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REPORT
STRUCTURES 160

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ROYAL AIRCRAFT ESTABLISHMENT

FARNBOROUGH, HANTS

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REPORT No: STRUCTURES 160

THE STRENGTH PROPERTIES OF SOME LIGHT ALLOY CASTING MATERIALS

by

F. CLIFTON, B.Sc.(Eng.), A.M.Inst.C.E.

to Confdl. Changed
E.O. # 10501
dtd 5/11/53
res 5/5/54

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Structures E1/13336/FC

Report No. Structures 160

March, 1954

ROYAL AIRCRAFT ESTABLISHMENT, FARNBOROUGH

The Strength Properties of Some Light Alloy Casting Materials

by

F. Clifton, B.Sc.(Eng), A.M.Inst.C.E.

ADDENDUM

1. Add the following footnote to page 5

"*The 'correlation coefficient'[15] is here a measure of the validity of an assumed relationship between corresponding values of two variables.

A value of zero indicates no correlation and a value of 1.0 complete correlation".

2. Add an asterisk after 'correlation coefficients' in line 10 of para. 4.3, page 5.

3. Add the following to the list of references on page 9:-

"15	J. Moroney	Facts from Figures (page 286) Pelican Book No. A236."

4. Add the following footnote to Table XI:-

"++The proof strength values for material to specification DTD.298 are unexpectedly low and the elongation is unexpectedly high. These values may not be representative of present-day material".

5. Add a sign ++ after "D.T.D.298" in Table XI.

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Report No. Structures 160

January, 1954

ROYAL AIRCRAFT ESTABLISHMENT, FARNBOROUGH

The Strength Properties of Some Light Alloy Casting Materials

by

F. Clifton, B.Sc.(Eng.), A.M.Inst.C.E.

RAE Ref:- Structures/C1/13336/FC

SUMMARY

Mean strength values and coefficients of variation obtained from tensile, torsion, shear, bearing and bending tests on thirteen aluminium and two magnesium casting alloys are tabulated. Values of the various strength properties are plotted, and the degree of inter-dependence of these properties is examined and discussed. An estimated true mean strength and coefficient of variation is shown for each alloy tested.

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1 Introduction

A large series of strength tests has been completed on specimens extracted from light alloy test castings of a special pattern, made in various light alloy materials and by several founders. In these tests, material from various parts of each casting was tested in tension, torsion, shear, bearing and bending, to obtain representative values of the strength and strength variation for each material.

The detailed test results have been given in earlier papers[1-14]. In the present paper the results of all the tests are summarised and discussed. The tests show that the various strength properties are closely related, but in most cases the scatter of values is wide, so that individual values of a given property cannot be predicted very accurately from known values of any other property.

2 Test Specimens

The test casting is shown on Fig.1 and the method of extraction of the test specimens on Fig.2. The various alloys tested are listed against founders in Table I and the number of specimens in each set of tests is given in Table II. All the castings (except those to Specification BS L.53, made in 1950) were made in the years 1944-45 and all were released in accordance with A.I.D. requirements for Class I castings in force at the time. The surfaces of the specimens were machined, so that none of the original cast surface remained in the regions subjected to test.

The results of the torsion, shear, bending and lug tests are directly applicable only to specimens of the same proportions as those tested.

Additional tensile tests were made on specimens taken from test bars cast with the test castings. The number of such specimens tested varied from alloy to alloy and was often as small as three.

3 Test Results

3.1 Presentation of Results

Mean test values for the various strength properties for each material are recorded as stresses in Tables III to X inclusive.

The number of test results is generally insufficient to warrant the calculation of coefficients of variation, except for the tensile properties (see Table IV).

Table XI gives conservative estimates of true mean strength values for each material. These estimates are derived statistically from the test results, on an arbitrarily-fixed probability of 0.975 that the true mean strength will not be lower than the estimated value.

Table XI also gives an estimated coefficient of variation for each property in each material. These have been fixed by judgments based on the test evidence, or on general experience where the test evidence is scanty. No values for lug or bending stresses are given in Table XI, because of the limited range of shapes to which the test values for the lug and bending specimens apply.

3.2 Proof Loads

All the proof stress values given, except where otherwise stated in the tables, have been determined from the load at which the load/extension curve departs from linearity by the prescribed amount.

4 Discussion

The trends of material strength and the relationships between the various material strength properties are examined empirically by a comparison of the mean test values of the various groups. This method of comparison of means is perforce adopted because the test results for the various properties vary in number and are in general taken from different parts of different castings, so that no point-for-point comparison is possible. The method has the drawback that the means are obtained from varying numbers of results and are thus not all of equal significance.

4.1 Variation of Strength with Foundry

The mean values of 0.1% tensile proof stress t_1 and of ultimate tensile stress f_t for each material from each foundry are shown diagrammatically on Fig.3. This figure shows that the difference in the strength of material in castings made to the same specification by different founders is in some cases considerable, and that this difference does not always correspond to the difference in test bar strength. There is no evidence that the castings from any one foundry are consistently high or low in strength, and the order of strength between different founders is sometimes reversed between the proof and ultimate strengths. Founder A is an apparent exception, but the castings from this foundry were possibly made to non-standard compositions under a war-time concession, and the evidence from this source is therefore doubtful.

4.2 Difference in Strength Between Different Parts of the Castings

In Table XII the mean tensile strengths of material in various parts of the casting have been expressed in terms of the mean tensile strength of the material in the barrel.

There is on the average a slight tendency for the flange material to be stronger than the boss and barrel material and this tendency is more marked for the ultimate strength than for the proof strength. Some alloys show a large strength difference between different parts of the casting, but the same part is not consistently high or low for all alloys and the relative level of strength sometimes differs for the proof and ultimate strengths of the same material.

4.3 Correlation Between the Various Strength Properties

The degree of inter-dependence of the various strength properties of the cast material has been examined by plotting the mean strength values of the various alloys, as shown on Figures 4 to 15. Each point represents the mean of all values from the product of a single foundry for one alloy. Mean lines have been drawn through the points, in the position giving minimum scatter about the lines, and approximate limits are shown between which 80 per cent of all mean values are estimated to lie. These limits, quoted as a percentage, are given as 'probable limits of error' in Table XIII. The equations of the mean lines and the correlation coefficients have been calculated and are summarised in Table XIII. The high value of these coefficients indicates that the various properties considered are closely related, but in many cases the scatter of strength is too wide to permit individual values of one property to be predicted from individual values of another with a useful degree of accuracy. It is emphasised that the comparisons made in Figs. 4 to 15 and in Table XIII are comparisons of mean values, so that the scatter of individual values would be even wider. The mean lines, correlation coefficients and limits have been derived from the aluminium alloy results only, as the results for magnesium alloys are too few for this method of analysis to be used. The magnesium alloy points have, however, been added to Figs. 4 to 15 for comparison with the aluminium alloy points.

Some of the materials, notably the D.T.D.300 and L.53 alloys, gave results that depart widely from the general trend (see Fig.4) and these anomalous results have been omitted in calculating the positions of the mean lines and the probable limits of error.

4.4 Variation of Bearing Strength with Joint Proportions

The mean test values of the proof bearing stress b_{10} have been plotted separately on Fig.11 for each of three values of the ratio:

$$\frac{\text{bearing pin diameter}}{\text{bearing plate thickness}}.$$

A mean line has been put through each of these three sets of points and a mean line for all points combined is also shown. The limits of error are shown for the combined results only, but these limits have also been calculated for each set separately, and are listed in Table XIII.

The proof bearing stress b_{10} increases with decrease of the ratio of pin diameter to sheet thickness. The values of b_{10} for $\frac{d}{t} = 0.74$ and 1.0 are respectively 18.5 per cent and 6 per cent (average) higher than the values at $\frac{d}{t} = 1.25$. The proof bearing stresses for these cast materials are considerably higher, relative to the tensile proof stresses, than is the case with wrought materials.

4.5 Values of the Elastic Moduli

Mean values and coefficients of variation of Young's Modulus, E, and of the torsional modulus, G, have been calculated from all the available results, as shown on Table XIV. The mean values of these moduli are usual for the respective materials but the scatter of the values is rather wide.

Values of Poisson's ratio, calculated from the mean values of the elastic moduli, are 0.36 for the aluminium alloys and 0.32 for the magnesium alloys, which are again about the usual values.

4.6 Variability of the Material

The variability of strength, as shown by the estimated true coefficient of variation, V, differs fairly widely for the different alloys (see Table XI). The mean values of V for the individual results of all the aluminium alloys are 10.6% for t_1, 9% for t_2, 8.5% for t_5 and 8.5% for f_t. This drop in the values from t_1 to t_5 is exhibited by most of the alloys individually. In some cases the coefficient for f_t is high, in particular for the alloys L.53 and D.T.D.300 which have values of V, for the ultimate tensile strength, of 16.5% and 21.5% respectively. If the values for all alloys are assumed to belong to one 'population' the overall coefficient of variation for the individual results of this population is 10% for both the 0.1% proof strength t_1 and the ultimate strength f_t. The number of magnesium alloys tested is too few to show any general trend of variability or whether these alloys differ in variability from the aluminium alloys.

5 Conclusions

The main points shown by this series of tests are summarised below.

Comparison on the test bar tensile properties with casting tensile properties and of the various mechanical properties amongst themselves shows that all these properties are closely linked, though the scatter of values is wide. Correlation is highest for the relationship between the tensile proof stresses t_1 and t_2, and lowest for the relationship between the ultimate torsional strength f_{qA} and the ultimate tensile strength f_t. No regular trends have been found in the scatter, except that in general the 0.5% tensile proof stress t_5 is less variable than the 0.2% proof stress t_2, which in turn is less variable than the 0.1% proof stress t_1. As a consequence of the wide scatter, the value of any one property of a material can be only approximately estimated from a knowledge of a value of some other property. For some pairs of properties, the accuracy of prediction of one from the other is too low for practical use, e.g. q_1 from t_1.

The mean values of the elastic moduli are usual for these alloys, but their variance is again rather wide.

The values of the 1.0% bearing proof stress b_{10} are higher, relative to the tensile proof stress t_1 than is the case with wrought materials. The value of the proof bearing strength b_{10} increases with decrease of the ratio of $\frac{\text{pin diameter}}{\text{bearing plate thickness}}$ within the range tested.

No consistent trends of strength with foundry have been discovered. There is some evidence that the flanged parts of the casting are stronger than the boss and barrel.

The above conclusions are based on the results of the tests on the aluminium alloys, as the tests on the magnesium alloys are too few in number for trends to be examined. It is, however, possible to make a limited comparison between the magnesium alloy and aluminium alloy results, and this comparison suggests that the trends for magnesium alloys are the same as for aluminium alloys.

LIST OF SYMBOLS

Symbol	Units	Definition	Notes
t_1	tons/sq in	0.1% proof stress in tension	Elongation based on gauge length
t_2	tons/sq in	0.2% proof stress in tension	Elongation based on gauge length
t_5	tons/sq in	0.5% proof stress in tension	Elongation based on gauge length
f_t	tons/sq in	ultimate stress in tension	
E	lb/sq in × 10^6	Young's Modulus in tension	
e	%	elongation at fracture	
q_1	tons/sq in	proof stress in torsion (defined in A.P.970, Vol.2, Leaflet 401/5). (Calculated on the assumption that stress is proportional to distance from centre.)	
f_{qA}	tons/sq in	ultimate stress in torsion. (Calculated on the assumption that stress is proportional to distance from centre.)	
G	lb/sq in × 10^6	Modulus of rigidity	
f_s	tons/sq in	ultimate shear stress	
b_{10}	tons/sq in	1.0% proof stress in bearing. (Elongation based on pin diameter.)	
L_{10}	tons/sq in	1.0% proof stress	Lug stresses with suffix T or S indicating tension or shear. Elongation based on pin diameter
L_F	tons/sq in	ultimate stress	Lug stresses with suffix T or S indicating tension or shear. Elongation based on pin diameter
$B_{0.5}$	tons/sq in	0.5% proof stress in bending	Elongation based on surface strain
B_1	tons/sq in	1.0% proof stress in bending	Elongation based on surface strain
B_2	tons/sq in	2.0% proof stress in bending	Elongation based on surface strain
B_F	tons/sq in	ultimate stress in bending	

x individual test result

n number of test results in group

$\bar{x}$ mean value from a group of test results $\left(\bar{x} = \frac{\Sigma x}{n}\right)$

v coefficient of variation for a group of test results

$$v = \frac{1}{\bar{x}}\sqrt{\frac{\Sigma(x-\bar{x})^2}{n-1}}$$

$\bar{X}$ estimated true mean value (see para.3.1)

V estimated true coefficient of variation (see para.3.1)

REFERENCES

No.	Author	Title, etc.
1	F. Clifton and A.J. Beard	Analysis of Strength Tests on Aluminium Silicon Alloy Castings to Specification B.S.S.2 L.33 RAE Report No. Structures 105, April 1951
2	E.L. Ripley and F. Clifton	Analysis of Strength Tests on Aluminium Alloy Sand Castings to Specification D.T.D.287 RAE Tech Note No. Structures 78, November 1951
3	F. Clifton	Analysis of Strength Tests on Aluminium Alloy Sand Castings to Specification D.T.D.133B RAE Tech Note No. Structures 82, April 1952
4	F. Clifton	Analysis of Strength Tests on Aluminium Alloy Sand Castings to Specification D.T.D.298 RAE Tech Note No. Structures 83, March 1952
5	F. Clifton	Analysis of Strength Tests on Aluminium Alloy Sand Castings to Specification D.T.D.304 RAE Tech Note No. Structures 84, April 1952
6	F. Clifton	Analysis of Strength Tests on Magnesium Alloy Sand Castings to Specification D.T.D.289 RAE Tech Note No. Structures 86, April 1952
7	F. Clifton	Analysis of Strength Tests on Magnesium Alloy Sand Castings to Specification D.T.D.281 RAE Tech Note No. Structures 94, July 1952
8	F. Clifton	Analysis of Strength Tests on Aluminium Alloy Sand Castings to Specification D.T.D.424 RAE Tech Note No. Structures 95, July 1952
9	F. Clifton	Analysis of Strength Tests on Aluminium Alloy Sand Castings to Specification D.T.D.255 RAE Tech Note No. Structures 96, July 1952
10	F. Clifton	Analysis of Strength Tests on Aluminium Alloy Sand Castings to Specification D.T.D.245 RAE Tech Note No. Structures 97, July 1952
11	F. Clifton	Analysis of Strength Tests on Aluminium Alloy Sand Castings to Specification D.T.D.165 RAE Tech Note No. Structures 98, July 1952
12	F. Clifton	Analysis of Strength Tests on Aluminium Alloy Sand Castings to Specification D.T.D.250 RAE Tech Note No. Structures 99, July 1952
13	F. Clifton	Analysis of Strength Tests on Aluminium Alloy Sand Castings to Specification D.T.D.240 RAE Tech Note No. Structures 105, July 1952
14	F. Clifton	Analysis of Strength Tests on Aluminium Alloy Sand Castings to Specifications D.T.D.300 and B.S. L.53 RAE Tech Note No. Structures 110, January 1953

Attached:- Tables I - XIV
Figs. 1 - 15 Drgs. Nos. SME 74446/R to SME 74459/R incl.
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TABLE I

