Metals Fatigue Forgings Testing 108811
Aluminum Axial Load

WRIGHT AIR DEVELOPMENT CENTER
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

DIRECTORATE OF LABORATORIES — MATERIALS LABORATORY

(9) EVALUATION REPORT

(6) AXIAL LOADING FATIGUE PROPERTIES OF 7079-T6, 7075-T6 and 2014-T6 ALUMINUM ALLOY HAND FORGINGS

(14) WCLT-L

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CONTRACT NR:

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TYPE TEST: Axial Loading Fatigue

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(23) 1

SUBMITTED BY: Kaiser Aluminum & Chemical Corp.

ITEM SERIAL NR:

(35) 400358

I. PURPOSE:

To evaluate the axial loading fatigue properties of 7079-T6 regular hand forging in longitudinal and short transverse directions as compared to 2014-T6 and 7075-T6 aluminum alloy regular hand forgings.

II. FACTUAL DATA:

1. The notched and unnotched fatigue specimens were cut from the longitudinal and short transverse direction on three different sections of 3"x6"x38" forgings submitted by Kaiser Aluminum & Chemical Corp.

The notched and unnotched specimens were machined and mechanically polished. They had a minimum test section of 0.10 in. in diameter. The notched specimens had a theoretical stress concentration factor of 2.4. The detailed specimen drawings are shown in Fig. 1 and Appendix 1.

2. The axial loading fatigue test program was performed on a 300 Kg. Schenck fatigue testing machine at a stress ratio:

$$A = \frac{\text{Alternating stress}}{\text{mean stress}} = \infty$$

3. The results of the fatigue tests of 2014-T6, 7075-T6 and 7079-T6 hand forged aluminum alloys are plotted in Figs. 3 to 6, Appendix 1.

All three alloys show higher unnotched fatigue strength in the longitudinal direction than in the short transverse direction, ranging from 25% for 7075-T6 to 12% for 2014-T6 alloy. The fatigue strengths in the notched longitudinal and short transverse directions were rather uniform. All three alloys have a notched fatigue strength of 11,000 psi to 11,500 psi in both directions at 2×10^7 cycles.

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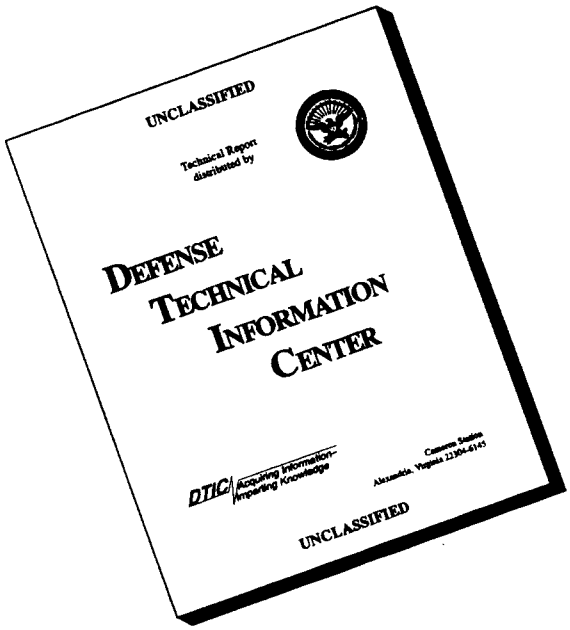

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Comparison of the fatigue strength of the three alloys at various number of cycles is shown in Table IV, Appendix I. The unnotched 7075-T6 in the longitudinal direction had a fatigue strength of 25,000 psi at 2×10^7 cycles as compared to 24,000 psi for 2014-T6 and 7079-T6.

The unnotched 7075-T6 in the short transverse direction had the lowest fatigue strength of the three materials being 20,000 psi at 2×10^7 cycles, as compared to 22,000 psi for 2014-T6 and 21,000 psi for 7079-T6.

4. In all three alloys, more scatter occured in the unnotched short transverse direction than in the unnotched longitudinal direction. The 7079-T6 and 7075-T6 unnotched in the short transverse direction reveal the worst scatter.

In general, the notched specimens had a more narrow scatter band than the unnotched. Comparison of the fatigue strengths in the different sections of the forgings of the three materials showed the difference to be within the scatter band.

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III. CONCLUSIONS

1. The unnotched fatigue strength of the three alloys ranged from 25,000 psi to 20,000 psi at 2×10^7 cycles.

At 2×10^7 cycles, the 7075-T6 had the highest fatigue strength (25,000 psi) in the longitudinal direction and the lowest fatigue strength (20,000 psi) in the short transverse direction.

2. The notched fatigue strength of the three alloys ranged from 11,000 psi to 11,500 psi at 2×10^7 cycles. The 2014-T6 had a fatigue strength of 11,500 psi at 2×10^7 cycles in both directions.

3. The unnotched fatigue strength of 7079-T6 in the longitudinal direction was slightly lower than of the 7075-T6 and about the same as of the 2014-T6. In the short transverse direction, however, it was slightly higher than the 7075-T6 and slightly lower than the 2014-T6.

The notched fatigue strength of 7079-T6 was slightly lower than of the 2014-T6 and 7075-T6 in both directions. END.

4. In general, there was no consistant fatigue ratio found in comparing the three materials and two directions.

IV. RECOMMENDATIONS:

None

COORDINATION:

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W. J. Trapp

PREPARED BY:

D. Y. Wang
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PUBLICATION REVIEW

This report has been reviewed and is approved.

