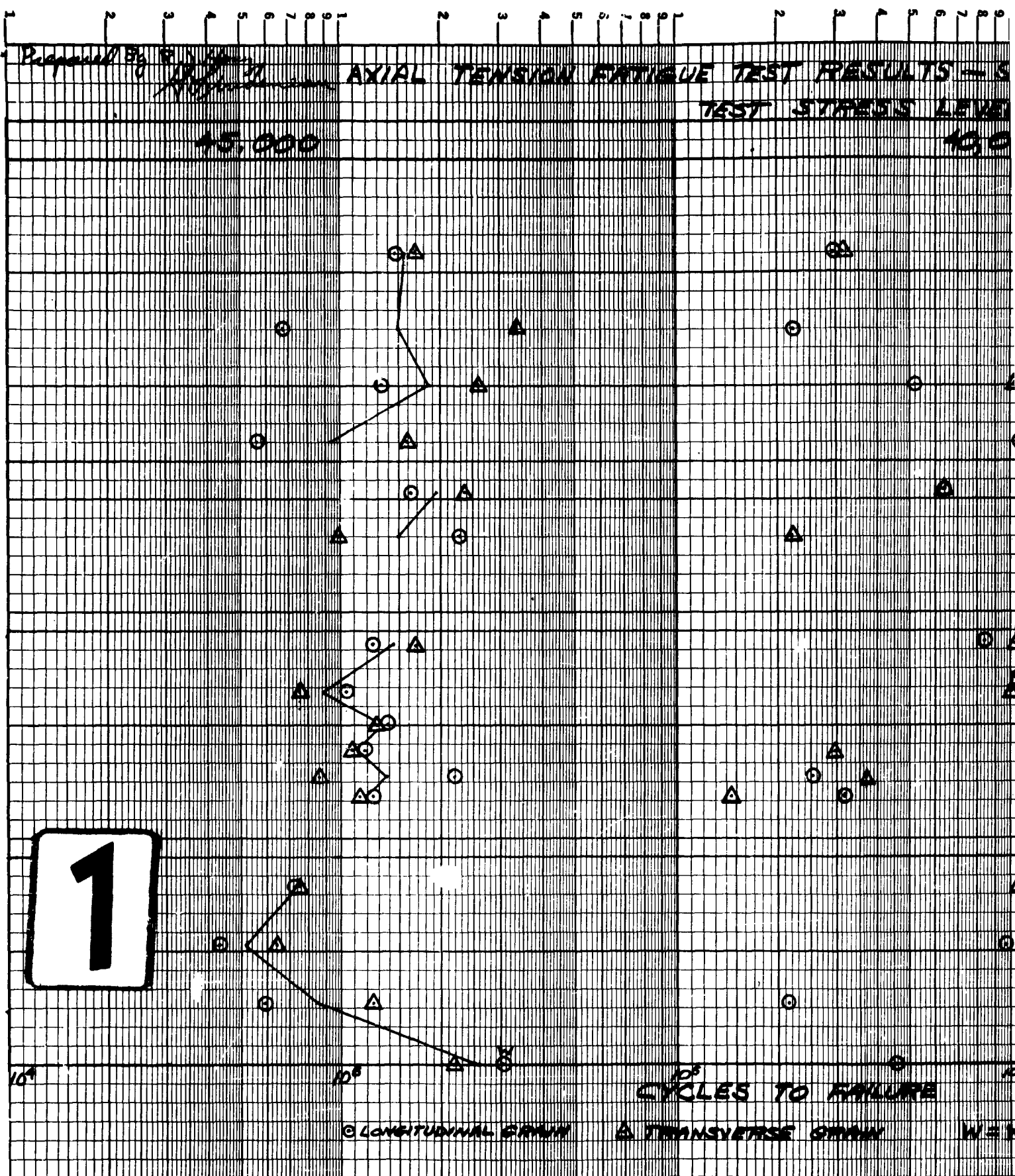
10⁶

CYCLES TO FAILURE

○ LONGITUDINAL GRAIN

▲ TRANSVERSE GRAIN





WE TEST RESULTS - STRETCHED 2024 EXTRUSION

TEST STRESS LEVEL - R.S.I.