Distribution of Alloys Between Founders

Material Specification	Founders										Remarks
	A	B	C	D	E	F	G	H	J	K	
Aluminium Alloys											
BS L33						X	X				
BS L53		X						X		X	
DTD 133B			X	X							Replaced by L51
DTD 165								X	X		Replaced by DTD 165A
DTD 240						X	X				Now Cancelled
DTD 245						X	X				Replaced by DTD 245A
DTD 250					X						Now Cancelled
DTD 255					X						Replaced by L52
DTD 287					X						Replaced by L51
DTD 298	X	X									Replaced by DTD 298A
DTD 300	X	X									Replaced by L53
DTD 304	X	X									Replaced by DTD 304A
DTD 424			X	X				X			Replaced by DTD 424A
Magnesium Alloys											
DTD 281				X				X	X		Replaced by L124
DTD 289			X		X				X		Replaced by L122

TABLE II

Tests and Test Specimens

Test			Number of Specimens per Set	
			L53	All other materials
Tension				
Cylinder flange			10	12
Cylinder boss			-	6
Beam flange			-	6
Barrel			10	6
Torsion				
External Diameter / Wall Thickness	= 11.3	nominal	10	3
Shear				
Pin Diameter / Shearing Plate Thickness	= 1.0	nominal	-	9
Bearing				
Pin Diameter / Plate Thickness	= 0.74	nominal	-	3
"	= 1.00	"	-	3
"	= 1.25	"	10	3
Lug			3	9
Bending			3	3
Cast Test Bars			Various	Various

TABLE III

Means of Tensile Test Values for each Part of Casting

Material Specification	Source	Part of Casting	t_1 $\bar{x}$	t_1 n	t_2 $\bar{x}$	t_2 n	t_5 $\bar{x}$	t_5 n	f_t $\bar{x}$	f_t n	E $\bar{x}$	E n
Aluminium Alloys												
BS L33	F	Cylinder flanges	4.44	9	5.05	9	6.14	9	9.71	9	9.36	9
		Cylinder boss	3.87	6	4.42	6	5.34	6	9.61	6	9.81	6
		Beam flanges	5.24	6	5.90	6	6.85	6	9.61	6	9.72	6
		Barrel	4.50	6	5.03	6	6.15	5	9.03	6	10.00	6
		All parts combined	4.51	27	5.09	27	6.12	26	9.52	27	9.68	27
	G	Cylinder flanges	4.87	12	5.57	12	6.72	12	10.66	12	10.79	12
		Cylinder boss	4.15	6	4.82	6	6.02	6	9.96	6	11.33	6
		Beam flanges	4.64	6	5.32	6	6.51	6	10.60	6	11.19	6
		Barrel	4.44	4	5.06	4	6.18	4	10.18	4	10.28	4
		All parts combined	4.61	28	5.28	28	6.45	28	10.43	28	11.02	28
BS L53	B	Cylinder flanges	11.10	10	11.95	10	13.26	10	21.60	10	9.64	10
		Cylinder boss	-	-	-	-	-	-	-	-	-	-
		Beam flanges	-	-	-	-	-	-	-	-	-	-
		Barrel	11.78	10	12.85	10	-	-	15.87	10	9.70	10
		All parts combined	11.44	20	12.40	20	-	-	18.74	20	9.67	20
	H	Cylinder flanges	10.58	10	11.26	10	12.31	10	16.94	10	9.19	10
		Cylinder boss	-	-	-	-	-	-	-	-	-	-
		Beam flanges	-	-	-	-	-	-	-	-	-	-
		Barrel	10.11	10	11.06	10	-	-	14.24	10	9.51	10
		All parts combined	10.34	20	11.16	20	-	-	15.59	20	9.35	20
	K	Cylinder flanges	11.59	10	12.64	10	13.94	8	15.55	10	8.51	10
		Cylinder boss	-	-	-	-	-	-	-	-	-	-
		Beam flanges	-	-	-	-	-	-	-	-	-	-
		Barrel	11.42	10	12.38	10	-	-	14.13	10	9.90	10
		All parts combined	11.51	20	12.51	20	-	-	14.84	20	9.21	20
DTD 133B	C	Cylinder flanges	7.03	12	7.92	12	9.19	12	10.52	12	10.49	12
		Cylinder boss	6.97	6	7.59	5	8.79	5	9.93	6	10.26	6
		Beam flanges	7.23	6	8.05	6	9.32	6	10.29	6	10.12	6
		Barrel	6.72	6	7.55	6	8.82	6	10.27	6	10.91	6
		All parts combined	7.00	30	7.81	29	9.07	29	10.31	30	10.45	30
	D	Cylinder flanges	8.18	12	9.11	12	10.40	12	11.82	12	11.52	12
		Cylinder boss	7.02	6	7.90	6	9.14	6	10.23	6	9.40	6
		Beam flanges	7.90	6	8.90	6	10.31	6	11.09	6	10.74	6
		Barrel	7.88	6	8.72	6	9.94	6	11.02	6	9.72	6
		All parts combined	7.83	30	8.75	30	10.04	30	11.36	30	10.58	30
DTD 165	H	Cylinder flanges	6.62	12	7.37	12	8.38	12	12.81	12	9.33	12
		Cylinder boss	6.49	6	7.06	6	7.92	6	11.54	6	10.27	6
		Beam flanges	6.39	6	7.07	6	8.06	6	10.41	6	9.22	6
		Barrel	6.44	6	7.04	6	7.80	6	10.16	6	10.48	6
		All parts combined	6.51	30	7.18	30	8.11	30	11.54	30	9.73	30
	J	Cylinder flanges	6.10	12	6.87	12	7.74	10	8.35	12	10.38	12
		Cylinder boss	6.05	6	6.69	6	7.37	5	7.94	6	10.32	6
		Beam flanges	5.89	6	6.71	6	7.69	6	8.73	6	10.35	6
		Barrel	6.30	6	6.99	6	7.77	5	7.93	6	10.84	6
		All parts combined	6.09	30	6.83	30	7.66	26	8.26	30	10.46	30

/TABLE III (Contd.)

TABLE III (Contd.)

Means of Tensile Test Values
for Each Part of Casting (contd.)

Material Specification	Source	Part of Casting	t_1		t_2		t_5		f_t		E	
			$\bar{\bar{x}}$	n	$\bar{\bar{x}}$	n	$\bar{\bar{x}}$	n	$\bar{\bar{x}}$	n	$\bar{\bar{x}}$	n
Aluminium Alloys (contd.)												
DTD 240	F	Cylinder flanges	8.23	11	8.73	8	10.00	6	11.12	12	10.54	11
		Cylinder boss	7.23	6	8.27	6	9.72	6	10.61	6	10.07	6
		Beam flanges	8.16	6	9.18	5	10.21	4	10.54	6	8.42	6
		Barrel	7.10	5	7.99	5	9.19	4	9.97	5	10.36	5
		All parts combined	7.80	28	8.55	24	9.80	20	10.70	29	9.95	28
	G	Cylinder flanges	7.62	12	8.71	12	10.14	11	11.56	12	10.89	12
		Cylinder boss	7.93	6	9.10	6	10.58	6	11.28	6	10.20	6
		Beam flanges	8.28	6	9.29	6	10.69	6	11.94	6	9.18	6
		Barrel	7.68	6	8.83	6	10.19	4	10.63	6	11.62	6
		All parts combined	7.82	30	8.93	30	10.36	27	11.39	30	10.55	30
DTD 245	F	Cylinder flanges	14.64	6	15.68	6	16.87	5	16.56	12	10.51	6
		Cylinder boss	14.01	6	15.18	6	-	-	15.76	6	10.02	6
		Beam flanges	14.36	6	15.62	6	16.63	3	17.37	6	10.94	6
		Barrel	12.54	4	13.61	4	-	-	14.23	5	10.83	4
		All parts combined	14.01	22	15.15	22	16.78	8	16.16	29	10.55	22
	G	Cylinder flanges	13.20	12	14.68	12	16.48	7	16.87	12	10.98	12
		Cylinder boss	12.68	6	14.06	4	-	2	15.20	6	12.08	6
		Beam flanges	13.42	6	14.92	6	16.57	4	16.62	6	11.32	6
		Barrel	12.30	6	13.73	6	-	-	14.66	6	11.19	6
		All parts combined	12.96	30	14.44	28	16.48	13	16.04	30	11.31	30
DTD 250	E	Cylinder flanges	9.44	12	11.03	12	13.12	12	15.28	12	10.14	12
		Cylinder boss	9.89	6	11.09	6	12.85	5	13.54	6	10.45	6
		Beam flanges	11.33	6	12.67	6	14.45	6	16.44	6	9.73	6
		Barrel	10.12	6	11.28	6	13.00	6	13.94	6	10.49	6
		All parts combined	10.04	30	11.42	29	13.32	30	14.90	30	10.19	30
DTD 255	E	Cylinder flanges	17.04	12	18.54	7	-	-	19.10	12	9.86	12
		Cylinder boss	16.48	4	-	-	-	-	16.78	6	9.75	6
		Beam flanges	17.47	6	19.04	6	-	-	20.28	6	10.30	6
		Barrel	15.97	6	-	-	-	-	16.44	6	10.02	6
		All parts combined	16.81	28	18.77	13	-	-	18.31	30	9.96	30
DTD 287	E	Cylinder flanges	5.82	12	6.98	12	8.48	12	10.58	12	10.39	12
		Cylinder boss	5.28	6	6.11	6	7.47	6	9.45	6	11.14	6
		Beam flanges	5.88	6	6.83	6	8.27	6	10.30	6	10.00	6
		Barrel	5.85	6	6.60	6	7.88	6	9.34	6	11.57	6
		All parts combined	5.73	30	6.70	30	8.12	30	10.05	30	10.70	30
DTD 298	A	Cylinder flanges	9.15	12	10.19	12	11.61	12	14.71	12	10.67	12
		Cylinder boss	9.45	6	10.29	6	11.54	6	16.70	6	9.98	6
		Beam flanges	10.22	6	11.17	6	12.50	6	15.38	6	10.04	6
		Barrel	10.11	6	11.05	6	12.46	6	15.28	6	11.01	6
		All parts combined	9.61	30	10.58	30	11.94	30	15.36	30	10.47	30
	B	Cylinder flanges	6.02	12	6.79	12	7.89	12	15.23	12	10.36	12
		Cylinder boss	5.37	6	5.96	6	6.89	6	13.96	6	10.27	6
		Beam flanges	5.62	6	6.35	6	7.39	6	14.13	6	9.80	6
		Barrel	6.21	6	6.88	6	7.89	6	13.95	6	10.77	6
		All parts combined	5.85	30	6.55	30	7.59	30	14.50	30	10.31	30

/TABLE III (Contd.)

TABLE III (Contd.)

Means of Tensile Test Values
for Each Part of Casting (contd.)

Material Specification	Source	Part of Casting	t_1		t_2		t_5		f_t		E	
			$\bar{x}$	n	$\bar{x}$	n	$\bar{x}$	n	$\bar{x}$	n	$\bar{x}$	n
Aluminium Alloys (contd.)												
DTD 300	A	Cylinder flanges	12.92	12	14.16	12	15.94	11	16.73	12	8.63	12
		Cylinder boss	13.19	6	14.13	6	15.03	5	18.06	6	9.90	6
		Beam flanges	15.04	6	16.35	6	18.15	6	19.68	6	9.44	6
		Barrel	14.91	6	15.96	6	17.65	6	18.55	6	9.17	6
		All parts combined	13.80	30	14.95	30	16.62	28	17.95	30	9.15	30
	B	Cylinder flanges	9.05	12	10.08	12	11.29	12	15.73	12	10.44	12
		Cylinder boss	8.95	6	9.70	6	10.74	6	12.34	6	9.94	6
		Beam flanges	9.88	6	10.82	6	12.04	6	13.72	6	9.65	6
		Barrel	9.66	6	10.50	6	11.64	5	12.20	6	10.08	6
		All parts combined	9.32	30	10.24	30	11.39	29	13.94	30	10.11	30
DTD 304	A	Cylinder flanges	12.11	12	13.26	12	14.82	12	16.75	12	10.41	12
		Cylinder boss	12.46	6	13.40	6	14.72	6	18.13	6	9.87	6
		Beam flanges	12.61	6	13.80	6	15.38	6	17.04	5	10.64	6
		Barrel	12.88	6	13.85	4	15.23	4	16.04	6	9.54	6
		All parts combined	12.44	30	13.49	28	14.98	28	16.94	30	10.16	30
	B	Cylinder flanges	10.69	12	11.85	12	13.50	12	19.70	12	10.96	12
		Cylinder boss	10.62	6	11.55	6	12.88	6	16.75	6	9.94	6
		Beam flanges	11.75	6	12.68	6	14.10	6	18.03	6	9.37	6
		Barrel	11.65	6	12.67	6	14.10	6	18.09	6	10.77	6
		All parts combined	11.08	30	12.12	30	13.61	30	18.45	30	10.40	30
DTD 424	C	Cylinder flanges	6.24	12	7.31	12	8.69	10	10.09	12	10.49	12
		Cylinder boss	5.06	6	6.10	6	7.87	6	10.42	6	10.35	6
		Beam flanges	5.95	6	6.95	6	8.69	6	9.86	6	10.53	6
		Barrel	5.04	6	5.99	6	7.70	6	10.02	6	10.92	6
		All parts combined	5.71	30	6.73	30	8.30	28	10.10	30	10.56	30
	D	Cylinder flanges	6.56	11	7.62	11	8.67	8	9.82	12	10.51	12
		Cylinder boss	5.68	6	6.70	6	8.33	6	8.62	6	10.96	6
		Beam flanges	5.51	6	6.47	6	8.20	6	9.85	6	9.55	6
		Barrel	6.07	6	7.04	6	8.66	6	9.11	6	10.25	6
		All parts combined	6.06	29	7.07	29	8.48	26	9.44	30	10.36	30
	H	Cylinder flanges	7.35	12	8.56	12	10.44	12	11.70	12	10.33	12
		Cylinder boss	6.33	6	7.45	6	9.23	6	9.98	6	10.60	6
		Beam flanges	6.87	6	8.04	6	9.94	6	11.22	6	10.41	6
		Barrel	6.89	6	7.90	6	9.58	6	10.89	6	10.20	6
		All parts combined	6.96	30	8.10	30	9.93	30	11.10	30	10.38	30

/TABLE III (Contd.)

TABLE III (Contd.)

Means of Tensile Test Values for Each Part of Casting (contd.)