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APPENDIX I

TABLE I

Axial Loading Fatigue Test Data of Regular Hand Forged 7079-T6 Aluminum Alloy at Stress Ratio A=∞

1. Longitudinal Direction Unnotched Specimen

Specimen No.	Alternating Stress in ± psi	Cycles to Rupture	
A9L - 35	24,000	19,605,900	No Failure
A9L - 21	25,000	7,541,900	
A9L - 15	25,000	6,114,700	
A9L - 33	26,000	7,912,100	
A9L - 14	27,000	599,700	
A9L - 25	28,000	1,011,400	
A9L - 13	28,000	563,800	
A9L - 23	30,000	238,700	
A9L - 34	32,000	108,300	
A9L - 12	36,000	121,000	
A9L - 24	36,000	96,500	
A9L - 31	42,000	49,100	
A9L - 32	42,000	42,800	

2. Short Transverse Direction Unnotched Specimen

A9S - 25	21,000	20,092,200	No Failure
A9S - 35	23,000	297,200	
A9S - 31	24,000	21,483,300	
A9S - 13	24,000	1,303,900	
A9S - 24	24,000	71,300	
A9S - 23	26,000	36,000	
A9S - 14	28,000	104,800	
A9S - 33	28,000	44,000	
A9S - 21	32,000	55,700	
A9S - 11	36,000	38,900	
A9S - 34	39,000	5,900	
A9S - 22	42,000	10,000	
A9S - 32	42,000	11,500	

3. Longitudinal Direction Notched Specimens.

B9L - 21	11,000	20,614,100	No Failure
B9L - 35	11,000	2,958,000	
B9L - 15	11,500	1,449,400	
B9L - 13	11,500	725,700	
B9L - 14	12,000	725,100	
B9L - 33	12,000	170,800	
B9L - 22	13,000	149,000	
B9L - 11	15,000	221,300	
B9L - 34	16,000	66,900	
B9L - 24	18,000	45,800	

TABLE I cont'd

3. Longitudinal Direction Notched Specimens.(cont'd)

Specimen No.	Alternating Stress in ± psi	Cycles to Rupture	
B9L - 23	21,000	16,400	
B9L - 32	21,000	17,000	
B9L - 12	24,000	14,600	
B9L - 31	27,000	7,900	

4. Short Transverse Direction Notched Specimens

B9S - 14	11,000	19,509,600	No Failure
B9S - 35	11,000	10,067,000	No Failure
B9S - 15	11,500	25,734,700	No Failure
B9S - 32	12,000	321,700	
B9S - 25	12,000	118,200	
B9S - 22	13,000	100,200	
B9S - 11	14,000	125,800	
B9S - 34	15,000	72,800	
B9S - 24	17,000	48,600	
B9S - 12	19,000	27,800	
B9S - 33	22,000	10,000	
B9S - 21	24,000	15,400	
B9S - 31	25,000	10,900	
B9S - 13	27,000	6,300	

APPENDIX I

TABLE II

Axial Loading Fatigue Test Data of Regular Hand Forged 2014-T6 Aluminum Alloy at Stress Ratio A=∞

1. Longitudinal Unnotched Specimen

Specimen No.	Alternating Stress in ± psi	Cycles to Rupture	
A4L - 31	24,000	19,097,200	
A4L - 14	25,000	14,268,800	
A4L - 15	26,000	9,277,100	
A4L - 25	26,000	7,918,800	
A4L - 34	27,000	2,790,700	
A4L - 33	28,000	469,300	
A4L - 13	28,000	565,000	
A4L - 23	32,000	473,900	
A4L - 22	36,000	150,400	
A4L - 35	36,000	108,100	
A4L - 32	39,000	58,100	
A4L - 12	42,000	53,500	
A4L - 24	42,000	45,500	

2. Short Transverse Unnotched Specimen

A4S - 21	21,000	20,180,500	No Failure
A4S - 31	23,000	19,828,200	
A4S - 24	24,000	7,771,600	
A4S - 13	24,000	1,893,000	
A4S - 33	26,000	346,500	
A4S - 32	28,000	309,200	
A4S - 11	28,000	251,500	
A4S - 25	32,000	69,900	
A4S - 23	36,000	87,600	
A4S - 14	36,000	68,600	
A4S - 22	38,000	33,600	
A4S - 34	42,000	32,000	
A4S - 15	42,000	16,800	

3. Longitudinal Direction Notched Specimen

B4L - 22	11,500	30,746,300	No Failure
B4L - 14	12,000	553,700	
B4L - 15	12,000	352,900	
B4L - 31	12,000	4,985,300	
B4L - 34	13,000	401,100	
B4L - 35	13,000	205,200	
B4L - 21	15,000	220,800	
B4L - 13	15,000	89,000	
B4L - 12	17,000	124,400	
B4L - 25	17,000	45,300	
B4L - 33	20,000	55,400	

TABLE II cont'd

3. Longitudinal Direction Notched Specimen (cont'd)

Specimen No.	Alternating Stress in ± psi	Cycles to Rupture	
B4L - 11	20,000	43,400	
B4L - 23	22,000	27,400	
B4L - 24	27,000	13,100	
B4L - 32	27,000	13,100	

4. Short Transverse Direction Notched Specimen

B4S - 25	11,000	24,611,100	No Failure
B4S - 33	11,500	4,100,400	
B4S - 35	12,000	21,997,900	
B4S - 11	12,000	20,320,300	No Failure
B4S - 22	12,000	192,000	
B4S - 34	13,000	842,700	
B4S - 15	13,000	77,800	
B4S - 13	15,000	92,100	
B4S - 21	15,000	105,000	
B4S - 14	18,000	55,000	
B4S - 31	18,000	45,100	
B4S - 12	22,000	33,500	
B4S - 23	22,000	24,600	
B4S - 24	27,000	9,600	
B4S - 32	27,000	12,100	

