THE SPRING RESEARCH AND MANUFACTURERS' ASSOCIATION

FATIGUE OF STRIP IN BENDING

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SUMMARY

An investigation has been carried out to determine the fatigue performance in bending of hardened and tempered CS70 carbon steel, hard rolled 302 type stainless steel, and extra hard PB102 phosphor bronze.

S/N curves have been produced for each material in the 'as-slit' condition using an initial stress of 100 N/mm^2. The fatigue limit for the three materials tested was 800 N/mm^2, 650 N/mm^2 and 300 N/mm^2 respectively.

It was observed that many of the strips failed from the burr on the as-slit edge which was stressed in tension, and so a further investigation was carried out into the effect of edge conditioning processes such as barrelling on the fatigue performance of CS80 strip.

Use of as-slit strip with the burr stressed in compression instead of tension was found to improve fatigue life, but no significant further improvement was realised by use of tool dressed strip or as a result of any of the three barrelling process conditions examined here. Higher energy edge conditioning by means of vibratory deburring, or centrifugal processing gave significant improvements in spring fatigue life.

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FATIGUE OF STRIP IN BENDING

1. INTRODUCTION

A previously described method [1] used for fatigue testing strip material in a buckling mode has been further refined to ensure that the results obtained are both accurate and repeatable. Establishing a reliable test procedure has made it possible to undertake with confidence a test programme to establish design data for strip materials which are stressed in bending.

In this programme of work the fatigue test results have been illustrated by S/N curves for three commonly used spring strip materials in the as-slit condition, and for one of these materials the effect of edge conditioning processes on fatigue performance has been evaluated.

2. MATERIALS EVALUATION

2.1 Materials

The three spring strip materials were each obtained in coil form. with as-slit form, with as-slit edges. The three grades of material tested were 0.8% carbon steel conforming to BS 5770 Pt 3 CSHT80 Range 2, stainless steel to BS 5770 Pt 4 302S25 TR 380 and phosphor bronze to BS 2870 PB102 EH. Details of material section size, hardness and tensile strength are given in Table I.

2.2 Test Procedure

The coils of material were initially cut to length to provide the necessary quantities of test samples. The samples were then individually jig drilled to allow location on the dowels on the test jig. The purpose of using dowels to locate the test samples (Fig 1) was to ensure that repeatable set ups, and therefore stress levels, could be achieved.

Three samples of each material type were commercially strain gauged. These strain gauged strips were used, in conjunction with the necessary strain measuring equipment, to produce calibration curves of stress against end deflection for each fatigue machine buckling jig combination. Use of three strain gauged samples per material type allowed variations in strain gauge output to be accounted for when producing the calibration curves.

Samples of each material type were fatigue tested on SRAMA's single station machines at 1000 rpm using the buckling jigs. An initial stress of 100 N/mm^2 was employed and a range of maximum stress levels were selected to produce S/N curves. Tests were carried out to failure or to 4 million cycles. The necessary end deflections to set up the test stress levels were obtained for each machine-jig using the calibration curves previously produced. All samples were tested with the burr of the as-slit strip in tension in order that minimum fatigue strength values would be obtained.

2.3 Results

The results of the fatigue tests are shown in Figures 2 to 4 on which are also drawn the 50% and 95% confidence lines. The graphs show the fatigue limits for carbon steel CSHT 80, stainless steel 302S25, and phosphor bronze PB102, to be 800 N/mm^2, 650 N/mm^2 and 300 N/mm^2 respectively.

It was observed that the fatigue cracks generally developed from the edge of the strips - i.e. from the slitting burr which has been stressed in tension throughout this programme of fatigue testing. It was concluded that the slitting burr was a significant stress raiser, which had a markedly adverse effect on the fatigue performance of all these materials. Hence a further investigation was carried out in which the effect of edge conditioning processes, designed to remove burrs, was evaluated.

2.4 Conclusions

S/N curves have been produced for CS70 hardened and tempered, stainless steel 302S25 and phosphor bronze PB102 strip material with as-slit edges stressed in bending. The fatigue limit for these materials is 800 N/mm^2, 650 N/mm^2 and 300 N/mm^2 respectively for an initial stress level of 100 N/mm^2.

Having produced minimum fatigue life data for these materials, it is now possible to investigate the effect of different methods of edge conditioning on fatigue life.

3. EVALUATION OF THE EFFECT OF EDGE CONDITION ON FATIGUE LIFE

3.1 Introduction

A survey was conducted of the various edge conditioning processes currently in use within the spring industry, and of those commercially available. A range of these processes was applied to a single batch of test pieces made from hardened and tempered CS80 steel strip.

The raw material had as-slit edges, but a small quantity was obtained with a tool dressed edge. The slit edge material was tested as received, with the burr in tension as well as in compression, both after the application of three different low energy barrelling processes, and after two higher energy surface finishing processes.

The effect of these various processes on fatigue performance was calculated and compared by means of Weibull analyses.

This investigation did not seek to draw any conclusions about individual edge conditioning process times or conditions. It may be that optimisation of a particular process may alter its position in the fatigue life hierarchy, but such a conclusion is beyond the scope of this report. The best batches do, however, represent current state-of-the-art in surface finishing and as such are indicative of the improvement in fatigue peformance that spring designers can expect.

3.2 Edge Conditioning Processes

The strip edge conditions compared in this study were as follows:-

1. As-slit edge - tested with the burr in compression (Fig I/1)
2. As-slit edge - tested with the burr in tension
3. Tool dressed edge (Fig I/2)
4. Barrelled B1 (Fig I/3)
5. Barrelled B2 (Fig I/4)
6. Barrelled B3 (Fig I/5)
7. Vibratory deburred (Fig I/6)
8. Centrifugal process (Fig I/7)

A full description of processes 4-8 are given in Appendix I and the appearance of the edges is illustrated by SEM micro-graphs as indicated by the figure numbers opposite each process.