Material Specification	Source	Part of Casting	t_1		t_2		t_5		f_t		E	
			$\bar{\bar{x}}$	n	$\bar{\bar{x}}$	n	$\bar{\bar{x}}$	n	$\bar{\bar{x}}$	n	$\bar{\bar{x}}$	n
Magnesium Alloys												
DTD 281	D	Cylinder flanges	6.00	12	7.50	12	9.57	12	16.95	12	6.60	12
		Cylinder boss	5.56	6	7.05	6	9.28	6	16.08	6	6.74	6
		Beam flanges	6.39	6	7.98	6	10.16	6	18.30	6	6.53	6
		Barrel	6.03	6	7.37	6	9.52	6	15.23	6	6.32	6
		All parts combined	6.00	30	7.48	30	9.62	30	16.70	30	6.56	30
	H	Cylinder flanges	5.92	12	7.20	11	9.17	11	13.74	12	5.30	12
		Cylinder boss	5.26	6	6.62	6	8.70	6	14.87	6	5.69	6
		Beam flanges	6.61	6	8.11	6	10.15	6	15.17	6	6.36	6
		Barrel	5.54	6	6.73	6	8.78	6	12.28	6	5.97	6
		All parts combined	5.85	30	7.17	29	9.20	29	13.96	30	5.72	30
	J	Cylinder flanges	4.46	12	5.57	12	7.37	12	12.04	12	6.09	12
		Cylinder boss	4.93	6	6.13	6	8.17	6	11.12	6	6.60	6
		Beam flanges	5.22	6	6.58	6	8.59	6	12.97	6	6.01	6
		Barrel	4.68	6	5.92	6	7.98	5	9.52	6	6.42	6
		All parts combined	4.75	30	5.95	30	7.89	29	11.54	30	6.24	30
DTD 289	C	Cylinder flanges	4.42	12	5.38	12	7.01	12	13.04	12	5.95	12
		Cylinder boss	4.00	6	4.82	6	6.33	6	11.24	6	6.18	6
		Beam flanges	4.20	6	5.21	6	6.88	6	12.10	6	5.99	6
		Barrel	4.11	6	4.94	6	6.44	6	10.78	6	6.44	6
		All parts combined	4.23	30	5.15	30	6.73	30	12.04	30	6.12	30
	E	Cylinder flanges	4.85	12	5.94	12	7.56	10	15.47	12	6.21	10
		Cylinder boss	4.70	4	5.84	4	7.47	4	15.52	4	6.61	4
		Beam flanges	5.42	5	6.45	5	8.04	4	15.45	5	6.47	6
		Barrel	4.57	6	5.65	6	7.15	4	13.16	6	7.13	6
		All parts combined	4.87	27	5.96	27	7.56	22	14.96	27	6.55	26
	J	Cylinder flanges	4.87	12	6.08	12	8.03	12	15.07	12	6.35	12
		Cylinder boss	4.59	6	5.65	6	7.38	6	13.84	6	8.05	6
		Beam flanges	4.82	6	6.03	6	8.01	6	16.28	6	6.43	6
		Barrel	4.55	6	5.63	6	7.43	6	13.33	6	7.00	6
		All parts combined	4.74	30	5.89	30	7.78	30	14.72	30	6.83	30

TABLE I

Summary of Tensile Test Mean Strength Va

Material Specification	Source	t_1 $\bar{x}$	t_1 v%	t_1 n	t_2 $\bar{x}$	t_2 v%
Aluminium Alloys						
BS L33	F	4.51	15.2	27	5.09	13.5
	G	4.61	8.9	28	5.28	7.9
	F and G combined	4.56	12.3	55	5.19	10.9
BS L53	B	11.44	7.7	20	12.4	8.0
	H	10.34	7.0	20	11.16	5.0
	K	11.51	6.1	20	12.51	6.0
	B, H and K combined	11.09	8.4	60	12.02	8.2
DTD 133B	C	7.00	8.7	30	7.81	8.0
	D	7.83	8.6	30	8.75	7.9
	C and D combined	7.41	10.4	60	8.29	9.7
DTD 165	H	6.51	5.0	30	7.18	5.4
	J	6.09	5.2	30	6.83	4.3
	H and J combined	6.30	6.1	60	7.00	5.5
DTD 240	F	7.80	13.8	28	8.55	8.1
	G	7.82	9.6	30	8.93	7.5
	F and G combined	7.81	11.7	58	8.76	8.0
DTD 245	F	14.01	7.6	22	15.15	6.9
	G	12.96	7.2	30	14.44	6.9
	F and G combined	13.40	8.4	52	14.75	7.3
DTD 250	E	10.04	12.9	30	11.42	9.0
DTD 255	E	16.81	4.8	28	18.77	3.1
DTD 287	E	5.73	10.9	30	6.70	9.5
DTD 298	A	9.61	7.2	30	10.58	6.5
	B	5.85	11.8	30	6.55	11.3
	A and B combined	- †	- †	- †	- †	- †
DTD 300	A	13.80	10.8	30	14.95	10.2
	B	9.32	9.6	30	10.24	9.0
	A and B combined	- †	- †	- †	- †	- †
DTD 304	A	12.44	6.7	30	13.49	6.4
	B	11.08	15.3	30	12.12	14.2
	A and B combined	11.76	12.7	60	12.78	12.0
DTD 424	C	5.71	15.5	30	6.73	14.3
	D	6.06	14.0	29	7.07	12.1
	H	6.96	10.6	30	8.10	9.3
	C, D and H combined	6.24	15.6	89	7.30	14.3
Magnesium Alloys						
DTD 281	D	6.00	21.5	30	7.48	22.6
	H	5.85	11.1	30	7.17	10.4
	J	4.75	12.2	30	5.95	13.3
	D, H and J combined	5.54	18.8	90	6.86	19.4
DTD 289	C	4.23	8.0	30	5.15	8.7
	E	4.87	11.0	27	5.96	8.8
	J	4.74	7.2	30	5.89	6.8
	C, E and J combined	4.60	10.7	87	5.66	10.4

* Flange material only.

† Not giv

TABLE V

Means of Torsion Test Values

Material Specification	Source	q_1		f_{qA}		f_{qB}		G	
		$\bar{x}$	n	$\bar{x}$	n	$\bar{x}$	n	$\bar{x}$	$\bar{n}$
Aluminium Alloys									
L33	F	1.66	6	6.67	3	6.12	3	2.95	6
	G	1.80	6	7.63	3	7.00	3	3.77	6
L53	B	6.68	20	14.27	10	13.10	10	3.88	20
	H	5.48	20	12.82	10	11.76	10	3.74	20
	K	7.79	20	16.32	10	15.04	10	3.95	20
DTD 133B	C	3.28	6	9.07	3	8.33	3	3.63	6
	D	3.45	6	9.37	3	8.60	3	3.68	6
DTD 165	H	3.52	6	9.00	3	8.23	3	3.93	6
	J	3.18	6	8.13	3	7.43	3	3.33	6
DTD 240	F	3.16	6	7.70	3	7.10	3	4.07	6
	G	3.10	6	8.57	3	7.80	3	3.43	6
DTD 245	F	6.95	5	9.90	3	9.08	3	4.04	6
	G	6.10	6	11.67	3	10.77	3	3.95	6
DTD 250	E	5.54	6	12.38	3	11.43	3	3.91	6
DTD 255	E	8.68	3	13.85	3	12.70	3	4.27	6
DTD 287	E	3.57	6	8.28	3	7.59	3	3.76	6
DTD 298	A	6.45	4	12.50	3	11.53	3	3.60	6
	B	4.27	6	13.90	2	12.80	2	3.77	6
DTD 300	A	9.39	6	11.53	3	10.53	3	3.73	6
	B	5.85	6	12.90	3	11.90	3	3.52	6
DTD 304	A	7.87	6	15.07	3	13.87	3	3.90	6
	B	6.25	6	14.47	3	13.30	3	3.83	6
DTD 424	C	2.75	6	8.50	3	7.87	3	3.45	6
	D	2.40	6	8.20	3	7.53	3	3.77	6
	H	2.62	6	8.87	3	8.27	3	3.45	6
Magnesium Alloys									
DTD 281	D	2.30	6	10.00	3	9.30	3	2.22	6
	H	2.29	6	9.66	3	8.86	3	2.42	6
	J	2.15	6	7.77	3	7.07	3	2.62	6
DTD 289	C	2.42	6	9.33	3	8.70	3	2.57	6
	E	2.13	6	9.11	3	8.35	3	2.10	6
	J	1.88	6	9.17	3	8.40	3	2.33	6

TABLE VI

Means of Shear Test Values

Material Specification	Source	f_s $\bar{\bar{x}}$	f_s n
Aluminium Alloys			
L33	F	7.43	9
	G	7.99	9
L53	B	-	-
	H	-	-
	K	-	-
DTD 133B	C	9.62	9
	D	9.80	9
DTD 165	H	11.08	9
	J	10.01	9
DTD 240	F	9.63	9
	G	9.08	9
DTD 245	F	13.02	9
	G	12.86	9
DTD 250	E	14.96	9
DTD 255	E	15.35	9
DTD 287	E	9.67	9
Aluminium Alloys (contd.)			
DTD 298	A	13.30	9
	B	11.47	9
DTD 300	A	17.14	9
	B	15.61	9
DTD 304	A	16.35	9
	B	15.20	9
DTD 424	C	9.53	9
	D	10.01	9
	H	10.49	9
Magnesium Alloys			
DTD 281	D	9.89	9
	H	10.12	9
	J	9.04	9
DTD 289	C	9.00	9
	E	9.65	9
	J	9.26	9

TABLE VII

Means of Bearing Test Values - b_{10}*

Material Specification	Source	Ratio: Hole Diameter / Sheet Thickness (nominal) 0.74 $\bar{x}$	0.74 n	1.00 $\bar{x}$	1.00 n	1.25 $\bar{x}$	1.25 n
Aluminium Alloys							
L33	F	14.30	3	11.77	3	10.69	3
"	G	16.33	3	13.34	3	12.32	3
*L53	B	-	-	-	-	23.99	10
"	H	-	-	-	-	20.91	10
"	K	-	-	-	-	24.01	10
DTD 133B	C	20.30	3	18.83	3	17.52	3
"	D	16.70	1	19.57	3	18.34	2
DTD 165	H	19.77	3	17.30	3	16.63	3
"	J	19.21	3	17.28	3	15.57	3
DTD 240	F	19.99	3	18.73	3	17.07	3
"	G	21.21	3	20.39	3	18.52	3
DTD 245	F	-	-	26.20	1	25.93	3
"	G	31.83	3	30.50	3	29.90	3
DTD 250	E	26.90	3	25.90	3	25.20	3
DTD 255	E	37.50	3	35.00	3	34.40	3
DTD 287	E	23.30	3	21.20	3	19.50	3
DTD 298	A	25.70	3	23.47	3	22.53	3
"	B	17.97	3	16.28	3	15.53	3
DTD 300	A	32.63	3	29.27	3	28.47	3
"	B	25.87	3	23.00	3	23.13	3
DTD 304	A	29.90	3	26.70	3	26.97	3
"	B	28.93	3	27.47	3	26.87	3
DTD 424	C	19.87	3	17.63	3	16.07	3
"	D	21.09	3	17.83	3	17.12	3
"	H	23.70	3	22.13	3	20.87	3
Magnesium Alloys							
DTD 281	D	18.13	3	15.83	3	14.77	3
"	H	17.84	3	16.05	3	14.81	3
"	J	19.40	3	15.97	3	15.23	3
DTD 289	C	15.67	3	13.92	3	12.52	3
"	E	15.54	3	13.06	3	12.37	3
"	J	16.28	3	14.47	3	12.90	3

* The extension is assumed equally divided between the two test holes. The values are derived by the "offset" method, except for L53, for which a method measuring the actual permanent set was used. Evidence at present is that the 'permanent set' method gives values about 10% lower than the 'offset' method.

TABLE VIII

Means* of Bending Test Values

Material Specification	Source	Tension Flange $B_{0.5}$	Tension Flange B_1	Tension Flange B_2	Tension Flange E	Compression Flange $B_{0.5}$	Compression Flange B_1	Compression Flange B_2	Compression Flange E	Ultimate Stress B_F
Aluminium Alloys										
L33	F	3.91	4.58	5.52	9.73	3.95	4.59	5.43	9.95	11.56
"	G	4.50	5.21	6.24	11.73	4.46	5.31	6.51	12.26	14.34
L53	B	12.19	13.37	15.05	8.52	13.43	14.53	15.60	8.91	21.53
"	H	11.68	12.52	13.22	8.92	11.97	13.07	13.99	9.21	20.61
"	K	12.35	13.33	14.60	8.92	13.10	14.17	15.35	9.11	19.56
DTD 133B	C	7.53	8.67	9.94	10.14	8.25	9.32	10.33	9.79	13.15
"	D	8.64	9.70	11.07	9.98	9.43	9.94	11.40	10.36	14.92
DTD 165	H	7.62	8.56	9.59	9.70	7.89	8.71	9.64	8.63	15.55
"	J	7.64	8.62	9.72	9.14	8.16	8.99	10.31	9.73	10.89
DTD 240	F	7.14	8.47	9.90	10.28	7.50	8.77	10.12	10.26	13.59
"	G	8.30	9.60	11.12	10.07	8.90	10.47	10.95	10.04	14.72
DTD 245	F	17.62	17.76	19.31	10.28	17.63	18.45	19.95	10.38	20.16
"	G	13.81	15.79	17.85	9.69	14.01	16.23	18.53	10.11	22.35
DTD 250	E	10.59	12.28	14.29	10.13	11.20	13.19	14.92	12.20	20.22
DTD 255	E	17.63	20.28	-	20.07	20.14	-	-	10.61	21.10
DTD 287	E	8.52	10.38	10.36	9.68	9.82	11.11	11.09	9.17	12.61
DTD 298	A	12.40	13.30	14.40	9.62	13.46	-	-	9.80	17.13
"	B	7.44	8.46	9.64	9.89	8.66	9.58	10.75	10.54	17.62
DTD 300	A	14.44	16.07	18.08	9.86	-	-	-	-	23.95
"	B	13.14	14.62	16.15	9.23	13.93	14.76	-	9.25	19.99
DTD 304	A	14.57	16.00	17.70	10.42	14.88	16.09	17.06	10.12	23.89
"	B	13.98	14.83	17.07	9.99	13.25	14.46	-	9.89	21.74
DTD 424	C	6.35	7.55	8.97	10.73	6.86	7.95	9.32	10.77	13.48
"	D	7.22	8.14	9.11	9.31	7.72	8.81	9.61	11.17	11.97
"	H	7.80	8.95	10.39	10.11	8.09	9.26	10.66	10.27	14.31
Magnesium Alloys										
DTD 281	D	5.33	6.47	7.78	5.41	5.56	6.95	-	5.88	17.22
"	H	5.54	6.88	-	5.74	5.93	7.45	-	5.90	15.74
"	J	4.91	6.36	8.20	6.74	6.00	7.36	8.92	6.57	14.18
DTD 289	C	4.58	5.57	6.76	5.30	4.98	5.87	6.78	5.40	16.24
"	E	4.66	5.81	7.46	5.95	4.78	5.94	7.69	5.86	15.25
"	J	4.96	6.02	7.52	5.88	4.69	5.75	7.26	5.77	15.69

* The values are means of not more than three results.