10,000

INITIAL
STRETCH%

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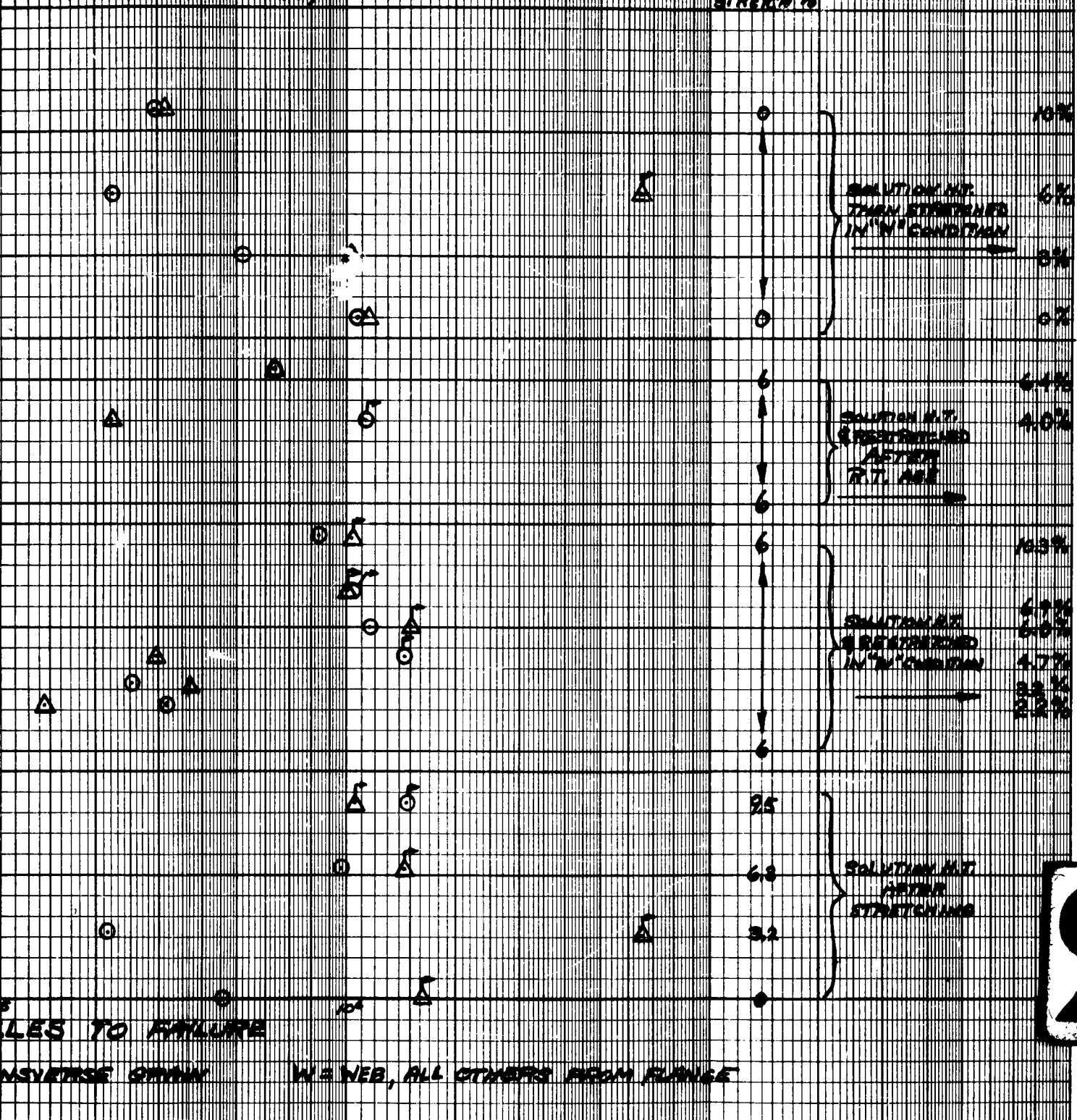


FIGURE 12

Prepared by: R. J. M. [unclear]
[unclear]

REVERSED BENDING FATIGUE TEST RESULTS

385,000

1

10^4

10^5

CYCLES TO FAILURE
○-LONGITUDINAL GRAIN ●-TRANSVERSE GRAIN
EACH POINT SHOWN IS THE AVERAGE

ENDING FATIGUE TEST RESULTS ~ STRETCHED 2024 EXTRUSION



FIGURE 13



FIGURE 14