APPENDIX I

TABLE III

Axial Loading Fatigue Test Data of Regular Hand Forged
7075-T6 Aluminum Alloy at Stress Ratio A=∞

1. Longitudinal Direction Unnotched Specimen $K_t = 1.0$

Specimen No.	Alternating Stress in ± psi	Cycles to Rupture	
A5L - 35	25,000	21,297,300	No Failure
A5L - 25	25,000	966,000	
A5L - 22	26,000	16,646,500	
A5L - 31	26,000	358,000	
A5L - 32	27,000	1,207,600	
A5L -155	27,000	701,000	
A5L -152	28,000	403,700	
A5L - 23	28,000	3,686,100	
A5L -154	30,000	180,100	
A5L - 34	33,000	139,000	
A5L - 21	36,000	72,000	
A5L -153	36,000	161,800	
A5L - 24	42,000	58,400	
A5L - 33	42,000	42,300	

2. Short Transverse Direction Unnotched Specimen $K_t = 1.0$

A5S - 25	20,000	20,401,900	No Failure
A5S - 15	21,000	88,200	
A5S - 31	22,000	485,700	
A5S - 35	22,000	4,328,600	
A5S - 33	23,000	1,269,400	
A5S - 22	23,000	58,900	
A5S - 24	24,000	121,400	
A5S - 14	24,000	79,700	
A5S - 12	28,000	54,100	
A5S - 21	28,000	142,000	
A5S - 32	32,000	34,000	
A5S - 11	36,000	19,100	
A5S - 23	36,000	28,100	
A5S - 13	42,000	8,800	
A5S - 34	42,000	14,000	

3. Longitudinal Direction Notched Specimens $K_t = 2.4$

B5L - 21	11,000	20,561,900	No Failure
B5L - 15	11,500	30,934,500	No Failure
B5L - 14	12,000	30,875,000	No Failure
B5L - 24	12,000	1,079,400	
B5L - 35	12,000	282,300	
B5L - 13	13,000	582,300	
B5L - 25	13,000	295,900	

TABLE III cont'd

3. Longitudinal Direction Notched Specimens (cont'd) $K_t = 2.4$

Specimen No.	Alternating Stress in ± psi	Cycles to Rupture	
B5L - 34	13,000	120,900	
B5L - 22	15,000	104,900	
B5L - 31	15,000	4,714,000	
B5L - 11	18,000	61,800	
B5L - 33	22,000	26,400	
B5L - 12	22,000	23,700	
B5L - 23	27,000	12,000	
B5L - 32	27,000	10,300	

4. Short Transverse Direction Notched Specimen $K_t = 2.4$

B5S - 34	11,000	24,000,000	No Failure
B5S - 24	11,000	19,128,000	
B5S - 31	11,500	1,188,700	
B5S - 15	11,500	1,771,600	
B5S - 12	12,000	1,272,000	
B5S - 35	12,000	370,700	
B5S - 13	13,000	123,400	
B5S - 25	13,000	287,300	
B5S - 32	14,000	116,500	
B5S - 21	15,000	48,100	
B5S - 22	18,000	29,000	
B5S - 14	20,000	19,500	
B5S - 33	22,000	18,000	
B5S - 23	24,000	10,900	
B5S - 11	27,000	6,600	

TABLE IV

Comparison of The Approximate Average Axial Loading Fatigue Strength for 7079-T6, 7075-T6 and 2014-T6 Hand Forged Aluminum Alloy at Various Number of Cycles
(Data taken from Figs. 3 to 6)

Type of Alloy	Specimen Position in Forging	Fatigue Strength, psi. at indicated numbers of cycles							
		Unnotched				Notched			
		10,000 cycles	100,000 cycles	1,000,000 cycles	20,000,000 cycles	10,000 cycles	100,000 cycles	1,000,000 cycles	20,000,000 cycles
7079-T6	Longitudinal		35,000	27,000	24,000	25,000	15,000	11,500	11,000
	Short Transverse	39,000	26,000	22,000	21,000	24,000	14,000	11,500	11,000
7075-T6	Longitudinal		35,000	26,000	25,000	28,000	16,000	12,000	11,500
	Short Transverse	42,000	24,000	21,000	20,000	24,000	14,000	12,000	11,000
2014-T6	Longitudinal		37,000	27,000	24,000	29,000	16,000	12,000	11,500
	Short Transverse		32,000	25,000	22,000	28,000	15,000	12,000	11,500

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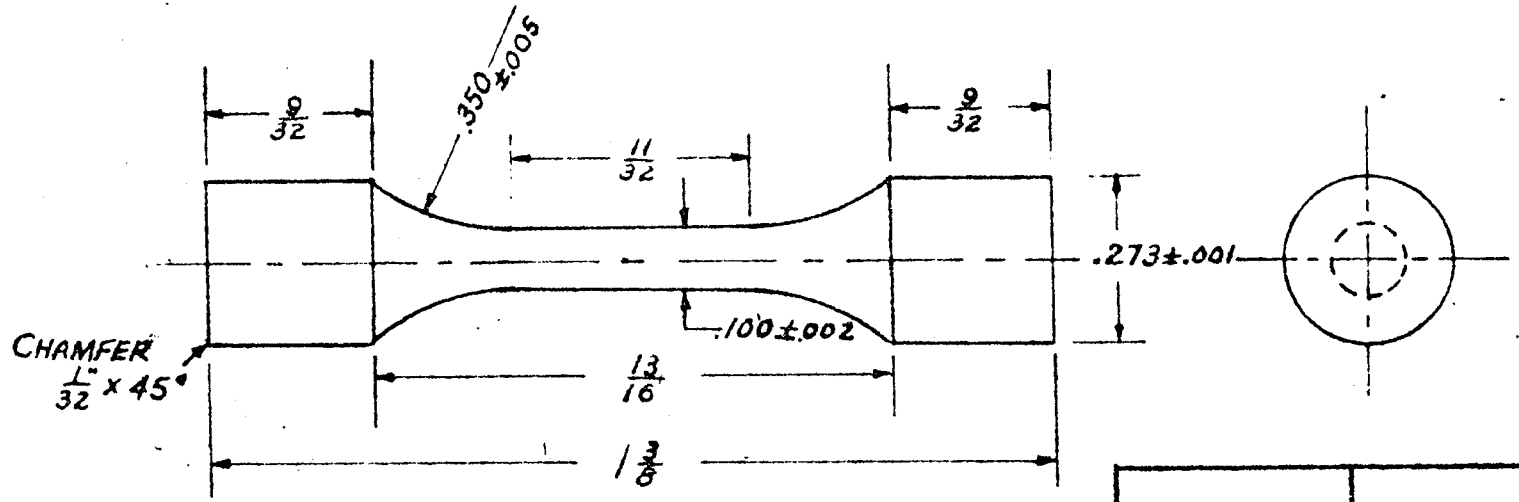