TABLE IX

Means* of Lug Test Values

Material Specification	Source	Proof Stresses L_{10} Tension Lug No.1	Proof Tension Lug No.2	Proof Tension Lug No.3	Proof Shear Lug No.1	Proof Shear Lug No.2	Proof Shear Lug No.3	Proof Bearing Lug No.1	Proof Bearing Lug No.2	Proof Bearing Lug No.3	Ultimate Stresses L_F Tension Lug No.1	Ultimate Tension Lug No.2	Ultimate Tension Lug No.3	Ultimate Shear Lug No.1	Ultimate Shear Lug No.2	Ultimate Shear Lug No.3	Ultimate Bearing Lug No.1	Ultimate Bearing Lug No.2	Ultimate Bearing Lug No.3
Aluminium Alloys																			
L33	F	3.11	4.32	5.10	3.50	3.30	2.54	8.41	6.88	5.02	4.58	6.33	9.08	5.16	4.83	4.51	12.39	10.03	8.93
"	G	3.54	4.82	6.08	3.84	3.58	3.03	9.52	7.79	6.12	5.25	6.95	8.96	5.69	5.16	4.50	14.12	11.23	9.11
L53	B	-	-	11.05	-	-	5.55	-	-	11.17	-	-	17.10	-	-	8.58	-	-	17.30
"	H	-	-	9.77	-	-	4.90	-	-	9.88	-	-	13.09	-	-	6.57	-	-	13.22
"	K	-	-	12.00	-	-	6.03	-	-	12.12	-	-	15.46	-	-	7.77	-	-	15.60
DTD 133B	C	3.78	5.74	8.76	4.35	4.33	4.44	10.08	9.24	8.89	4.69	7.07	9.22	5.40	5.34	4.68	12.53	11.39	9.37
"	D	4.19	5.83	8.98	4.60	4.35	4.43	11.28	9.49	8.93	5.21	7.37	9.86	5.72	5.47	4.86	14.00	11.92	9.81
DTD 165	H	3.96	5.11	7.29	4.42	3.95	3.60	10.32	8.35	7.14	5.22	6.88	9.05	5.83	5.30	4.48	13.65	11.23	8.89
"	J	4.00	5.21	7.24	4.35	3.99	3.59	10.73	8.35	7.25	4.42	5.65	7.29	4.79	4.35	3.62	11.78	9.08	7.30
DTD 240	F	4.59	6.40	8.72	5.56	4.97	4.56	12.26	9.96	8.69	5.18	7.01	9.43	6.27	5.61	4.77	13.81	10.91	9.40
"	G	4.54	6.70	9.14	4.97	4.99	4.56	12.22	10.83	9.17	5.08	7.27	9.39	5.57	5.40	4.68	13.70	11.74	9.30
DTD 245	F	6.70	9.60	-	7.53	7.36	-	18.03	15.21	-	7.60	10.09	14.43	8.44	7.71	7.74	20.24	16.11	15.23
"	G	7.03	9.66	-	7.64	7.23	-	18.98	15.61	-	7.10	9.90	12.12	7.76	7.49	6.05	19.18	16.04	12.26
DTD 250	E	6.08	8.78	12.36	7.02	6.73	6.20	16.29	13.69	12.09	7.05	9.64	14.36	8.18	7.54	7.00	18.72	15.56	13.65
DTD 255	E	-	11.53	-	-	8.83	-	-	17.99	-	8.19	11.68	14.74	9.22	8.95	7.58	21.70	18.42	14.64
DTD 287	E	4.44	5.95	8.11	4.89	4.57	3.93	11.88	9.58	7.85	4.84	7.07	8.94	5.33	5.38	4.40	12.94	11.37	8.75
DTD 298	A	5.68	7.79	12.07	6.46	5.92	5.90	14.90	12.52	11.79	7.06	10.73	15.25	8.03	8.15	7.47	18.52	17.23	14.94
"	B	4.01	5.79	8.09	4.51	4.33	4.14	10.78	9.31	8.33	7.16	10.35	14.76	8.04	7.74	7.57	19.24	16.62	15.23
DTD 300	A	6.40	10.82	15.47	7.37	8.14	7.72	17.07	17.25	15.47	8.00	11.65	18.80	8.99	8.75	9.35	21.03	18.25	18.73
"	B	6.57	8.89	12.80	7.16	6.61	6.41	17.72	14.35	12.96	8.51	11.77	16.54	9.28	8.76	8.29	22.99	19.02	16.74
DTD 304	A	6.99	10.44	14.93	7.83	7.93	7.59	18.65	16.88	15.23	8.30	11.97	17.18	9.30	9.09	8.74	22.14	19.35	17.53
"	B	5.50	8.82	12.04	6.23	6.65	6.08	14.62	14.11	12.24	8.65	13.27	16.45	9.80	10.02	8.31	23.00	21.27	16.73
DTD 424	C	4.24	-	8.44	4.72	-	4.23	11.45	-	8.68	4.59	5.77	8.31	5.11	4.40	4.26	12.41	9.39	8.55
"	D	4.48	6.28	7.85	4.93	4.51	3.89	12.06	9.71	7.83	4.57	6.39	7.85	5.03	4.87	3.90	12.29	10.33	7.83
"	H	4.45	6.64	-	4.84	4.91	-	11.98	10.78	-	5.52	6.47	8.21	6.00	4.82	4.11	14.86	10.48	8.31

* The values are means of not more than three results. The proof stress L_{10} is determined by the 'offset' method except for L53 for which a method using permanent set measurements was employed.

/TABLE IX (contd.)

TABLE IX (Contd.)

Means* of Lug Test Values

Material Specification	Source	Proof Stresses L_{10}									Ultimate Stresses L_F								
		Tension			Shear			Bearing			Tension			Shear			Bearing		
		Lug No.1	Lug No.2	Lug No.3	Lug No.1	Lug No.2	Lug No.3	Lug No.1	Lug No.2	Lug No.3	Lug No.1	Lug No.2	Lug No.3	Lug No.1	Lug No.2	Lug No.3	Lug No.1	Lug No.2	Lug No.3
Magnesium Alloys																			
DTD 281	D	4.35	5.88	7.86	4.76	4.52	4.06	11.77	9.70	8.15	5.42	8.46	11.09	7.02	6.50	5.73	17.37	13.96	11.51
"	H	4.50	5.82	9.00	5.13	4.33	4.61	12.74	9.66	9.32	6.03	8.45	12.02	6.88	6.27	6.13	17.12	14.17	12.44
"	J	4.07	6.11	8.85	4.68	4.56	4.38	10.88	9.84	8.86	5.24	7.48	10.15	6.04	5.58	5.04	14.07	12.05	10.17
DTD 289	C	3.94	5.24	6.61	4.46	4.00	3.28	10.67	8.54	6.64	4.82	6.41	7.41	5.48	4.89	3.66	13.00	10.44	7.44
"	E	4.04	5.14	6.94	4.60	3.98	3.41	10.99	8.58	7.01	5.04	6.98	9.78	5.75	5.40	4.81	13.73	11.62	9.87
"	J	4.04	4.91	7.43	4.47	3.72	3.88	10.91	7.97	7.78	5.93	7.98	10.48	6.56	6.04	5.47	16.00	12.95	10.96

* The values are means of not more than three results.

TABLE X

Means of Tensile Test Values from Cast Test Bars

Material Specification	Source	t_1 $\bar{x}$	n	t_2 $\bar{x}$	n	t_5 $\bar{x}$	n	f_t $\bar{x}$	n	E $\bar{x}$	n
Aluminium Alloys											
L33	F	3.89	9	4.49	9	5.75	9	10.30	9	10.72	9
"	G	3.47	3	4.18	3	5.53	3	10.42	3	11.14	3
L53	B	12.44	12	13.34	12	14.68	12	21.82	12	10.63	12
"	H	12.79	6	13.66	6	15.10	6	19.98	6	10.07	6
"	K	13.24	10	14.26	10	15.85	10	22.08	10	10.19	10
DTD 133B	C	7.16	3	8.03	3	9.44	3	11.72	3	11.06	3
"	D	7.51	3	8.49	3	9.93	3	12.19	3	11.76	3
DTD 165	H	4.84	10	5.45	10	6.32	10	11.72	10	10.64	10
"	J	6.17	3	6.81	3	7.59	3	9.22	3	9.70	3
DTD 240	F	6.80	14	7.96	14	9.60	14	11.40	16	10.13	14
"	G*	5.69	3	6.98	3	8.79	3	11.60	3	11.85	3
DTD 245	F	14.33	9	15.83	9	16.30	5	17.05	9	10.91	9
"	G	12.19	3	13.27	3	14.75	3	15.84	3	10.01	3
DTD 250	E	11.86	4	12.98	4	14.72	4	15.57	4	10.66	4
DTD 255	E	18.01	2	19.21	2	-	-	19.55	4	9.95	4
DTD 287	E	6.66	4	7.65	4	9.06	4	10.58	4	9.59	4
DTD 298	A	8.82	3	-	-	-	-	15.77	3	9.38	3
"	B	-	-	-	-	-	-	14.19	8	-	-
DTD 300	A	-	-	-	-	-	-	17.85	4	-	-
"	B	-	-	-	-	-	-	17.43	3	-	-
DTD 304	A	12.72	3	13.64	3	14.99	3	18.31	3	9.66	3
"	B	-	-	-	-	-	-	18.59	8	-	-
DTD 424	C	4.21	3	5.29	3	6.94	3	9.55	3	10.89	3
"	D	6.19	3	7.31	3	9.12	3	10.45	3	10.40	3
"	H	6.06	8	7.23	8	9.01	8	11.04	8	10.27	8
Magnesium Alloys											
DTD 281	D	5.18	8	6.32	8	8.00	8	18.34	8	6.13	8
"	H	4.87	15	6.07	15	8.01	15	13.23	15	5.97	15
"	J	4.66	3	5.79	3	7.57	3	16.29	3	6.23	3
DTD 289	C	4.55	3	5.52	3	7.12	3	16.32	3	6.15	3
"	E	4.56	6	5.46	6	6.92	6	15.79	6	5.34	6
"	J	4.57	3	5.61	3	7.20	3	14.63	3	6.81	3

* One specimen from this source had a coarser and darker grain structure and lower test values than the other two. The mean values are correspondingly lower.

TABLE XI

Summary of Typical Strength Data for Light Alloy Castings

Material Specification	Estimated True Values																						Estimated % on $\sqrt[4]{\text{cross sectional area}}$
	t_1		t_2		t_5		f_t		E		q_1		f_{qA}		f_{qB}		G		f_s		b_{10} **		
	$\bar{X}$	V	$\bar{X}$	V	$\bar{X}$	V	$\bar{X}$	V	$\bar{X}$	V	$\bar{X}$	V	$\bar{X}$	V	$\bar{X}$	V	$\bar{X}$	V	$\bar{X}$	V	$\bar{X}$	V	
Aluminium Alloys																							
L33	4.4	12.5	5.0	11.0	6.1	10.0	9.8	7.5	9.9	16.5	1.6	10.0*	6.6	10.0*	6.1	10.0*	3.1	16.5*	7.4	7.5*	11.0	15.0	9.0
L53	10.0	7.0	10.9	5.0	12.0	4.0	13.8	16.5	9.2	7.5	5.4	3.5ø	12.2	8.0	11.2	8.0	3.8	4.0	-	-	20.2	5.5	7.0
DTD 133B	7.2	10.5	8.1	9.5	9.4	8.5	10.6	8.5	10.3	9.0	3.2	10.0*	8.5	10.0*	7.8	10.0*	3.5	9.5	9.4	7.5	16.1	10.0*	4.5
DTD 165	6.2	6.0	6.9	5.5	7.8	6.0	8.0	9.0	9.8	10.0	3.2	6.0	7.9	10.0*	7.3	10.0*	3.4	10.0	10.1	10.5	15.2	9.0	3.5
DTD 240	7.6	11.5	8.6	8.0	10.0	6.0	10.8	8.5	9.8	19.0	3.0	7.5	7.5	10.0*	6.9	10.0*	3.5	11.0	9.1	5.5	16.8	8.0	2.5
DTD 245	13.1	8.5	14.5	7.5	-	-	15.7	9.5	10.7	11.5	6.1	10.0*	10.0	10.0*	9.2	10.0*	3.8	11.5*	12.7	4.5	25.1	9.0	2.0
DTD 250	9.6	13.0	11.1	9.0	13.0	7.0	14.4	9.5	10.0	5.0	5.1	10.0*	11.1	10.0*	10.3	10.0*	3.8	5.0*	14.0	10.0*	22.0	10.0*	3.5
DTD 255	16.5	5.0	18.5 ⁄	3.0	-	-	17.7	9.0	9.8	4.5	7.8	10.0*	12.4	10.0*	11.4	10.0*	4.1	5.5	14.5	9.0*	31.3	4.0	-
DTD 287	5.5	11.0	6.5	9.5	7.9	8.0	9.8	7.0	10.5	6.5	3.3	10.0*	6.8	10.0*	6.1	10.0*	3.5	10.0*	9.2	7.0*	18.0	10.0*	3.0
DTD 298	5.6	12.0	6.3	11.5	7.3	10.5	14.2	6.0	10.1	6.5	3.9	10.0*	12.2	10.0*	11.2	10.0*	3.6	6.5*	11.0	6.0*	14.0	10.0*	20.0
DTD 300	9.0	9.5	9.9	9.0	11.0	9.5	12.9	21.5	9.8	8.0	5.4	10.0*	11.6	10.0*	10.7	10.0*	3.3	8.0*	14.7	10.0*	20.6	7.0	7.5
DTD 304	10.5	15.5	11.5	14.0	13.0	13.0	17.8	9.5	10.0	10.0	5.8	10.0*	13.0	10.0*	12.0	10.0*	3.5	10.0*	14.3	10.0*	23.5	10.0*	9.0
DTD 424	6.0	15.5	7.1	14.5	8.7	11.5	10.0	9.5	10.2	9.0	2.4	14.5	8.2	6.0	7.6	6.0	3.4	11.0	9.8	5.0	16.8	13.0	3.0
Magnesium Alloys																							
DTD 281	4.6	12.0	5.7	13.5	7.5	13.0	10.8	19.0	6.1	7.5	2.0	10.0*	7.0	10.0*	6.4	10.0*	2.5	7.5*	8.5	10.0*	14.0	12.5	5.5
DTD 289	4.5	10.5	5.5	10.5	7.2	9.5	13.4	16.0	6.3	14.0	2.0	10.0*	8.6	10.0*	8.0	10.0*	2.2	10.0*	9.0	10.0*	12.2	10.5	9.0

* Assumed values.

⁄ Flange material only.

** Applicable to a $\frac{\text{pin diameter}}{\text{sheet thickness}}$ ratio of about 1.0. The values are reduced to correspond with those obtained by tests which measure the permanent set under load.

ø Average value taken.