3.3 Preliminary Testing

To ensure the stress/deflection calibration curves were applicable it was necessary to check that the mean dimensions of each batch of test pieces were consistent, both with each other and with the strip samples used earlier. The mean dimensions and weights resulting from each surface conditioning process are given in Table 2.

It was found that all batches were dimensionally within a small tolerance range except the vibratory deburred, which showed a significant reduction in cross-sectional dimensions. Hence a stress correction factor was required for this batch and this was derived via strain gauging.

Preliminary fatigue testing was carried out in order to establish a suitable stress range in which all batches would suffer some failures. It was found, however, that the centrifugally processed and vibratory deburred batches did not appear to fail even at stress levels approaching the onset of plastic set. It was therefore decided to carry out two separate programmes of testing at different stress levels. The first stress range was chosen to be 100-1350 N/mm^2. This was below the level necessary to cause significant plastic set.

The second stress range was chosen to be 100-1500 N/mm^2. At this level a small amount of plastic set was found to occur.

3.4 Test Results

At each of the two stress ranges, 100-1350 and 100-1500 N/mm^2, 10 springs from each of the eight batches were fatigue tested. The results are given in full in Appendix II together with the results of the Weibull analyses, and these are summarised in Table 3.

SRAMA's computer program was used for all calculations involved in the Weibull analysis.

3.5 Discussion

It was found that simply by using the as-slit strips with the burr in compression instead of tension the fatigue life improved significantly.

Neither the three barrelled nor the tool dressed batches showed any significant improvement in fatigue life compared with the as-slit batch tested with the burr in compression. This implies that the precise process conditions for barrelling do not have a significant effect on fatigue performance. Thus it would seem that optimisation of the barrelling procedure would serve little purpose. Indeed, if springs could be designed in which all the highly stressed areas of the design were loaded so that the strip edges at those locations were stressed in compression, then barrelling would be unnecessary for improvement of fatigue life. Similarly, if tool dressed strip were used in place of as-slit strip for spring components with no stamping at stressed regions then barrelling would not improve their fatigue life. However, if an as-slit edge is stressed in compression and tension, then use of tool dressed material or specifying barrelling would clearly be recommended.

It was noted in preliminary testing that the vibratory deburred batch showed a comparatively severe loss in weight and a significant reduction in dimension. The SEM micrographs (in Appendix II) show the surfaces produced by each process. The vibratory deburred batch exhibits a very smooth surface which is noticeably more free of flaws than any of the other batches. These observations suggest that, in the case of the vibratory deburred batch, the weight loss does not impair fatigue performance and may be advantageous in that the edge material damaged on slitting has been totally removed, thus improving resistance to crack propagation. It is possible that optimisation of this process may achieve a reduced weight loss without altering the fatigue performance.

The centrifugally processed batch also displayed a relatively smooth surface without suffering the weight loss and dimensional reduction of the vibratory deburred batch. During the centrifugal process, because of its high energy nature, it is probable that some degree of compressive prestress is imparted to the surface of processed parts - more so than in the other processes. In this respect the effect would be analagous to shot peening and would explain the superior fatigue performance of this batch.

The results of this work have been compared with the results of similar studies undertaken recently by Dr. Kaiser[2] at Damstadt College on behalf of the German Spring Association, and by the Japanese Spring Association[3]. Although the German and Japanese test methods are not identical to SRAMA's and the fatigue test results have been expressed in a radically different manner, it is interesting to note that there appears to be quite good correspondence between SRAMA's, the German, and the Japanese results and conclusions.

3.6 Conclusions

1. The fatigue performance of the as-slit batch tested with the burr in tension was significantly worse than all other batches.

2. There were no significant differences in the fatigue performance of the as-slit batch, in which the burr was tested in compression, the tool dressed batch, and any of the conventional barrelling processes used.

3. The higher energy burr removal processes of vibratory deburring and centrifugal processing both gave significant improvements in fatigue performance. Centrifugally processed samples gave a better performance than the vibratory deburred samples, both in terms of fatigue performance and process weight loss.

4. REFERENCES

(1) Rushton, C.J., "Fatigue of strip in bending." SRAMA Report 357

(2) Kaiser, B., "Fatigue investigations on strip steel springs under bending stresses". Wire, 37(1987),5

(3) "A study of methods for evaluating the characteristics of flat springs". Bane Ronbunshu, 1986 (31)

TABLE I MATERIAL PROPERTIES

Material	Section mm x mm	Hardness HV	Tensile Strength N/mm^2
CS80 Hardened	.70 x 12.40	520	1645
302S25	.72 x 12.44	414	1350
PB102	.73 x 12.40	210	675

TABLE II DIMENSIONS OF TEST PIECES

Batch	Thickness mm	Width mm	Area Reduction %	Mass g	Reduction %
As slit	.70	12.40	–	5.681	–
Tool dressed	.70	12.32	–	5.671	–
Barrelled B1	.68	12.39	2.4	5.659	0.4
Barrelled B2	.70	12.38	0.1	5.671	0.2
Barrelled B3	.69	12.32	2.1	5.563	2.1
Vibratory deburred	.65	12.29	7.9	5.296	6.8
High G	.68	12.32	3.5	5.505	3.1

TABLE III FATIGUE TEST RESULTS SUMMARY

	100-1500 N/mm^2		100-1350 N/mm^2 Test	
	Weibull Life B10/cycles	90% conf. band/cycles	Weibull Life B10/cycles	90% conf. band cycles
As slit (tension)	21,139	17615-24663	41,085	36239-45931
As slit (compression)	24,178	19069-29287	52,620	46585-58655
Barrelled B1	29,120	25780-32460	62,088	43965-80211
B2	23,433	13767-33099	56,585	53276-59894
B3	31,261	23001-39521	60,804	35300-86278
Tool Dressed	30,921	30217-31625	51,509	43990-59028
Vibratory deburred	53,228	51928-54528	>100,000	-
Centrifugally processed	84,340	80097-88583	>100,000	-