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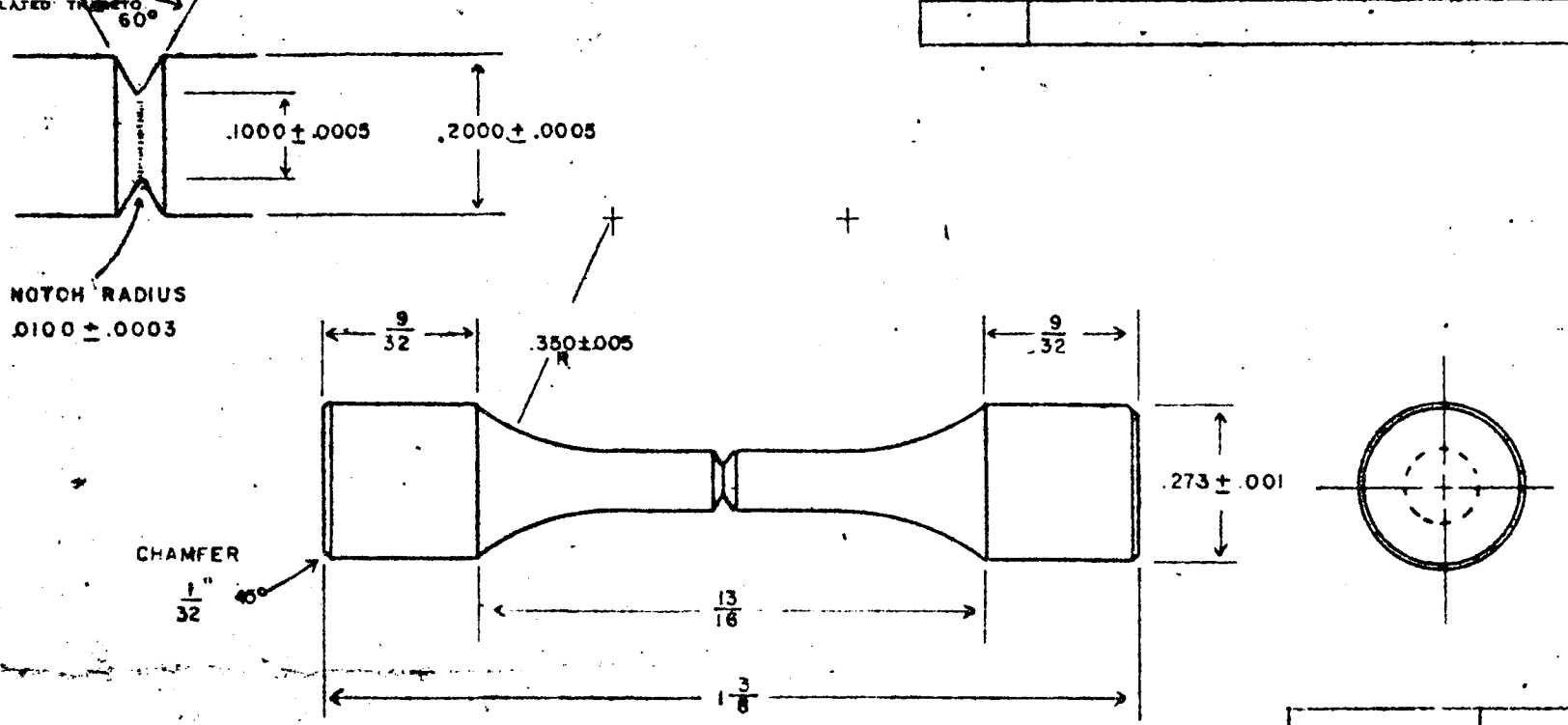

MIL-R WCLR 158-59 Figure 2, Page 12

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TREATMENT	ENGINEER HARMSWORTH	
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NAME