TABLE XII

Mean Tensile Strengths of Various Parts of the Casting Expressed in Terms of the Mean Tensile Strength of the Barrel

Material Specification	Source	Proof Stress t_1			Ultimate Stress f_t		
		Cylinder Boss	Cylinder Flange	Beam Flange	Cylinder Boss	Cylinder Flange	Beam Flange
Aluminium Alloys							
L33	F	0.86	0.99	1.16	1.06	1.08	1.06
"	G	0.93	1.10	1.04	0.98	1.05	1.04
L53	B	-	0.94	-	-	1.36	-
"	H	-	1.05	-	-	1.19	-
"	K	-	1.01	-	-	1.10	-
DTD 133B	C	1.04	1.05	1.08	0.97	1.02	1.00
"	D	0.89	1.04	1.00	0.93	1.07	1.08
DTD 165	H	1.01	1.03	0.99	1.14	1.26	1.02
"	J	0.96	0.97	0.93	1.00	1.05	1.10
DTD 240	F	1.02	1.16	1.15	1.06	1.12	1.06
"	G	1.03	0.99	1.08	1.06	1.09	1.12
DTD 245	F	1.12	1.17	1.15	1.11	1.16	1.22
"	G	1.03	1.07	1.09	1.04	1.15	1.13
DTD 250	E	0.98	0.93	1.12	0.97	1.10	1.18
DTD 255	E	1.03	1.07	1.09	1.02	1.15	1.23
DTD 287	E	0.90	0.99	1.01	1.01	1.13	1.10
DTD 298	A	0.93	0.90	1.01	1.09	0.96	1.01
"	B	0.86	0.97	0.90	1.00	1.09	1.01
DTD 300	A	0.88	0.87	1.01	0.97	0.90	1.06
"	B	0.93	0.94	1.02	1.01	1.29	1.12
DTD 304	A	0.97	0.94	0.98	1.13	1.04	1.06
"	B	0.91	0.92	1.01	0.93	1.09	1.00
DTD 424	C	1.00	1.24	1.18	1.04	1.01	0.98
"	D	0.93	1.08	0.91	0.95	1.08	1.08
"	H	0.92	1.07	1.00	0.92	1.07	1.03
Mean Values for Aluminium Alloys		0.96	1.02	1.04	1.02	1.10	1.08
Magnesium Alloys							
DTD 281	D	0.92	1.00	1.06	1.06	1.11	1.20
"	H	0.95	1.07	1.19	1.21	1.12	1.24
"	J	1.05	0.95	1.12	1.17	1.26	1.36
DTD 289	C	0.97	1.08	1.02	1.04	1.21	1.12
"	E	1.03	1.06	1.19	1.18	1.18	1.17
"	J	1.01	1.07	1.06	1.04	1.13	1.22
Mean Values for Magnesium Alloys		0.99	1.04	1.11	1.12	1.17	1.22

TABLE XIII

Summary of Correlation Data
(Aluminium Alloys only)

Properties Correlated		Mean Equation of Line	Correlation Coefficient	Percentage limits above and below the best line, within which 80% of results may be expected to lie.
Casting t_1 - Test bar t_1		Casting $t_1 = 0.81 \times$ Test bar $t_1 + 1.7$	0.940	± 12.4%
Casting f_t - Test bar f_t		Casting $f_t = 0.97 \times$ Test bar $f_t + 0.09$	0.970	± 5.9%
Casting t_2 - Casting t_1		$t_2 = 1.07\ t_1 + 0.4$	0.998	± 2.8%
Casting t_5 - Casting t_1		$t_5 = 1.12\ t_1 + 1.37$	0.992	± 5.4%
Casting f_t - Casting t_1		$f_t = 0.87\ t_1 + 5.6$	0.870	± 16.4%
Casting q_1 - Casting t_1		$q_1 = 0.63\ t_1 - 0.8$	0.924	± 24.0%
Casting f_{qA} - Casting f_t		$f_{qA} = 0.71\ f_t + 1.25$	0.843	± 17.4%
Casting f_s - Casting f_t		$f_s = 0.79\ f_t + 1.5$	0.888	± 15.0%
Casting f_{qA} - Casting f_s		$f_{qA} = 0.76\ f_s + 1.3$	0.864	± 14.3%
Casting b_{10} - Casting t_1	$\frac{\text{Pin diameter}}{\text{Sheet thickness}} = 0.74$	$b_{10} = 1.72\ t_1 + 8.8$	0.942	± 9.9%
	$\frac{\text{Pin diameter}}{\text{Sheet thickness}} = 1.00$	$b_{10} = 1.58\ t_1 + 7.9$	0.944	± 9.9%
	$\frac{\text{Pin diameter}}{\text{Sheet thickness}} = 1.25$	$b_{10} = 1.64\ t_1 + 6.3$	0.947	± 9.9%
	All ratios combined	$b_{10} = 1.62\ t_1 + 7.8$	0.917	± 15.0%
Casting B_1 - Casting t_1		$B_1 = 1.15\ t_1 + 1.3$	0.960	± 16.1%
Casting B_F - Casting f_t		$B_F = 1.19\ f_t + 1.3$	0.951	± 8.3%
* Casting $L_{10(tensile)}$ - Casting t_1		$L_{10_T} = 0.95\ t_1 + 1.9$	0.932	± 13.0%
† Casting $L_{10(shear)}$ - Casting t_1		$L_{10_S} = 0.43\ t_1 + 1.9$	0.932	± 11.4%
* Casting $L_{F(tensile)}$ - Casting f_t		$L_{F_T} = 1.01\ f_t - 1.3$	0.918	± 13.9%
† Casting $L_{F(shear)}$ - Casting f_t		$L_{F_S} = 0.50\ f_t + 0.38$	0.952	± 9.3%

* Values for Lug No.3 used. † Values for Lug No.1 used.

TABLE XIV

Mean Values and Coefficients of Variation of the Elastic Moduli

Material	E			G		
	$\bar{x}$	v%	n	$\bar{x}$	v%	n
Aluminium Alloys	10.27×10^6	11.1	825	3.76×10^6	9.3	186
Magnesium Alloys	6.27×10^6	13.6	214	2.38×10^6	10.3	36

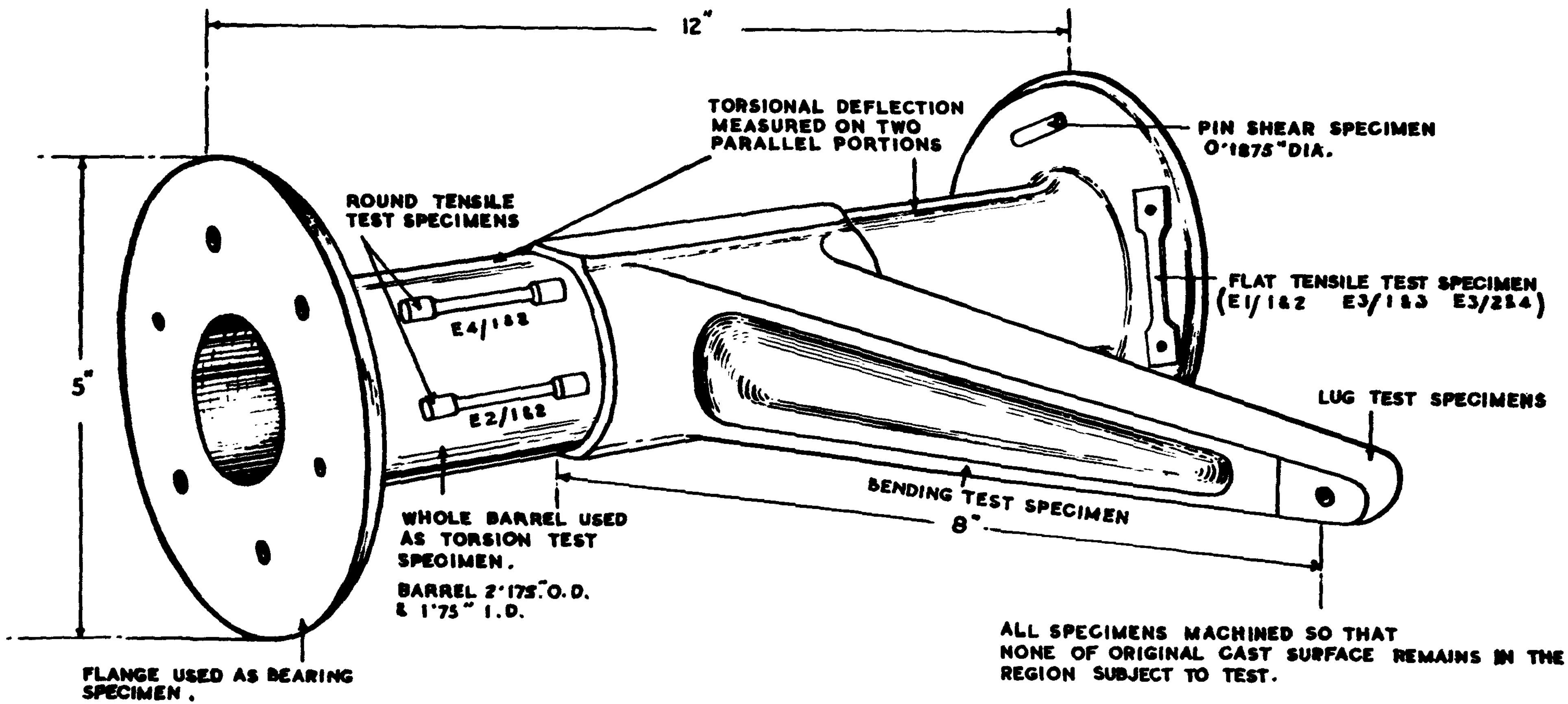


FIG. 2. LOCATION OF TEST SPECIMENS.

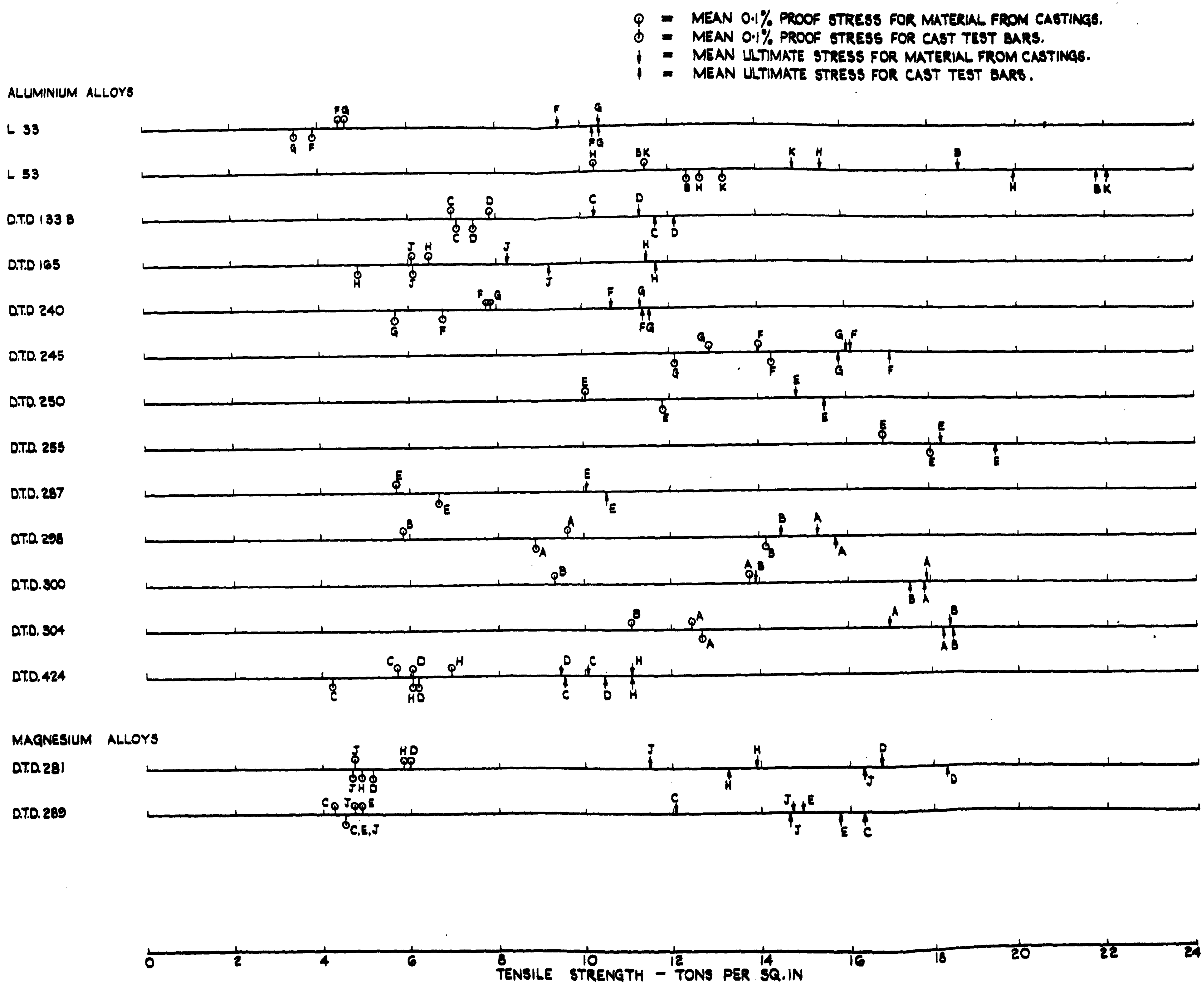
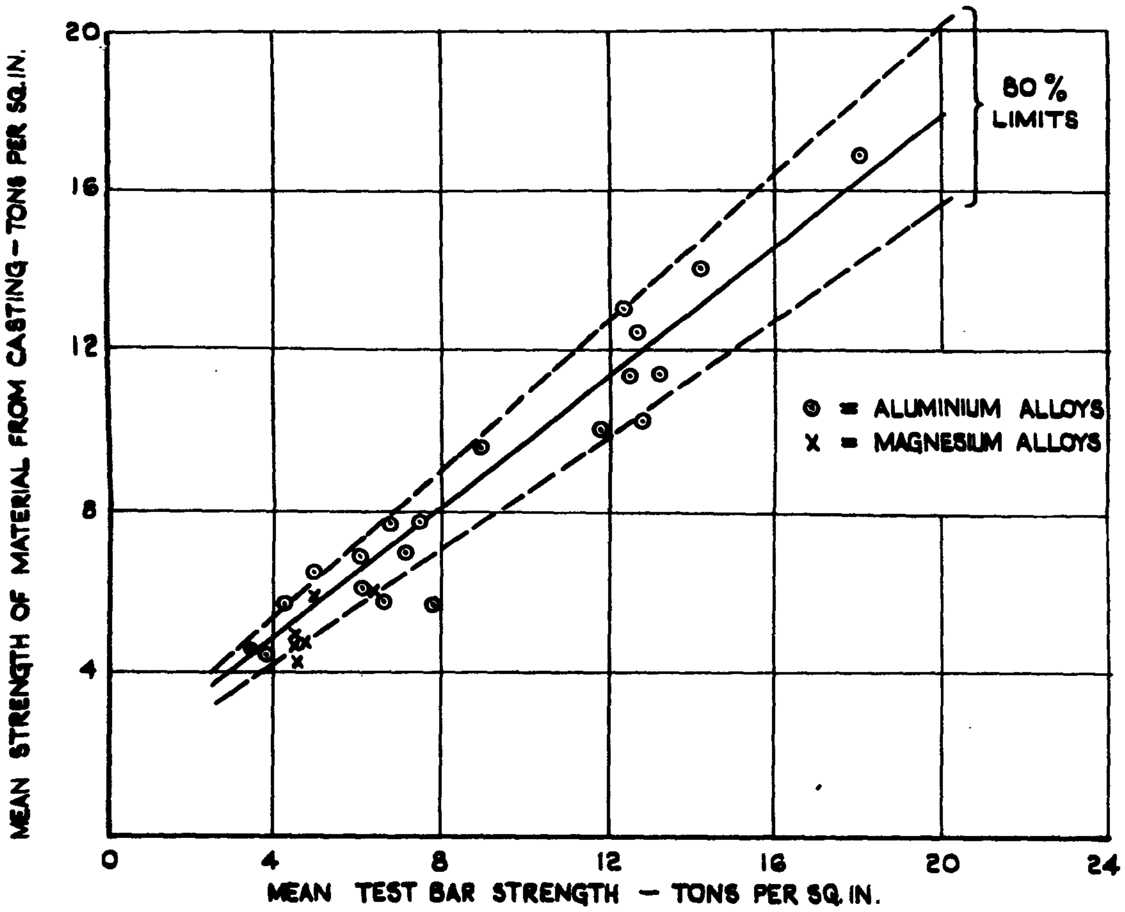
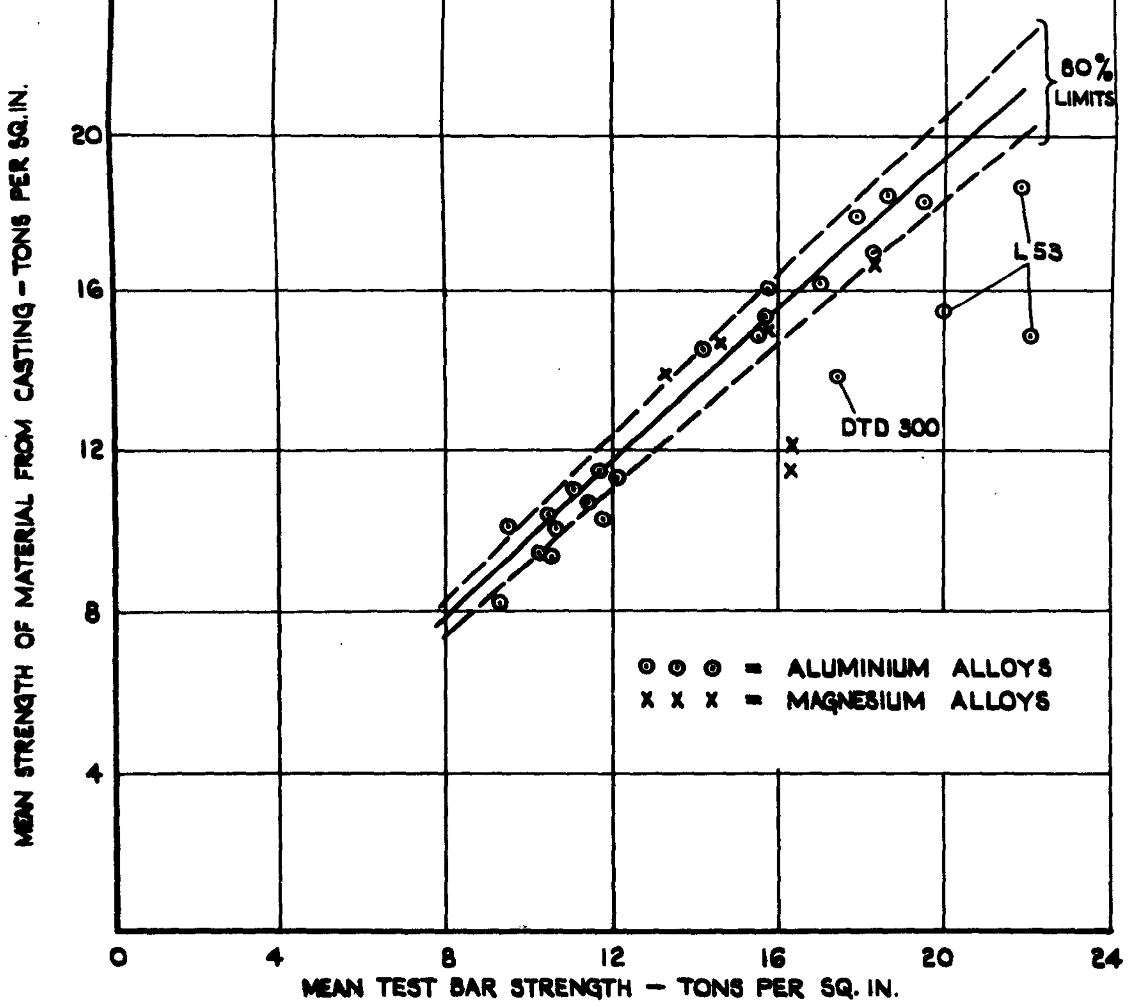