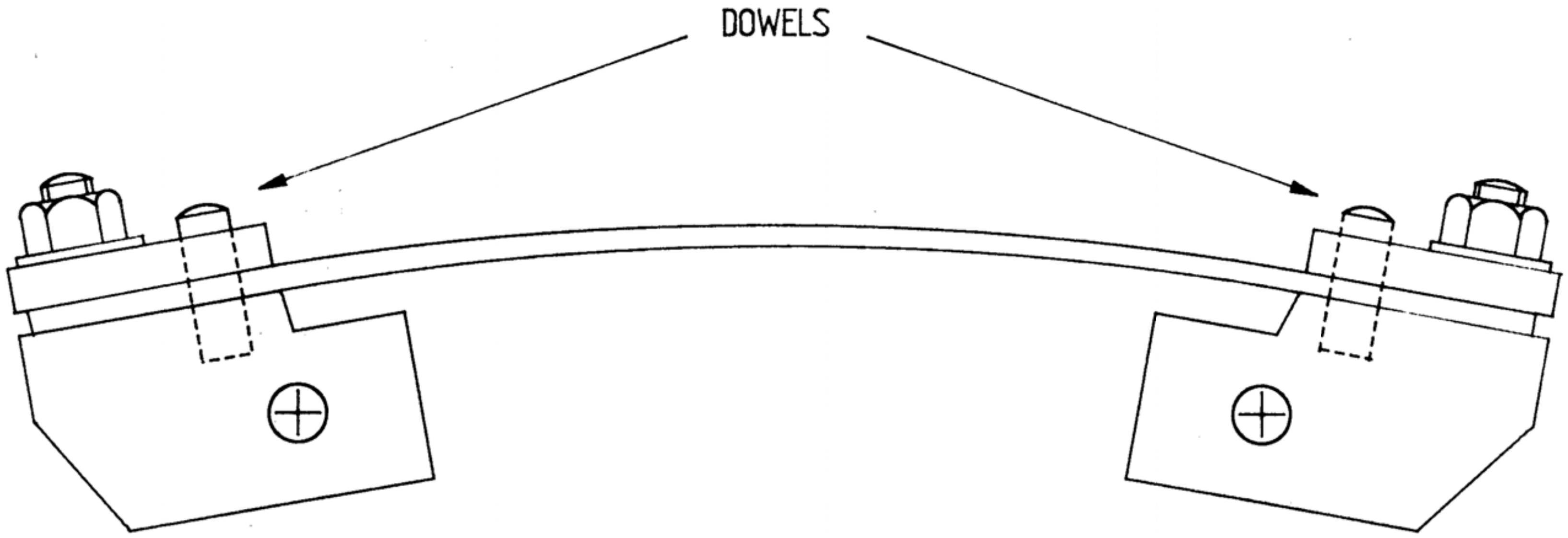

Fig 1 METHOD OF LOCATION OF STRIP

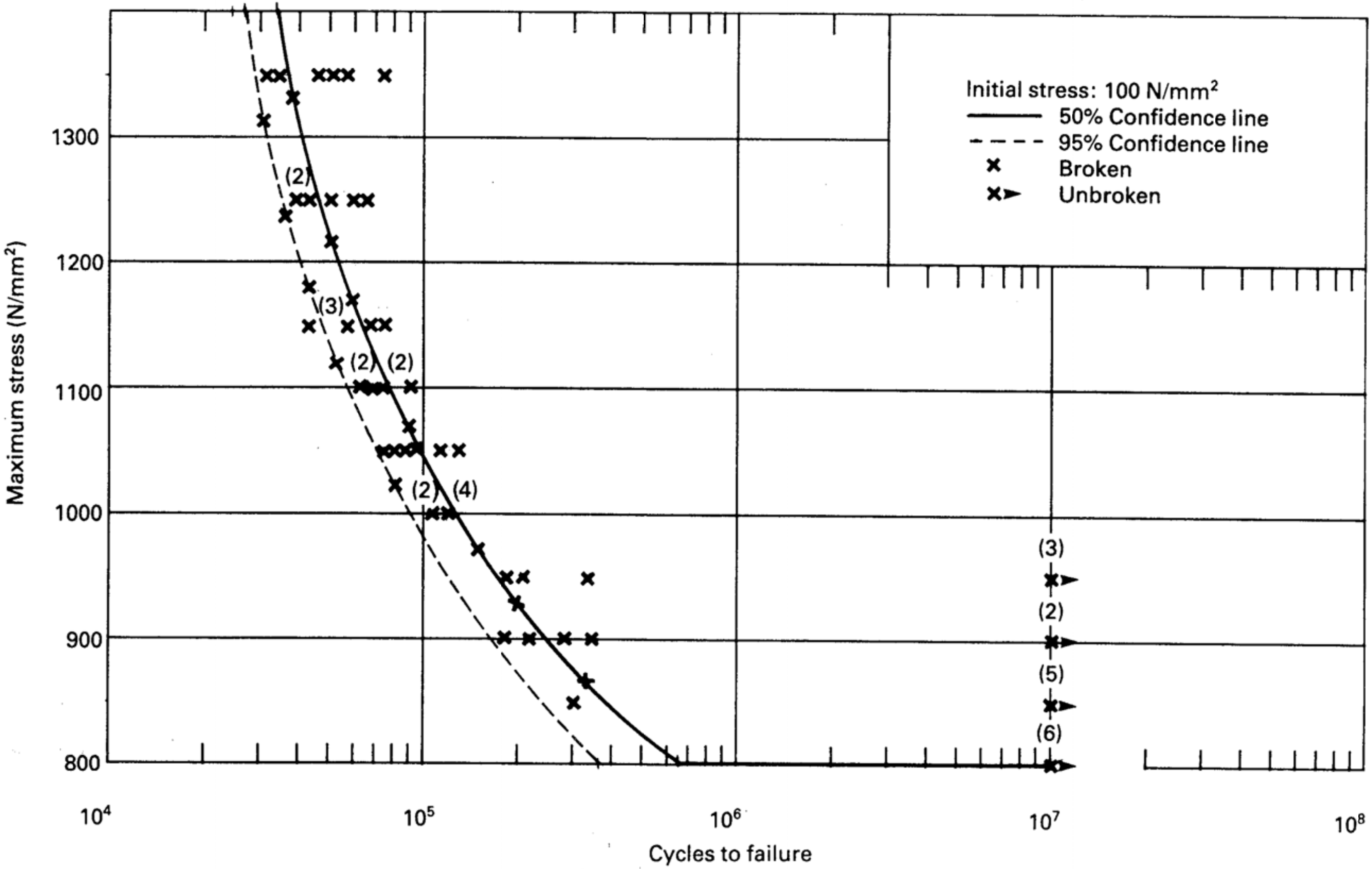

Fig 2: S/N CURVE FOR CS80 HARDENED AND TEMPERED STEEL STRIP

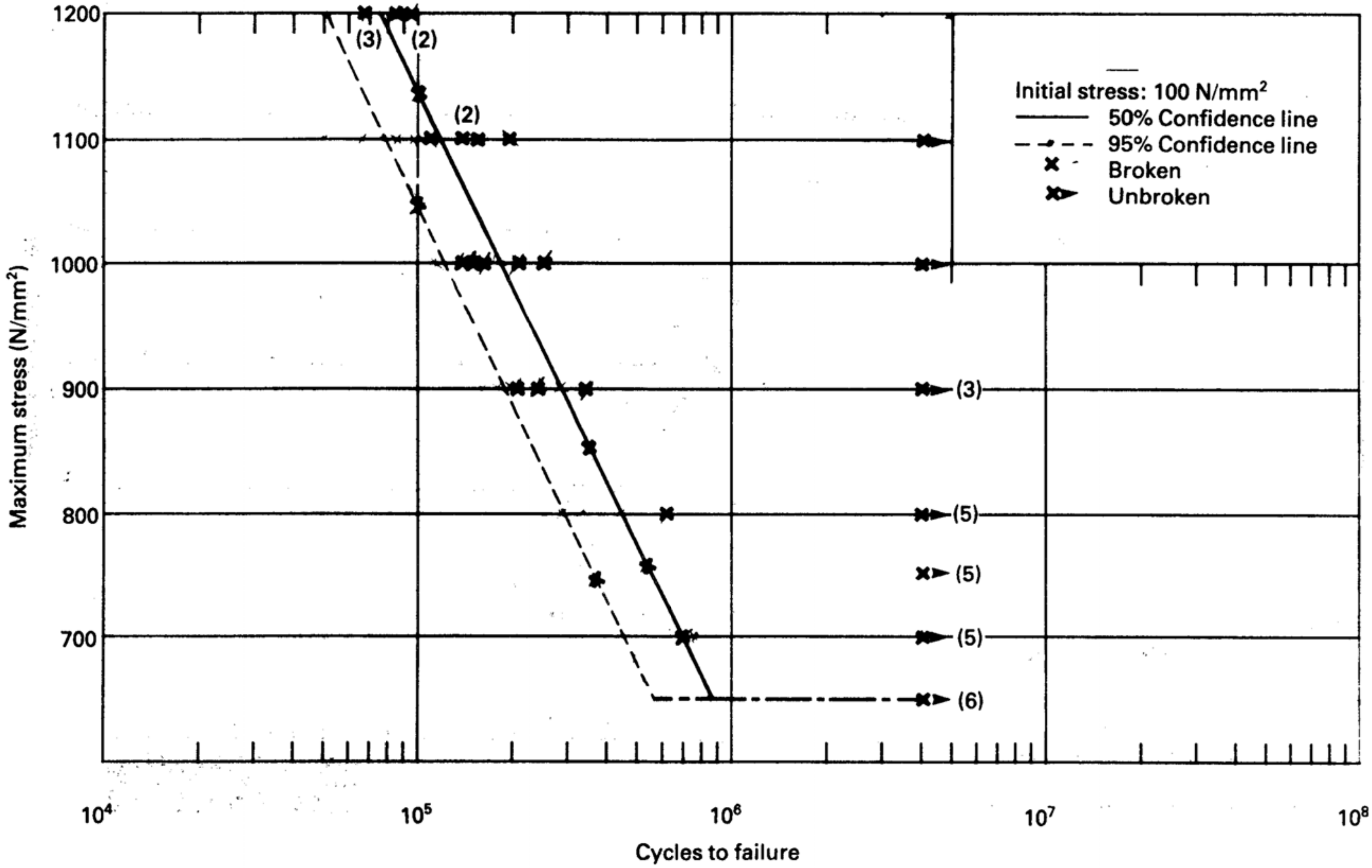

Fig 3: S/N CURVE FOR 302S25 STAINLESS STEEL STRIP

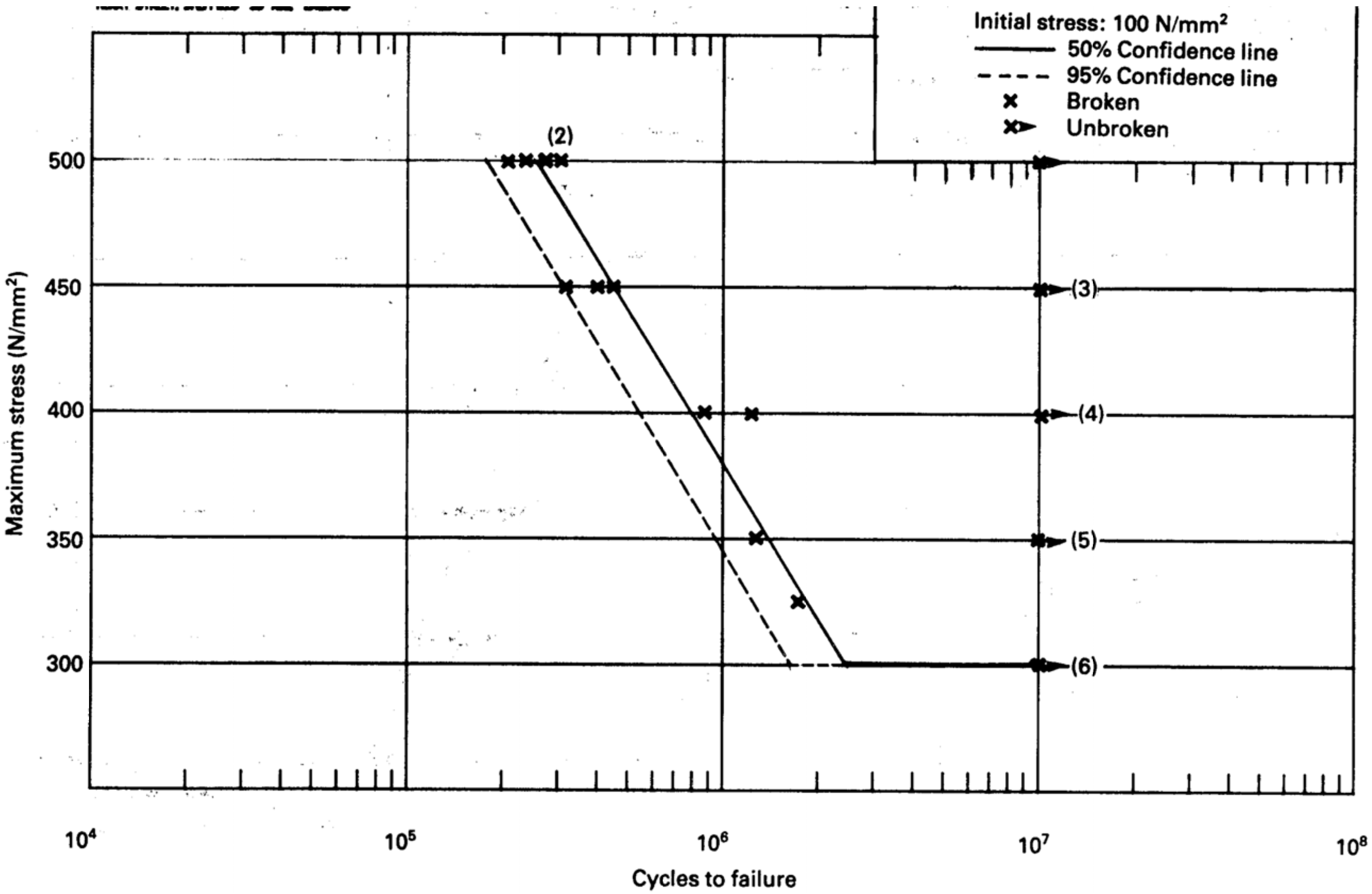

Fig 4: S/N CURVE FOR PB102 PHOSPHOR BRONZE STRIP

APPENDIX I

EDGE CONDITIONING PROCESSES

Barrelled B1

One hour processing in an hexagonal rubber lined barrel using a burnishing medium BPL9 and 1/4 ceramic chips RPM30 - see Fig I/3.

Barrelled B2

Two hours processing in an hexagonal rubber lined barrel using a burnishing medium BPL32C and 1/4 ceramic chips RPM30 - see Fig I/4.

Barrelled B3

Forty minutes processing in a Turbuton TT25 centrifugal barrel with P1 15 15 angle cut chips followed by 20 minutes processing with Trowelpast ET10 plastic finishing media. All processing done in a T77 liquid cleaning medium - see Fig I/5.

Vibratory Deburred

Five hours processing in a Cetema Eurotron vibratory deburring machine with 13mm A/C triangular chips in a 4% FM26 medium followed by one hour processing in a 1% FBC201 medium - see Fig I/6.

Centrifugal Process

Two hours processing in a Cetema HG machine with 6mm PM triangular chips in a 351 LX medium - see Fig I/7.