NOTCHED FATIGUE SPECIMEN

$K_T = 2.4$

300 KG. SCHENCK MACH.

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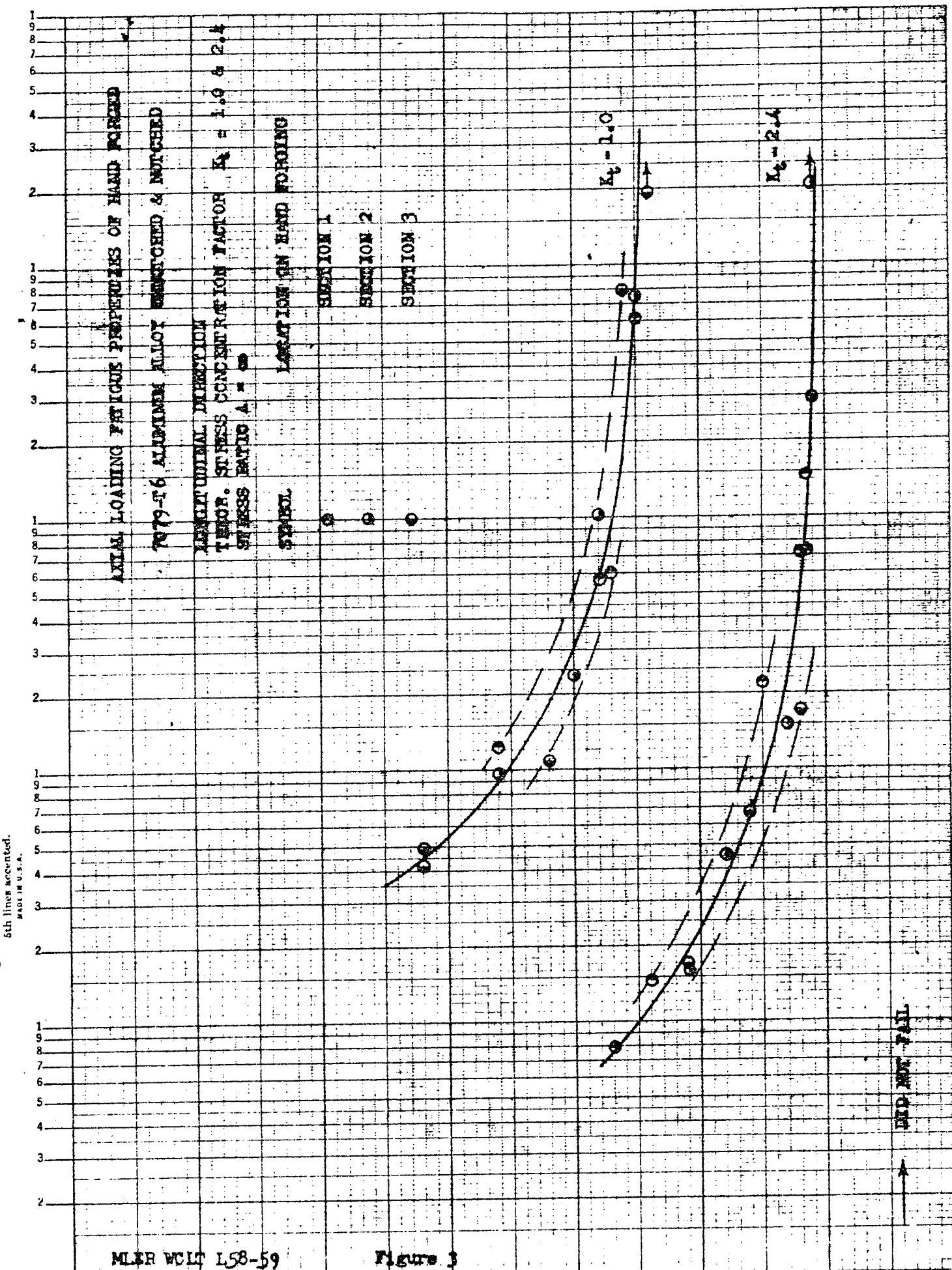

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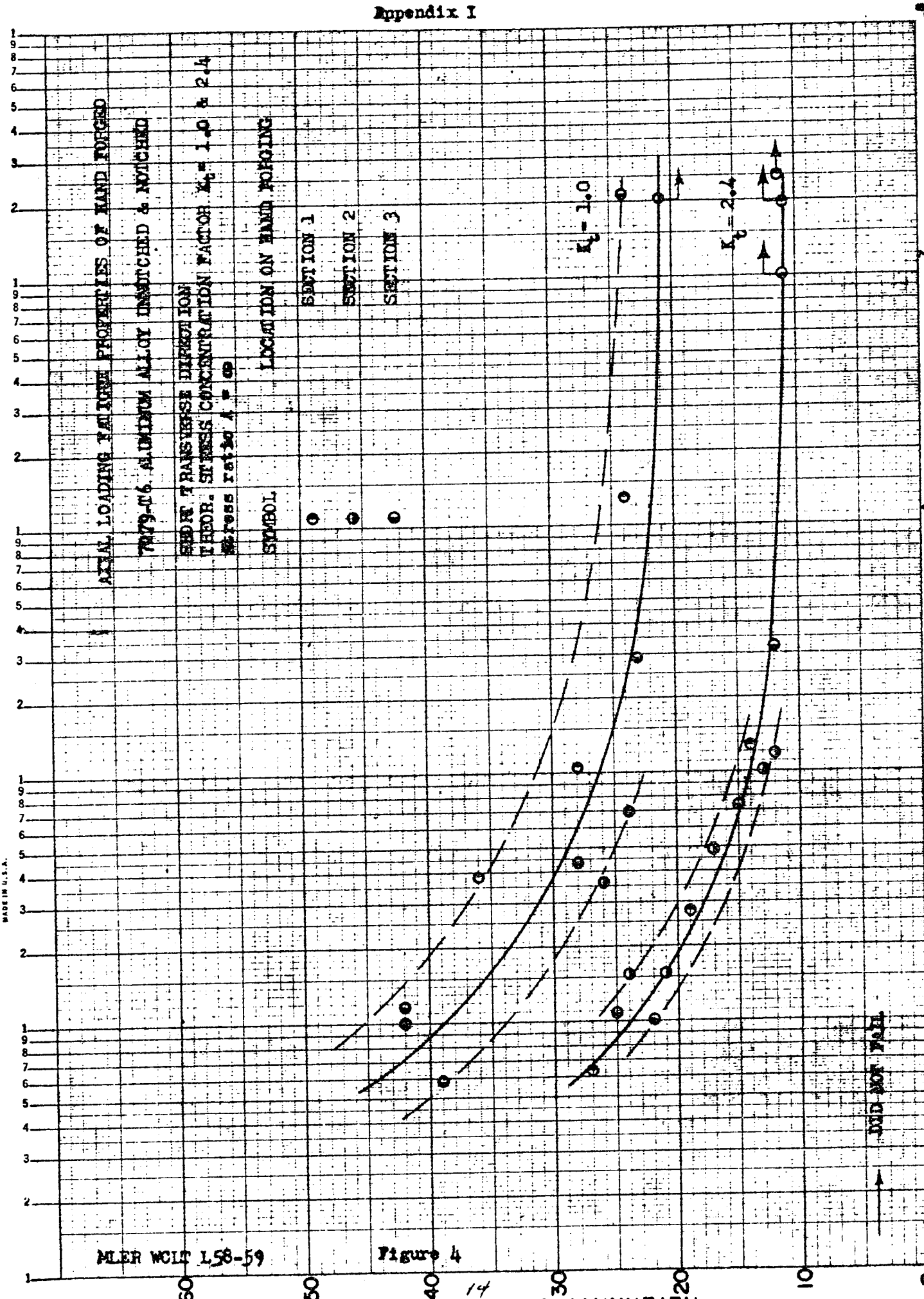