FIG. 3 COMPARISON OF MEAN TENSILE TEST STRENGTHS FOR VARIOUS FOUNDERS & MATERIALS.



(a) 0·1 % PROOF STRESS t_1 — TONS PER. SQ. IN.



(b) ULTIMATE STRESS f_T — TONS PER SQ. IN

FIG. 4 (a & b) RELATIONSHIP BETWEEN CASTING STRENGTH AND TEST BAR STRENGTH.

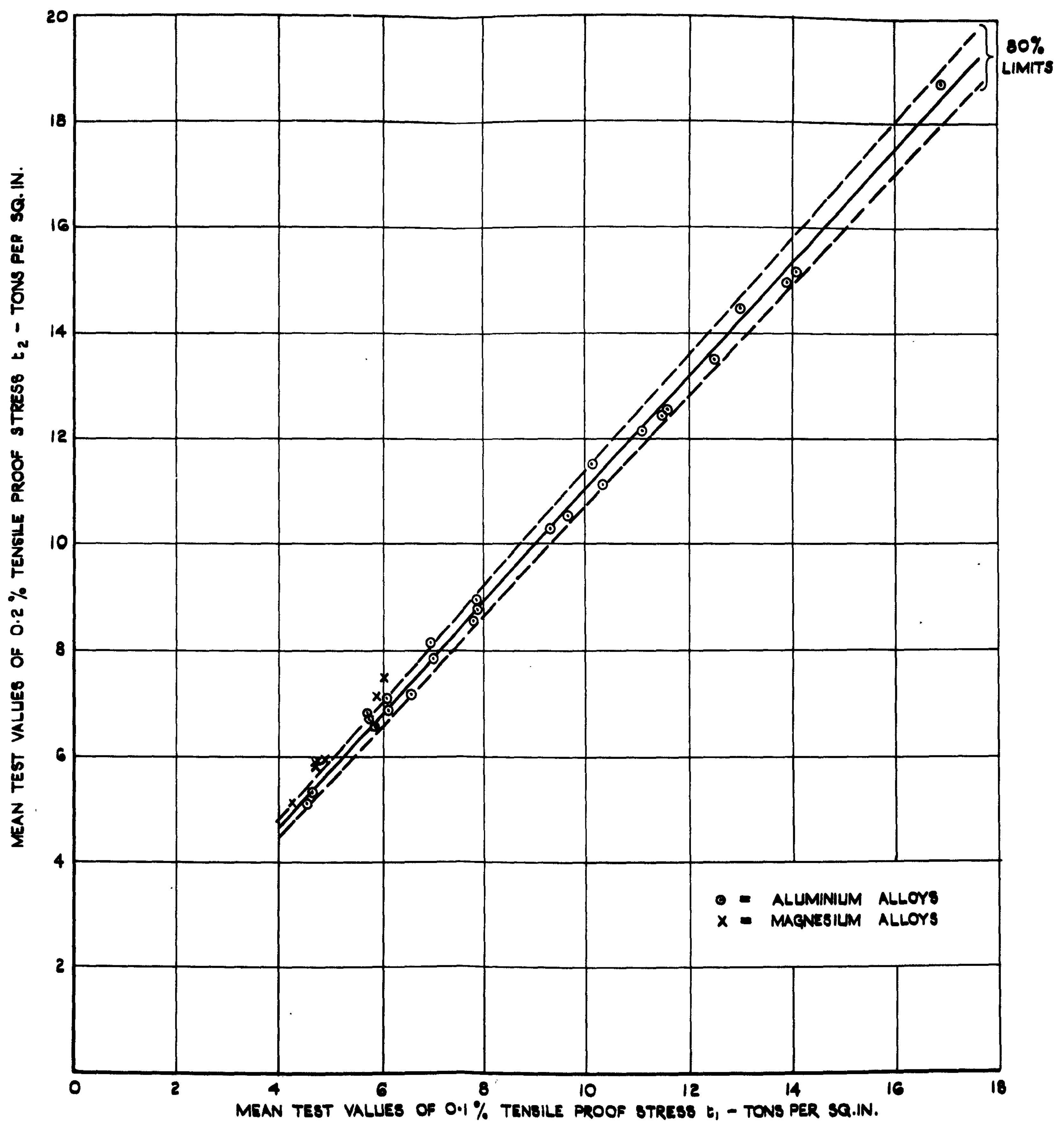


FIG. 5 RELATIONSHIP BETWEEN t_2 AND t_1

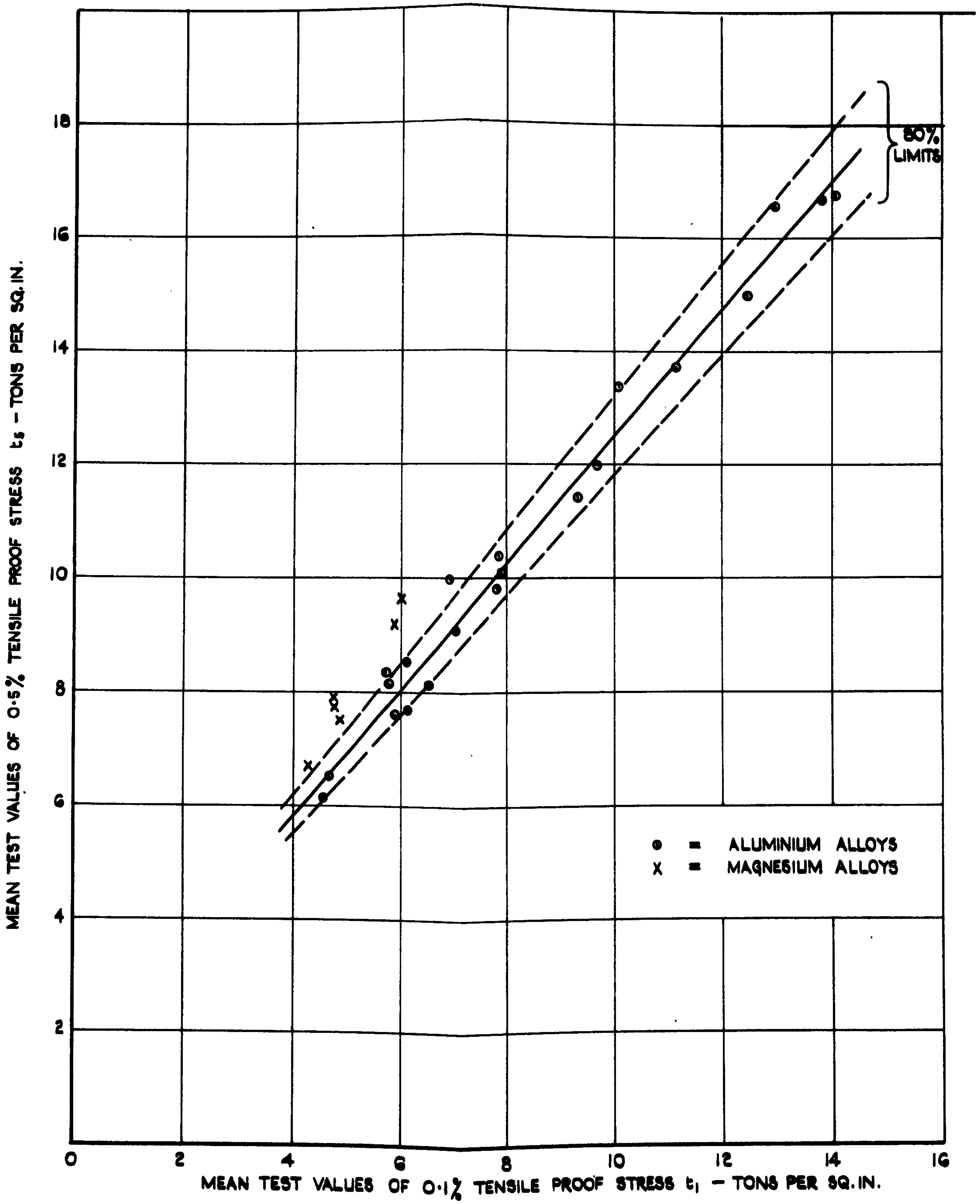


FIG.6 RELATIONSHIP BETWEEN t_5 AND t_1

S.M.E. 74461/R

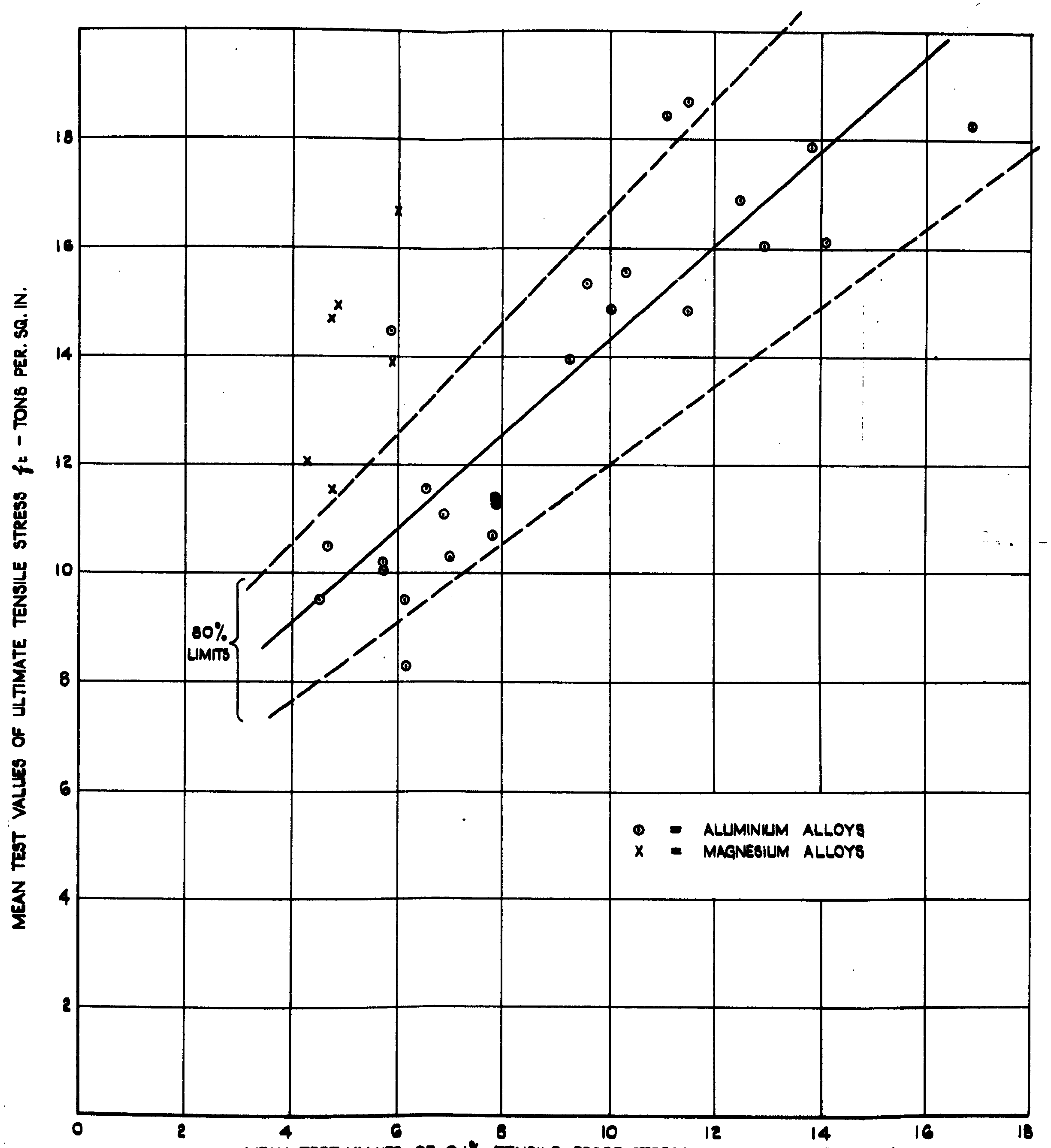