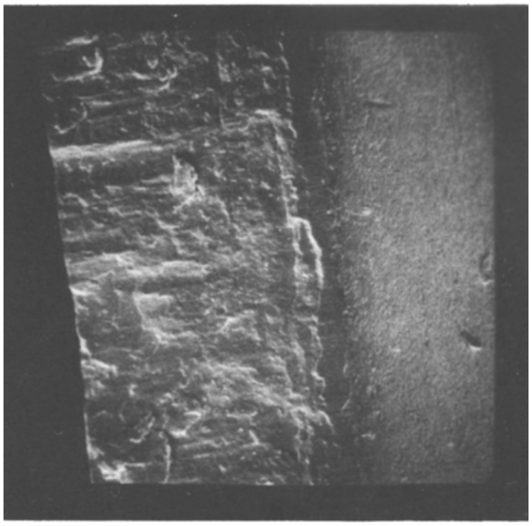

Fig I/1 X 66

As-slit edge

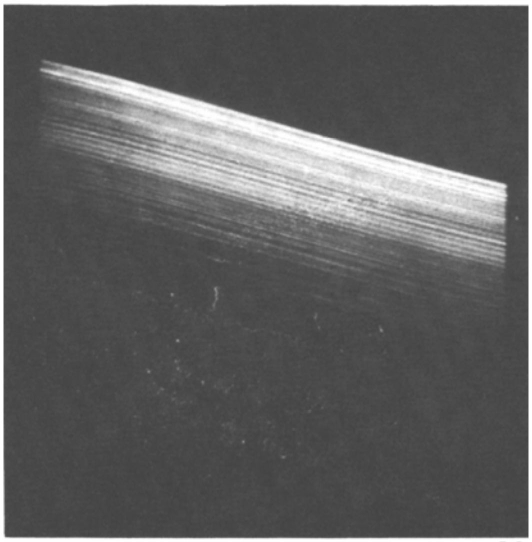

Fig I/2 X 60

Tool dressed edge

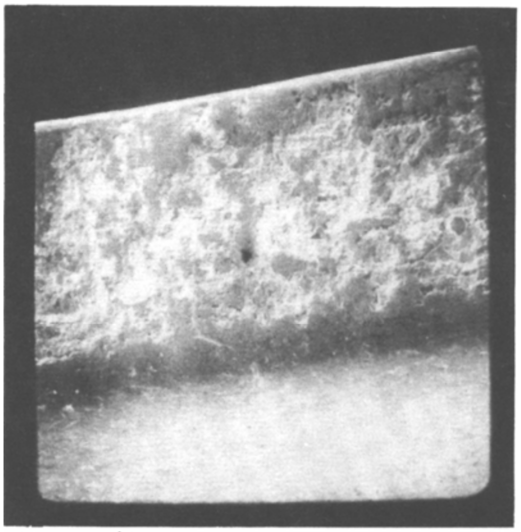

Fig I/3 X 68

Barrelled B1

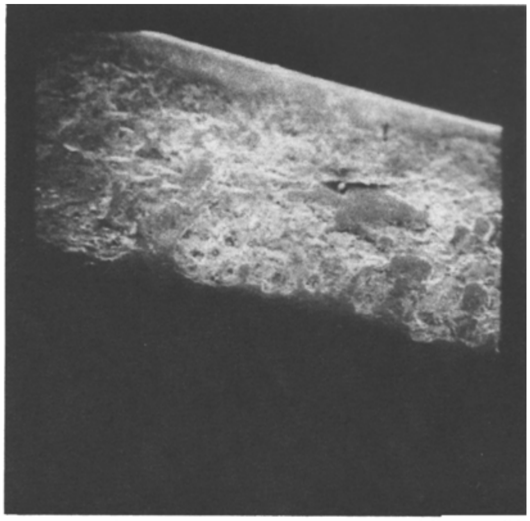

Fig I/4 X 72
Barrelled B2

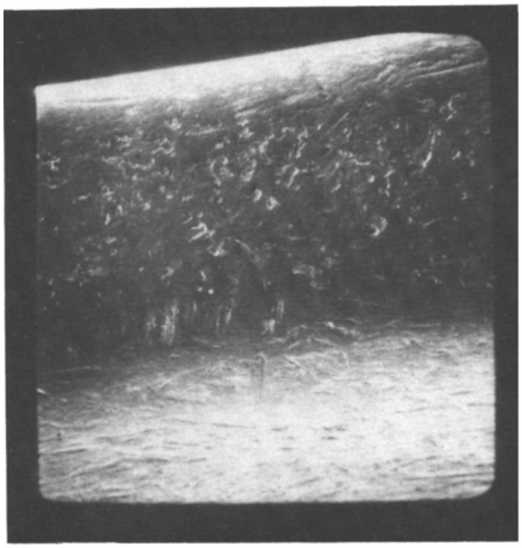

Fig I/5 X 66
Barrelled B3

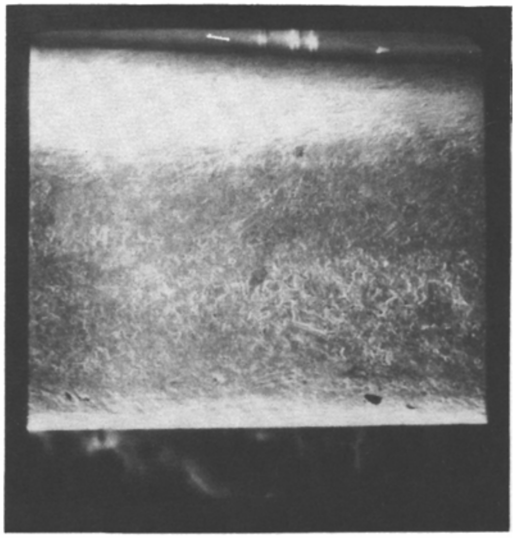

Fig I/6 X 66
Vibratory deburred

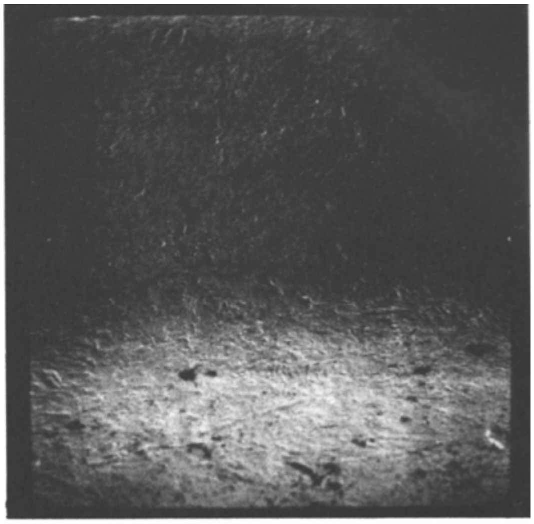

Fig I/7 X 80

Centrifugal process

APPENDIX II

TEST RESULTS AND DETAILS OF WEIBULL ANALYSES

FATIGUE TEST RESULTS AT 100-1500 N/mm^2 -AS SLIT STRIP TESTED WITH THE BURR IN TENSION

Order Number	Median Rank	Fatigue Life/cycles
1	6.73	21,180
2	16.35	21,670
3	25.96	21,790
4	35.58	25,210
5	45.19	25,990
6	54.81	26,810
7	64.42	27,840
8	74.14	27,880
9	83.77	29,440
10	93.30	29,700

RESULTS OF WEIBULL ANALYSIS

Using N_0	: 0
Weibull Slope	: 9.09
B10 Life	: 21,139 cycles
90% Confidence Band on B10	: 17,615 - 24663 cycles
Characteristic Life	: 27,079 cycles
N_0	: 0 is optimum