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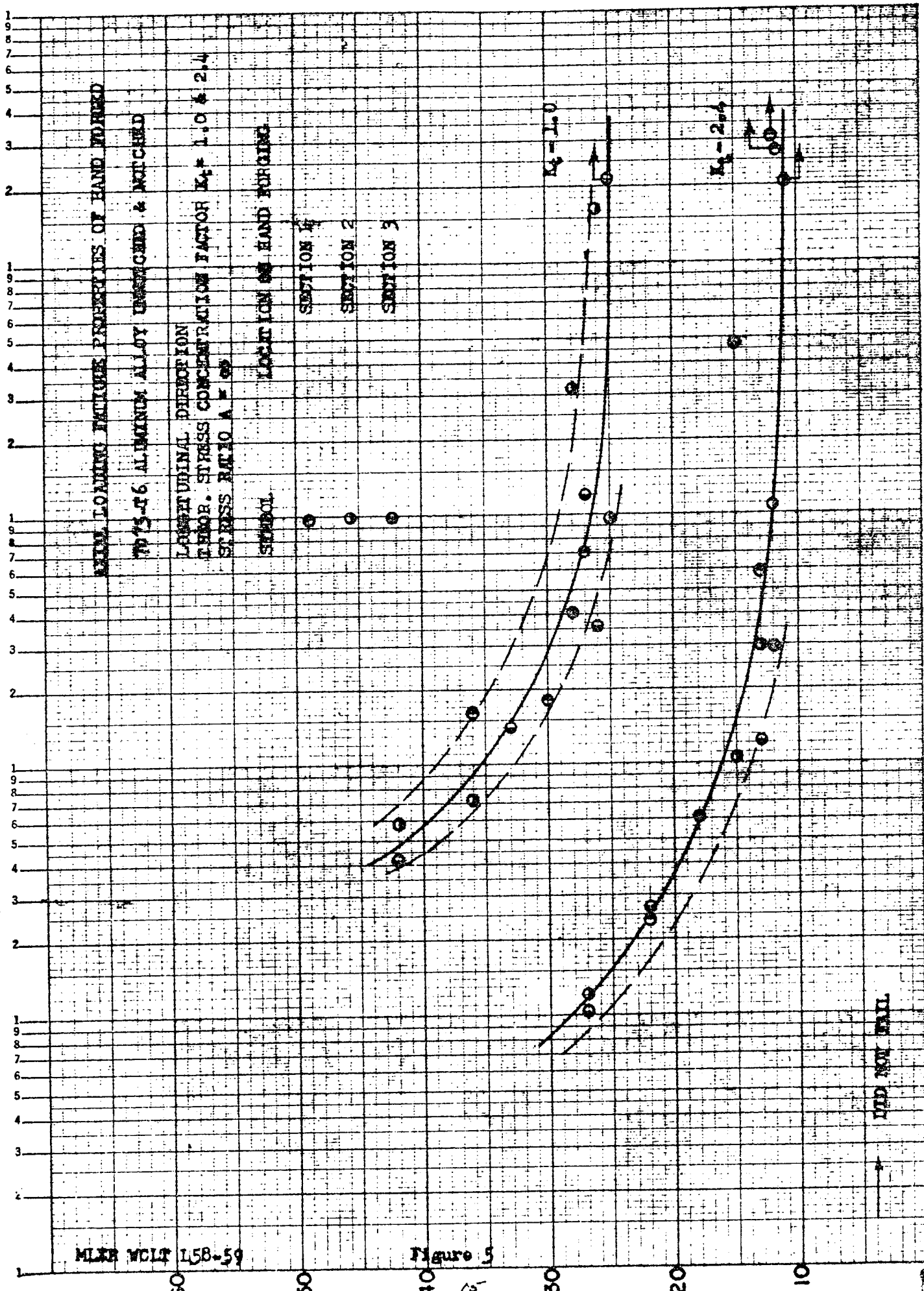
Figure 4