FIG. 7 RELATIONSHIP BETWEEN f_t AND t_1

S.M.E. 74452/R

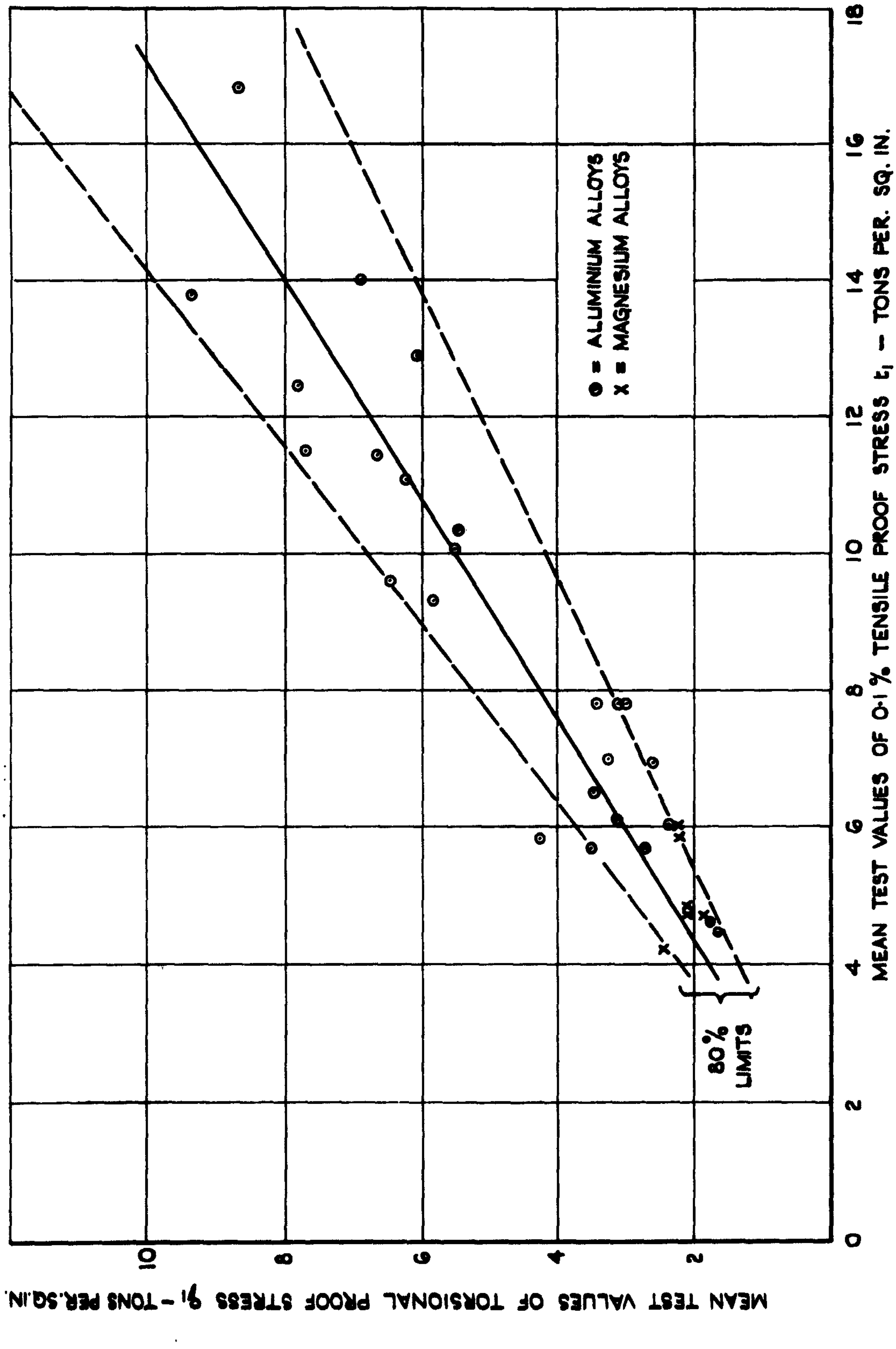


FIG. 8 RELATIONSHIP BETWEEN q_1 AND t_1.

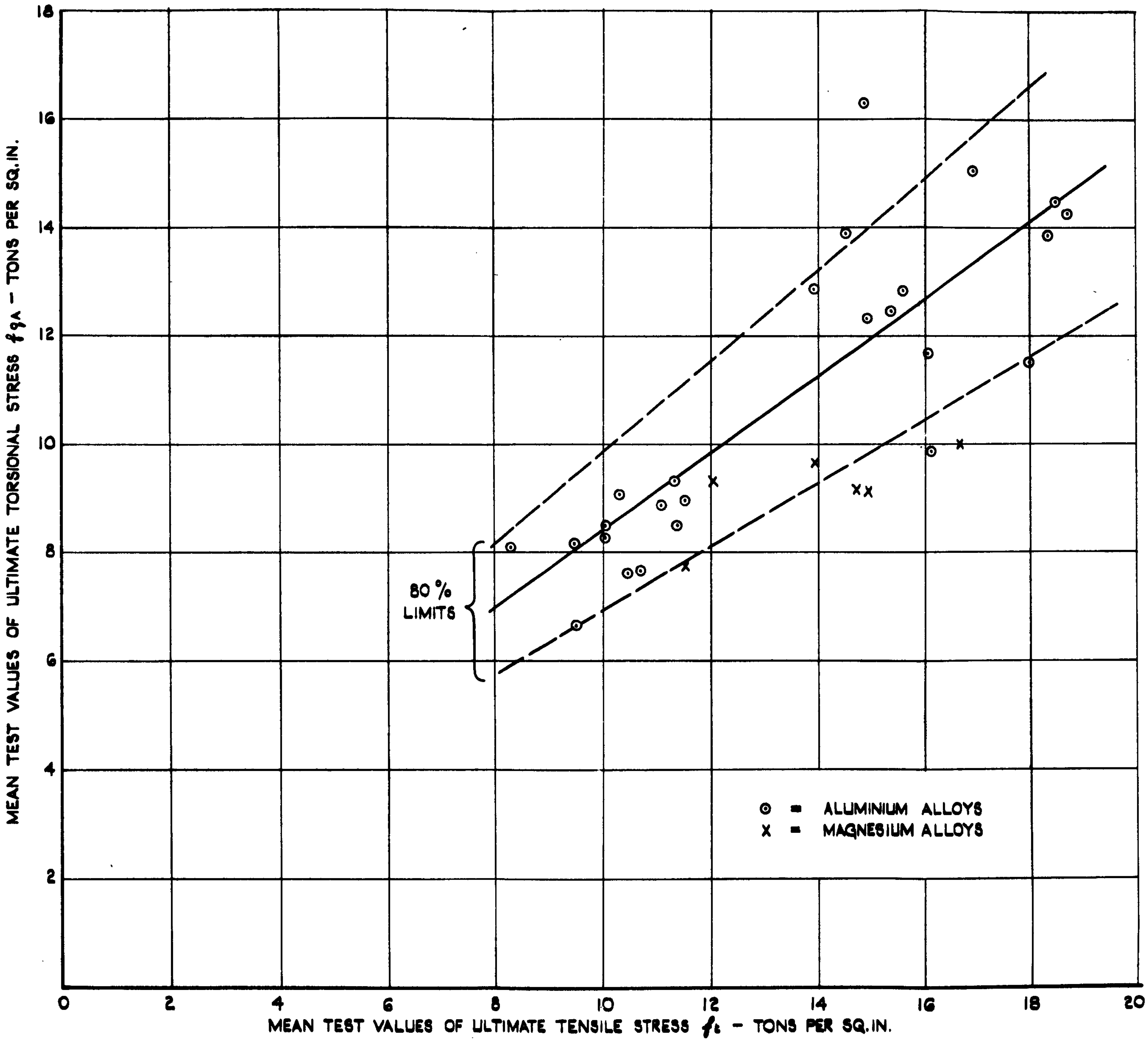


FIG.9 RELATIONSHIP BETWEEN f_{qA} AND f_t.

S.M.E. 74454/R

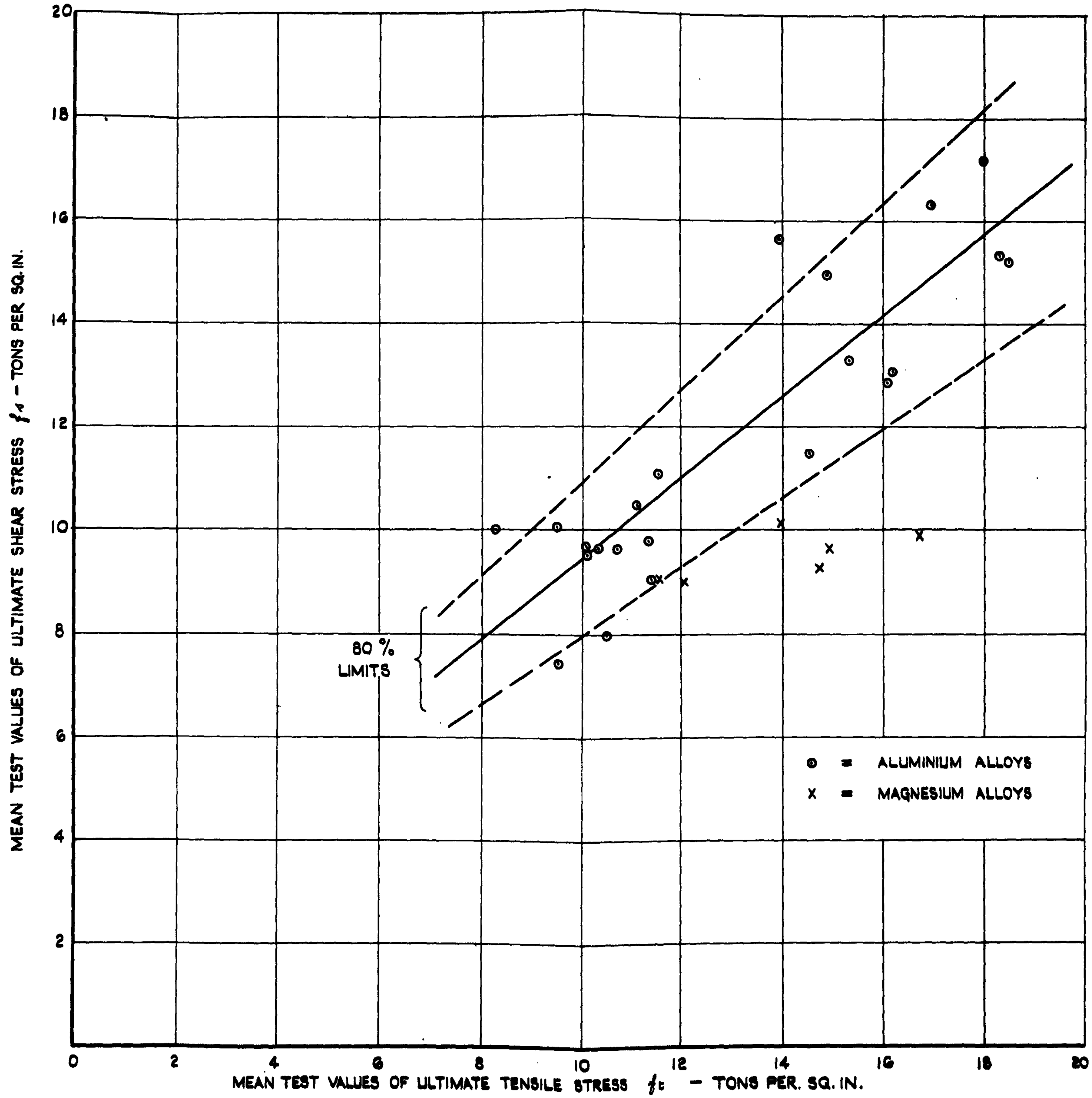


FIG. 10 RELATIONSHIP BETWEEN f_s AND f_t.

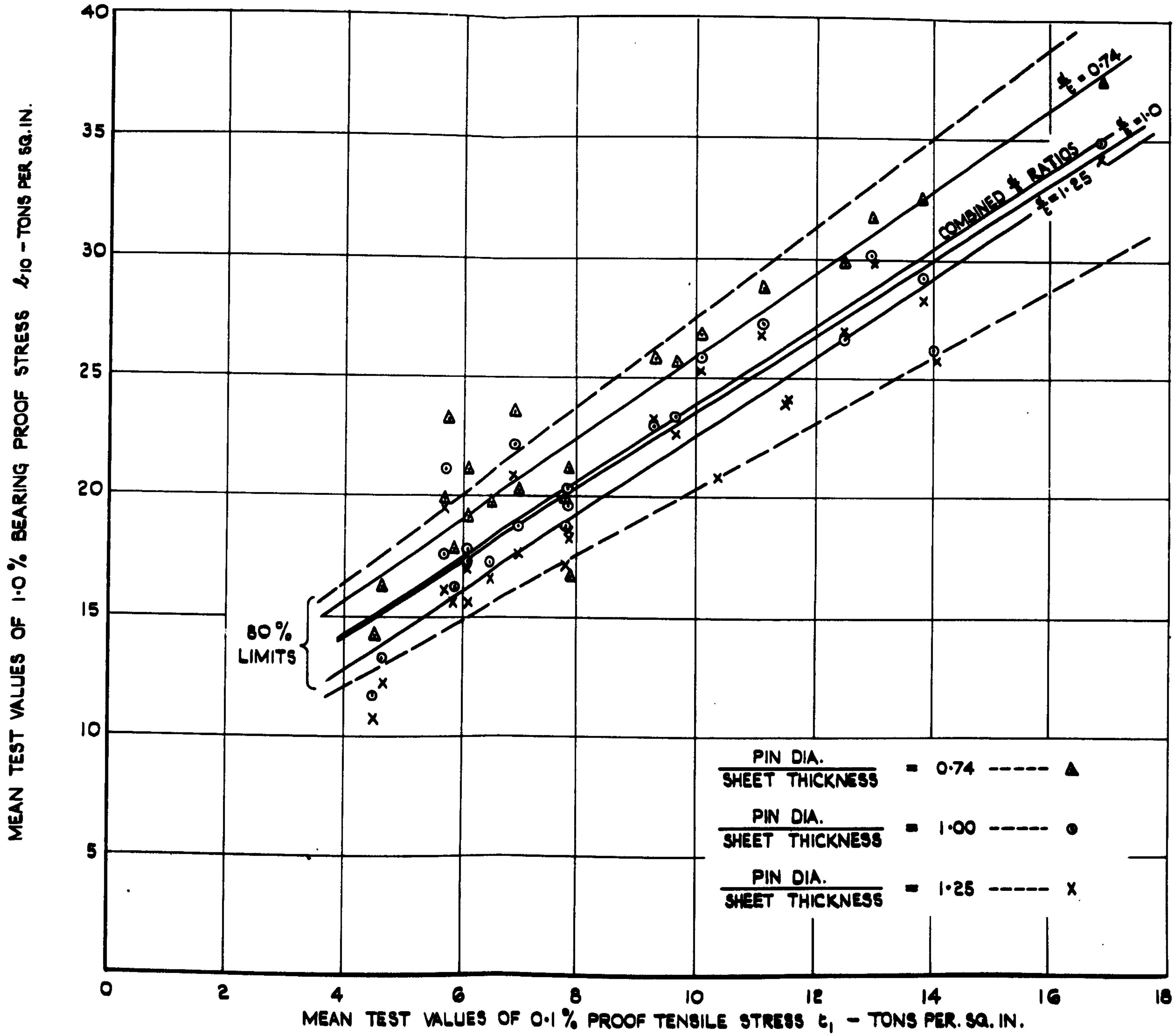


FIG. 11 RELATIONSHIP BETWEEN b_{10} AND t_1 (ALUMINIUM ALLOYS ONLY)