FATIGUE TEST RESULTS AT 100-1500 N/mm^2
AS SLIT STRIP TESTED WITH THE BURR IN COMPRESSION

Order Number	Median Rank	Fatigue Life/cycles
1	6.73	22,940
2	16.35	24,210
3	25.58	29,760
4	35.58	29,900
5	45.19	31,860
6	54.81	32,420
7	64.42	33,770
8	74.14	33,900
9	83.77	36,800
10	93.30	37,720

RESULTS OF WEIBULL ANALYSIS

Using N_0	:	0
Weibull Slope	:	6.98
B10 Life	:	24,178 cycles
90% Confidence Band on B10	:	29,278 cycles
Characteristic Life	:	33,377 cycles
N_0	:	0 is optimum

APPENDIX II (cont)

FATIGUE TEST RESULTS AT 100-1500 N/mm^2 - BARRELLED (B1)

Order Number	Median Rank	Fatigue Life/cycles
1	6.73	28,910
2	16.35	29,200
3	25.96	32,570
4	35.58	34,130
5	45.19	34,790
6	54.81	36,230
7	64.42	40,050
8	74.14	43,370
9	83.77	43,460
10	93.30	50,150

RESULTS FROM WEIBULL ANALYSIS

Using N_O : 0
Weibull Slope : 6.46
B10 Life : 28,122 cycles
90% Confidence Band on B10 : 21,763 - 34,481 cycles
Characteristic Life : 39,832 cycles

Using N_O : 25,500
B10 Life : 29,120 cycles
90% Confidence Band on B10 : 25,780 - 32,460 cycles

APPENDIX II (cont)

FATIGUE TEST RESULTS AT 100-1500 N/mm^2 - BARRELLED (B2)

Order Number	Median Rank	Fatigue Life/cycles
1	8.30	23,430
2	20.11	24,880
3	32.10	37,030
4	44.02	40,660
5	55.98	41,650
6	67.95	46,520
7	79.89	51,020
8	91.70	58,750

RESULTS OF WEIBULL ANALYSIS

Using N_O : 0
Weibull Slope : 3.45
B10 Life : 23,433 cycles
90% Confidence Band on B10 : 13,767 - 33,099 cycles
Characteristic Life : 44,988 cycles
N_O : 0 is optimum

APPENDIX II (cont)

FATIGUE TEST RESULTS AT 100-1500 N/mm^2 - BARRELLED (B3)

Order Number	Median Rank	Fatigue Life/cycles
1	6.73	30,180
2	16.35	34,390
3	25.58	34,570
4	35.58	35,120
5	45.19	41,050
6	54.81	48,410
7	64.42	48,860
8	74.14	49,980
9	83.77	58,350
10	93.30	64,430

RESULTS OF WEIBULL ANALYSIS

Using N_O : 0
Weibull Slope : 4.63
B10 Life : 29,791 cycles
90% Confidence Band on B10 : 20,829 - 38,753 cycles
Characteristic Life : 48,438 cycles

Using N_O : 27,800 cycles
B10 Life : 31,261 cycles
90% Confidence Band on B10 : 23001 - 39,521 cycles

APPENDIX II (cont)

FATIGUE TEST RESULTS AT 100-1500 N/mm^2 - TOOL DRESSED STRIP

Order Number	Median Rank	Fatigue Life/cycles
1	6.73	30,780
2	16.35	31,000
3	25.96	32,340
4	35.58	33,110
5	45.19	34,650
6	54.81	39,660
7	64.42	43,770
8	74.14	44,160
9	83.77	48,830
10	93.30	49,950

RESULTS OF WEIBULL ANALYSIS

Using N_0 : 0
Weibull Slope : 6.38
B10 Life : 29,141 cycles
90% Confidence Band on B10 : 22,476 - 35,806 cycles
Characteristic Life : 41,464 cycles

Using N_0 : 30,550 cycles
B10 Life : 30,921 cycles
90% Confidence Band on B10 : 30,217 - 31,625 cycles

APPENDIX II (cont)

FATIGUE TEST RESULTS AT 100-1500 N/mm^2 - VIBRATORY DEBURRED

Order Number	Median Rank	Fatigue Life/cycles
1	6.73	53,020
2	16.35	53,620
3	25.58	55,240
4	35.58	61,650
5	45.19	64,290
6	54.81	75,220
7	64.42	77,220
8	74.14	89,210
9	83.77	150,680*
10	93.30	218,400*

* Unbroken at 100,000 cycles for Weibull analysis

RESULTS OF WEIBULL ANALYSIS

Using N_O : 0
Weibull Slope : 5.67
B10 Life : 50,865 cycles
90% Confidence Band on B10 : 37,792 - 63,758 cycles
Characteristic Life : 75,659 cycles

Using N_O : 52,800 cycles
B10 Life : 53,228 cycles
90% Confidence Band on B10 : 51,928 - 54,528 cycles

FATIGUE TEST RESULTS AT 100-1500 N/mm^2 - CENTRIFUGALLY PROCESSED

Order Number	Median Rank	Fatigue Life/cycles
1	6.73	83,700
2	16.35	86,720
3	25.58	92,550
4	35.58	107,330
5	45.19	115,470
6	54.19	165,900
7	64.42	222,260
8	74.14	811,960 *
9	83.77	Unbroken *
10	93.30	Unbroken *

* Unbroken at 250,000 cycles for Weibull analysis.