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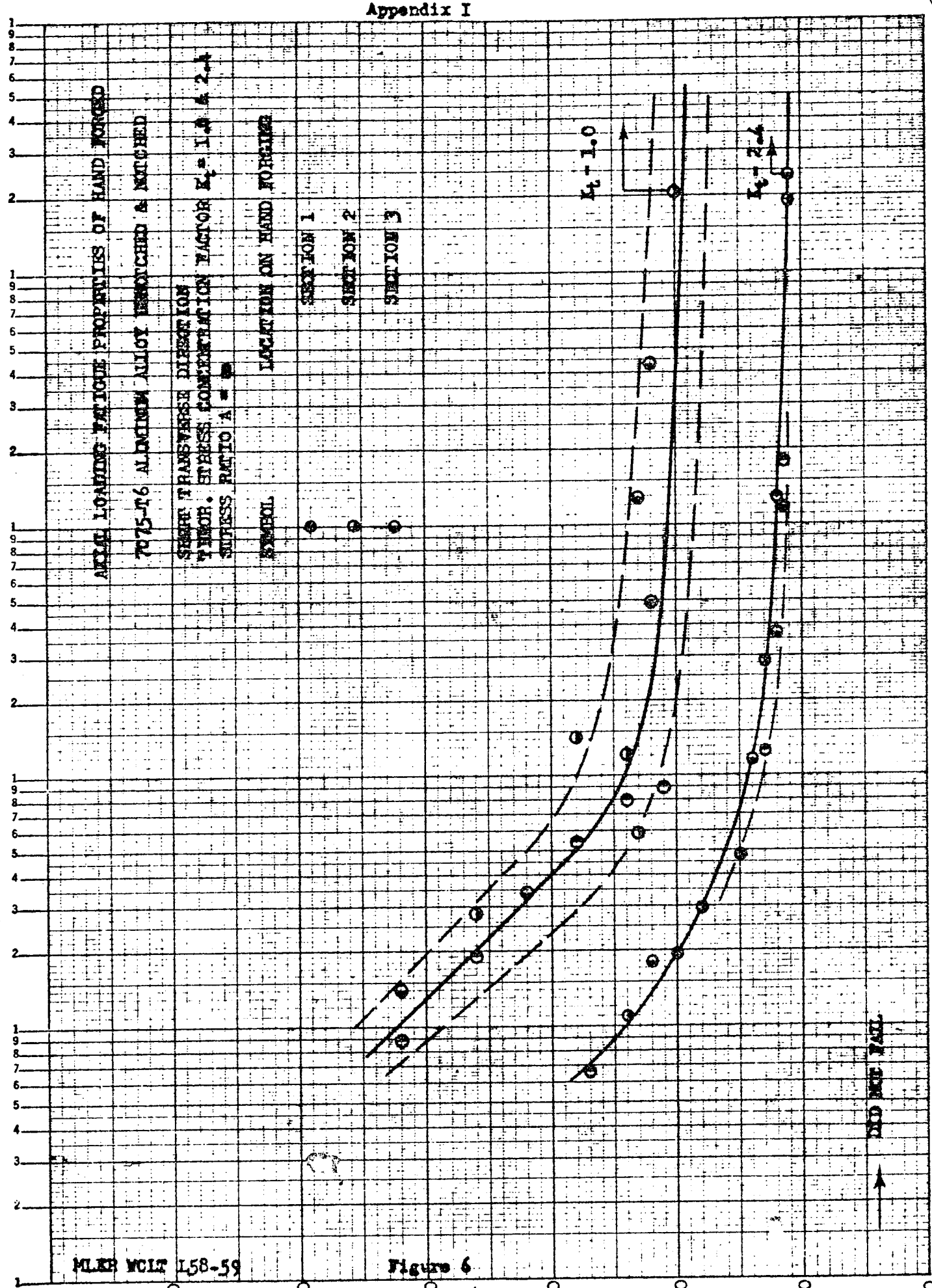

KEUFFEL & ESSER CO.
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Figure 6