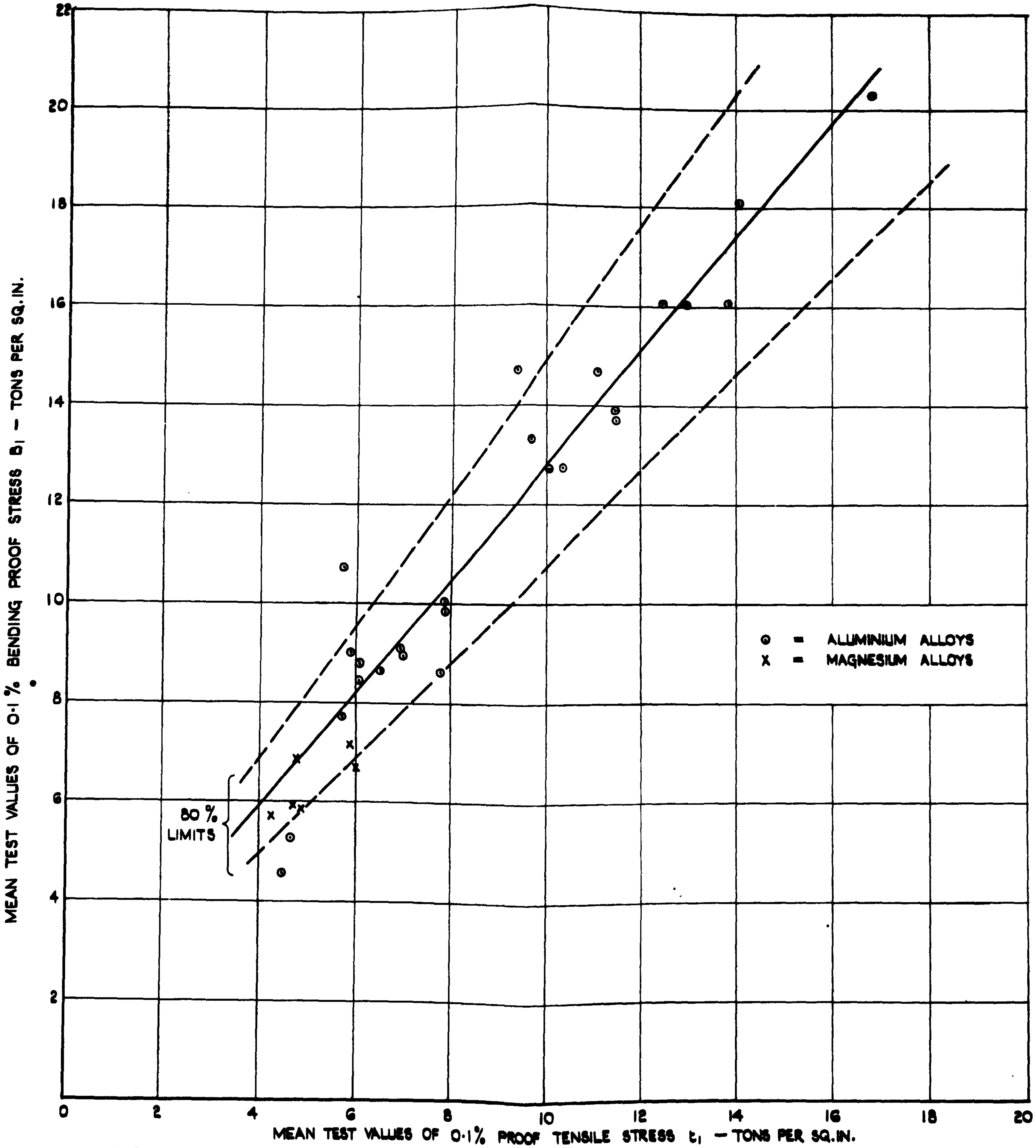


FIG.12 RELATIONSHIP BETWEEN B_1 AND t_1

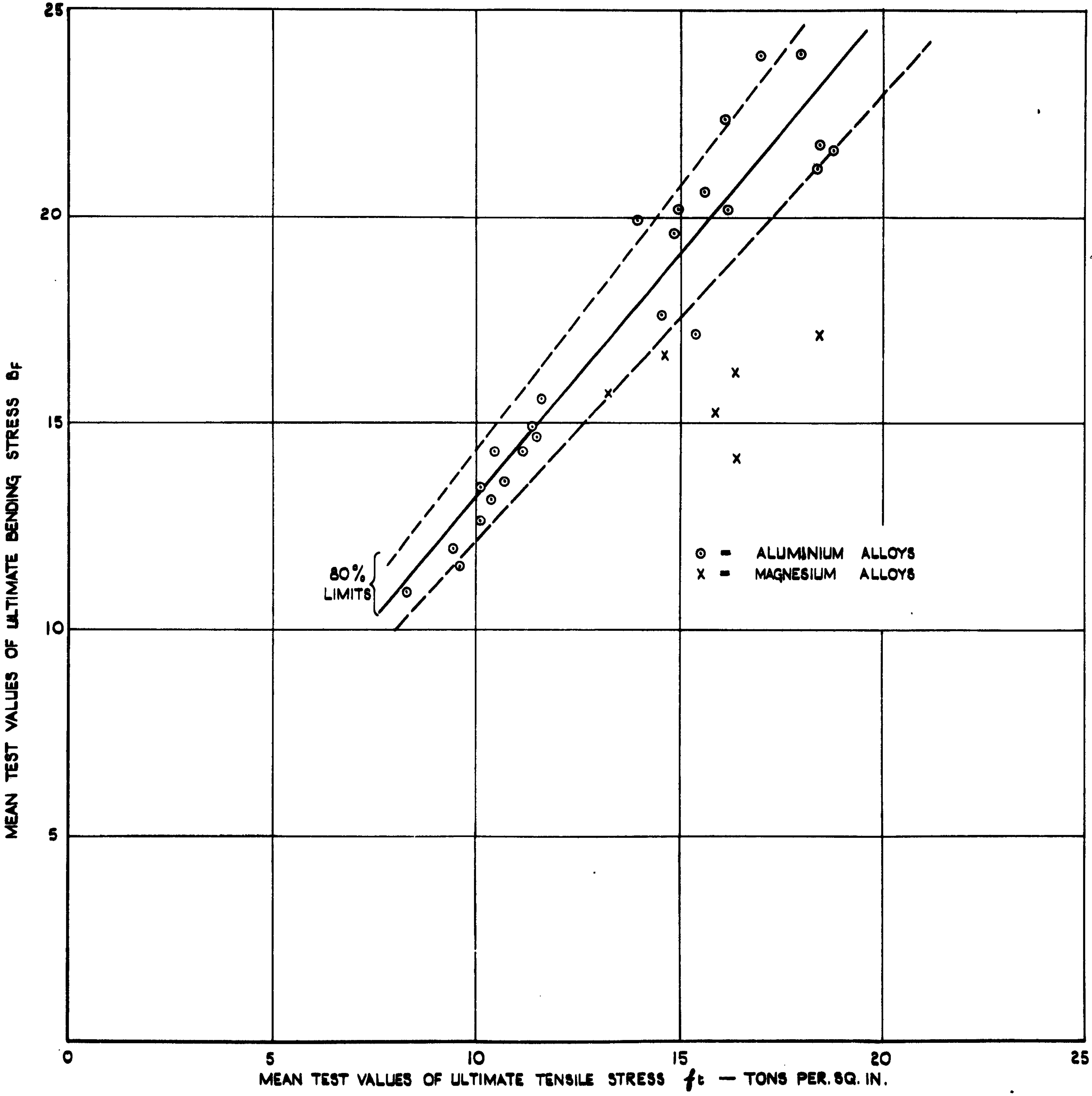


FIG. 13 RELATIONSHIP BETWEEN B_F AND f_t.

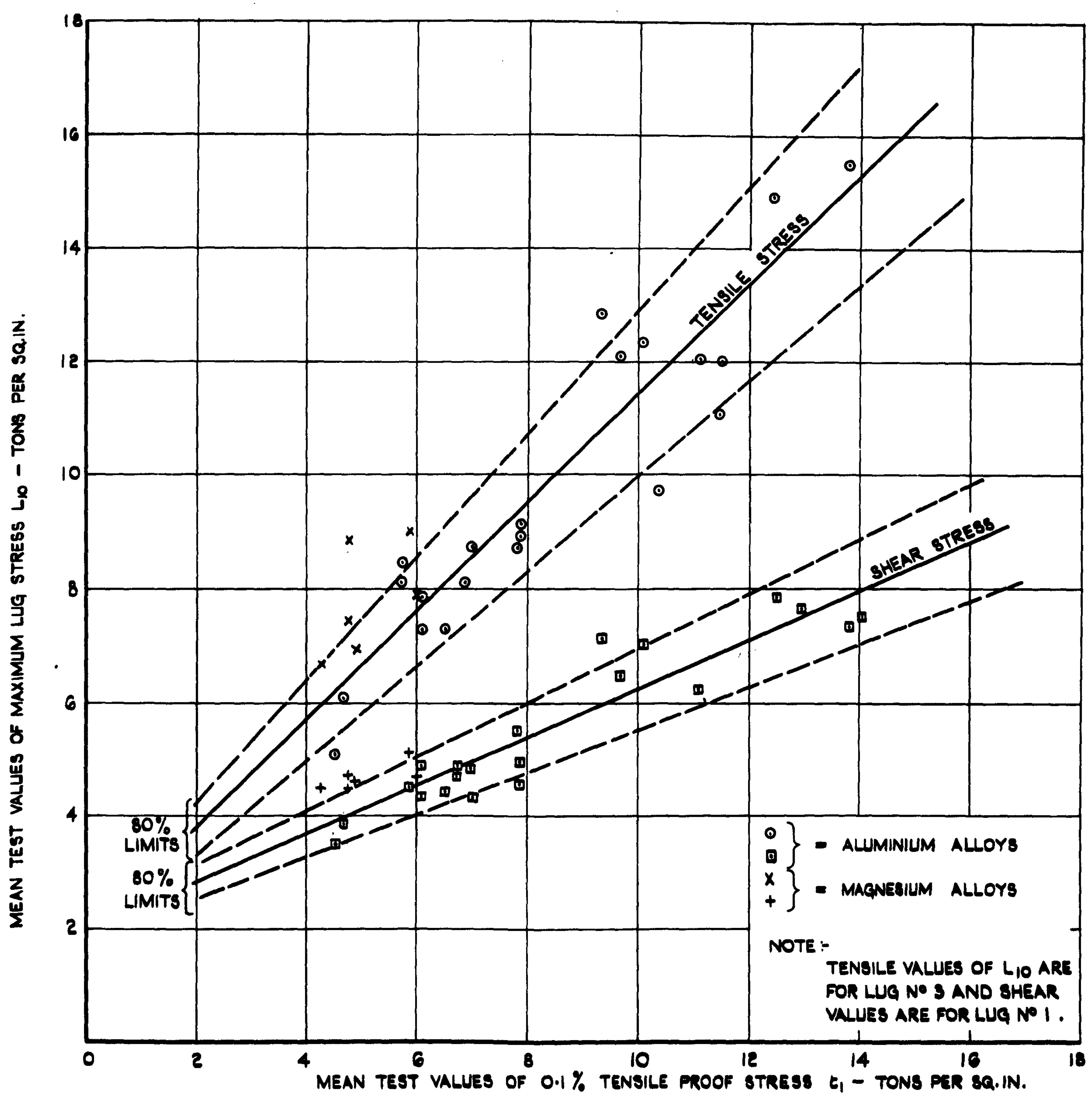


FIG. 14 RELATIONSHIP BETWEEN L_{10} AND t_1

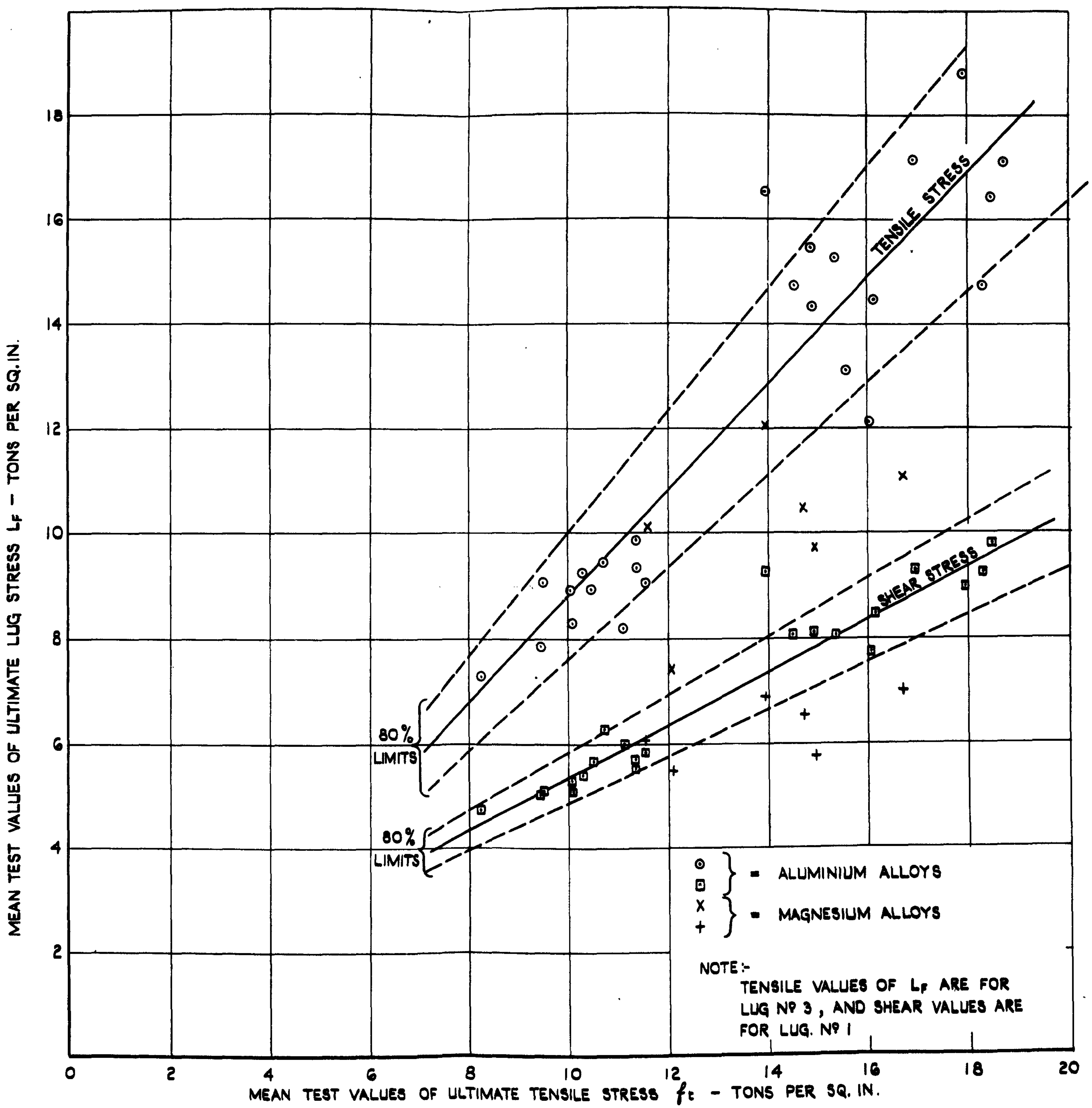


FIG. 15 RELATIONSHIP BETWEEN L_F AND f_T.

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