RESULTS OF WEIBULL ANALYSIS

Using N_0 : 0
Weibull Slope : 3.03
B10 Life : 78,083 cycles
90% Confidence Band on B10 : 45,218 - 110,948 cycles
Characteristic Life : 163,976 cycles

Using N_0 : 83,000 cycles
B10 Life : 84,340 cycles
90% Confidence Band on B10 : 80,097 - 88,583 cycles

FATIGUE TEST RESULTS AT 100-1350 N/mm^2 - AS SLIT STRIP TESTED WITH THE BURR LIP IN TENSION

Order Number	Median Rank	Fatigue Life/cycles
1	6.73	40,180
2	16.35	41,740
3	25.96	45,790
4	35.58	46,730
5	45.19	47,270
6	54.81	49,500
7	64.42	50,400
8	74.04	51,690
9	83.65	53,870
10	93.27	57,110

RESULTS OF WEIBULL ANALYSIS

Using N_O : 0
Weibull Slope : 10.38
B10 Life : 40,791 cycles
90% Confidence Band on B10 : 34,777 - 46,805 cycles
Characteristic Life : 50,660 cycles

Using N_O : 29,000 cycles
B10 Life : 41,085 cycles
90% Confidence Band on B10 : 36,239 - 45,931 cycles

APPENDIX II (cont)

FATIGUE TEST RESULTS AT 100-1350 N/mm^2 - AS SLIT STRIP TESTED WITH THE BURR LIP IN COMPRESSION

Order Number	Median Rank	Fatigue Life/cycles
1	6.73	51,440
2	16.35	54,720
3	25.96	55,820
4	35.58	63,940
5	45.19	66,670
6	54.81	68,640
7	64.42	72,970
8	74.04	75,650
9	83.65	83,830
10	93.27	91,020

RESULTS OF WEIBULL ANALYSIS

Using N_0 : 0
Weibull Slope : 6.16
B10 Life : 50,931 cycles
90% Confidence Band on B10 : 38,926 - 62,936 cycles
Characteristic Life : 73,374 cycles

Using N_0 : 46,500 cycles
B10 Life : 52,620 cycles
90% Confidence Band on B10 : 46,585 - 58,655 cycles

APPENDIX II (cont)

FATIGUE TEST RESULTS AT 100-1350 N/mm^2 - BARRELLED (B1)

Order Number	Median Rank	Fatigue Life/cycles
1	6.73	57,160
2	16.35	68,500
3	25.96	85,950
4	35.58	88,480
5	45.19	98,240
6	54.81	104,880
7	64.42	123,990
8	74.14	Unbroken *
9	83.77	Unbroken *
10	93.30	Unbroken *

* Unbroken at 200,000 cycles for Weibull analysis

RESULTS OF WEIBULL ANALYSIS

Using N_O : 0
Weibull Slope : 3.64
B10 Life : 62,049 cycles
90% Confidence Band on B10 : 39,348 - 87,750 cycles
Characteristic Life : 115,183 cycles

Using N_O : 38,000 cycles
B10 Life : 62,088 cycles
90% Confidence Band on B10 : 43,965 - 80,211 cycles

APPENDIX II (cont)

FATIGUE TEST RESULTS AT 100-1350 N/mm^2 - BARRELLED (B2)

Order Number	Median Rank	Fatigue Life/cycles
1	6.73	55,980
2	16.35	59,330
3	25.96	61,290
4	35.58	72,170
5	45.19	90,230
6	54.81	111,080
7	64.42	Unbroken *
8	74.14	Unbroken *
9	83.77	Unbroken *
10	93.30	Unbroken *

* Unbroken at 200,000 cycles for Weibull analysis

RESULTS OF WEIBULL ANALYSIS:

Using N_O : 0
Weibull Slope : 3.8
B10 Life : 54,994 cycles
90% Confidence Band on B10 : 35,559 - 74,429 cycles
Characteristic Life : 99,429 cycles

Using N_O : 55,000 cycles
B10 Life : 56,585 cycles
90% Confidence Band on B10 : 53,276 - 59,894 cycles

APPENDIX II (cont)

FATIGUE TEST RESULTS AT 100-1350 N/mm^2 - BARRELLED (B3)

Order Number	Median Rank	Fatigue Life/cycles
1	6.73	54,190
2	16.35	62,760
3	25.96	85,270
4	35.58	85,520
5	45.19	132,090
6	54.81	135,250
7	64.42	138,960
8	74.14	142,790
9	83.77	149,760
10	93.30	150,760

RESULTS OF WEIBULL ANALYSIS

Weibull Slope : 3.05
B10 Life : 60,804 cycles
90% Confidence Band on B10 : 35,330 - 86,278 cycles
Characteristic life : 127,111 cycles
N_0 : 0 is optimum

APPENDIX II (cont)

FATIGUE RESULTS AT 100-1350 N/mm^2 - TOOL DRESSED STRIP

Order Number	Median Rank	Fatigue Life/cycles
1	6.73	49,270
2	16.35	56,530
3	25.96	61,840
4	35.58	68,470
5	45.19	73,690
6	54.81	73,970
7	64.42	74,120
8	74.04	123,220*
9	83.65	493,360*
10	93.27	Unbroken *

* Unbroken at 100,000 cycles for Weibull analysis

RESULTS OF WEIBULL ANALYSIS

Using N_0 : 0
Weibull Slope : 4.19
B10 Life : 50,243 cycles
90% Confidence Band on B10 : 33826 - 66660 cycles
Characteristic Life : 85,990 cycles

Using N_0 : 46,200 cycles
B10 Life : 51,509 cycles
90% Confidence Band on B10 : 43,990 - 59,028 cycles

APPENDIX II (cont)

FATIGUE RESULTS AT 100-1350 N/mm^2 - VIBRATORY DEBURRED

Order Number	Median Rank	Fatigue Life/cycles
1	8.300	111,330
2	20.113	132,870
3	32,052	Unbroken
4	44,015	"
5	55,984	"
6	67,948	"
7	79,887	"
8	91,700	"

RESULTS OF WEIBULL ANALYSIS

Two points not sufficient
Weibull analysis not carried out

APPENDIX II (cont)

FATIGUE TEST RESULTS AT 100 -1350 N/mm^2 - CENTRIFUGALLY PROCESSED

Order Number	Median Rank	Fatigue Life/cycles
1	8.300	104,530
2	20.113	Unbroken
3	32.052	"
4	44.015	"
5	55.984	"
6	67.948	"
7	79.887	"
8	91.700	"

RESULTS OF WEIBULL ANALYSIS

One point not sufficient.
Weibull analysis not carried out