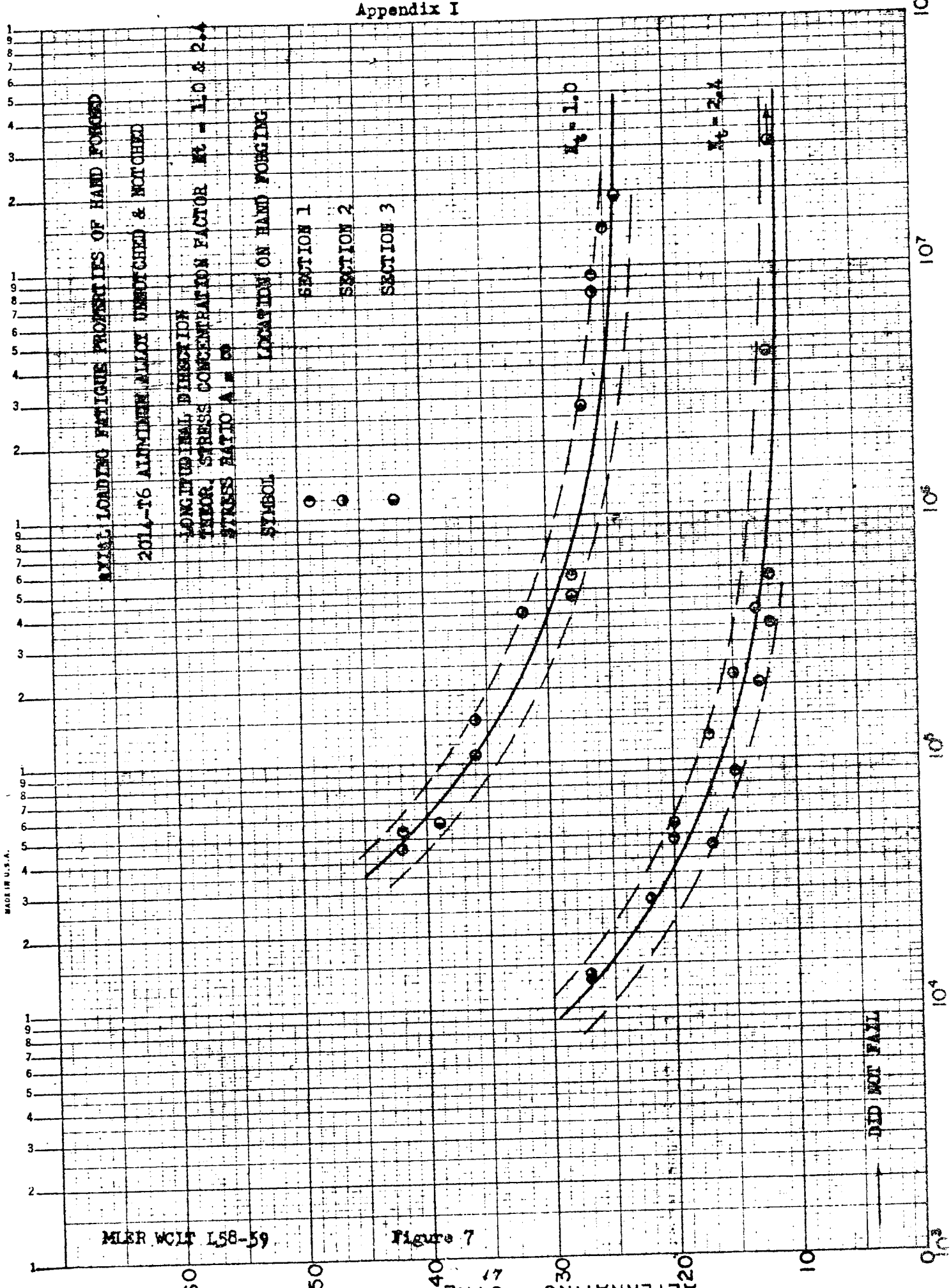

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Figure 7

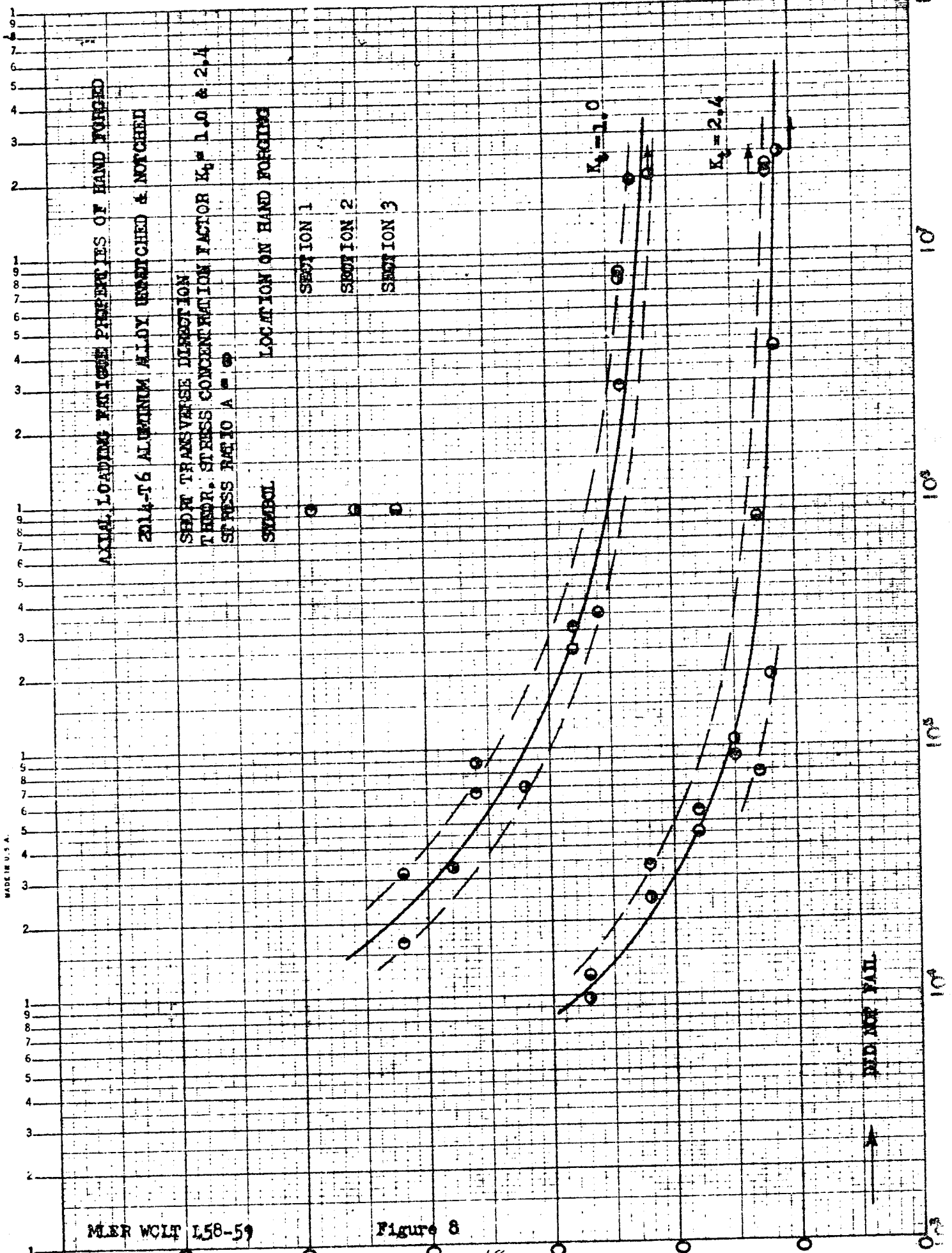

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Figure 8

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