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MELBOURNE, VICTORIA

Aircraft Systems Project Document 003

FATIGUE TESTING OF THE MK3 MOD0 2000 LB BAIL LUGS: TEST REPORT

by

J.L. JAEGER

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FATIGUE TESTING OF THE MK3 MOD0 2000 LB BAIL LUGS: TEST REPORT

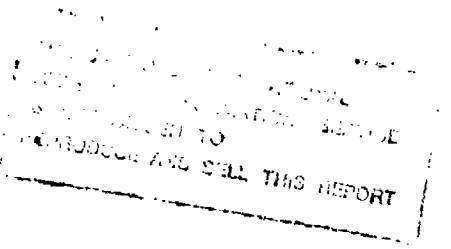
REQUESTING AUTHORITY: No. 1 Central Ammunition Depot, RAAF

ITEMS TESTED: Sixty one MK3 MOD0 2000 lb bail lugs from four different lot numbers

SUMMARY: This report details the procedure and results obtained for fatigue tests conducted on 2000 lb bail lugs in accordance with MIL-HDBK-5E.

PREPARED: J.L. JAEGER

REFERENCE: WA 800519



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506 Lorimer Street, Fishermens Bend Victoria 3207
Australia

CONTENTS

1. APPLICABLE DOCUMENTS

1.1 MIL-HDBK-5E

2. EQUIPMENT USED FOR TESTING

2.1 Instron Hydraulic Actuator, 306 Series, Serial No.8025.

2.2 Hydraulic Power Supply.

2.3 MOOG DC Servo Controller.

2.4 Load Cell, 400 kN.

2.5 Strain Gauge Signal Conditioner, Serial No.11331.

2.6 Function Generator BWD 160A, Serial No. 60474.

2.7 Control Box EEDL071.

2.8 Control Box EEDL074.

2.9 Auto Ranging Digital Voltmeter, B & K Type 2427, Serial No. 579958.

2.1 Oscilloscope UP-5220A, National, Plant No. E107901.

2.11 Timer Counter TC8, Advance Instruments, Plant No. E104445.

2.12 Power Supply, ± 15 Volts, Power Products.

3. TEST REQUIREMENT

The bail lugs shall be mounted into the testing rig, as shown in Figure 1 and Figure 2, and be subjected to selected levels of cyclic loading as detailed below, until such time as a failure occurs. All testing shall be carried out in accordance with MIL-HDBK-5E.

3.1 PRELIMINARY TESTS TO ESTABLISH THE GENERAL SHAPE OF THE S/N CURVES

For each of the two selected stress ratios of R = 0.1 and R = 0.6, four to six lugs shall be tested in order to establish the general shape of the S/N curves. The proposed maximum loads for these preliminary tests are 180 kN, 150 kN, 120 kN and 90 kN which are similar to the loads used in tests described in References 6.1 and 6.2.

3.2 THE FATIGUE TESTS

Once the general fatigue curves have been established, replicate tests shall be conducted at a minimum of three evenly spaced maximum load levels, in order to statistically define the fatigue curves. The number of lugs tested at each load level shall depend on the variability of the results. In accordance with MIL-HDBK-5E a minimum of two lugs is required, but for large variability the recommended number is four or more.

3.3 LOAD AND CYCLE MONITORING

The output from the calibrated load cell placed in series with the bail lug shall be monitored visually on an oscilloscope to ensure correct loading of the lugs. A frequency counter shall be used to count the number of cycles that the lugs have been subjected to.

3.4 VISUAL EXAMINATION

Each test item shall be subjected to a visual examination at the end of the test to note the failure mode.

4. TEST DETAILS

4.1 The bail lug is screwed into a threaded mount which is in turn connected to the calibrated load cell. A U-hook made to dimensions resembling those of an Ejector Release Unit hook is then placed through the lug and held in an upright position between two serrated plates. See Figure 3. The two plates are clamped together with six high tensile bolts and this unit is then held with a steel pin, between the two plates making up the load beam. See Figure 1 and Figure 2.

4.2 For each of the selected replicate load levels at least one lug from each lot number shall be tested in order to obtain representative curves. For the preliminary tests and the tests for identifying run-out, lugs from lot numbers 1 and 4 shall be used due to the availability of a larger quantity of these lugs in comparison to the others.

5. TEST RESULTS

A summary of the test results can be seen in Table 1 and Table 2. These tables contain the results from the preliminary testing as well as those from the replicate testing at the selected maximum loads. At the lower end of the load spectrum there are results which have been obtained whilst trying to locate the load resulting in run-out. These results are presented graphically in Figure 5. The lug identification in these tables refers to lugs from four different lot numbers as follows:

F1/** = MK3 MOD0
(ET)
30003-1380540
ETW-1 277

F2/** = MK3 MOD0
30003-1380540
SMN81J 001008

F3/** = MK3 MOD0
30003-1380540
SMN80G001 001

F4/** = MK3 MOD0
30003-1380540
SMN83F 001009

The results from the preliminary testing indicated that for the stress ratio of R = 0.1 the replicate tests should be carried out at loads of 180 kN, 135 kN, 90 kN and 60 kN. For the stress ratio of R = 0.6 the selected loads were 210 kN, 180 kN, 150 kN, 120 kN and 90 kN.

The items tested appear to exhibit several different failure modes, however, on closer examination it is noticed that for most of the lugs, the crack growth initiates horizontally at the base of the inside corner radius where it joins the vertical leg. After this initial cracking the failure either continues horizontally, at 45° across the corners, vertically up, or some combination of these. There were some lugs however, which broke in the centre of the bail, and these have been identified in the tables of results. Examples of these failures can be seen in Figure 4.

The lugs which failed in the centre of the bail also exhibited crack growth in the vertical legs. The sequence in which these cracks occurred is not known, however, it was thought most likely that the lug broke at the centre first, followed by the failures in the side legs. If the failures had initiated at the vertical legs there appears to be no reason for the occurence of the central failure.

TABLE 1. FATIGUE RESULTS FOR A STRESS RATIO OF R = 0.1

LOAD, S kN	LUG ID.	NO. CYCLES TO FAILURE, N	FAILURE MODE & COMMENTS
180 - 18	F1/11	3949	CENTRE OF BAIL
180 - 18	F2/10	5192	
180 - 18	F3/1	5068	CENTRE OF BAIL
180 - 18	F4/7	3897	
180 - 18	F1/12	4093	
180 - 18	F1/13	5593	CENTRE OF BAIL
150 - 15	F1/77	8691	
150 - 15	F1/80	5612	
135 - 13.5	F1/4	8511	
135 - 13.5	F2/5	11667	CENTRE OF BAIL
135 - 13.5	F3/10	9138	
135 - 13.5	F4/1	9625	
135 - 13.5	F4/11	10716	
120 - 12	F1/78	12187	
120 - 12	F1/73	13750	
90 - 9	F1/5	23454	
90 - 9	F2/3	35637	
90 - 9	F3/5	29067	
90 - 9	F4/3	40883	
90 - 9	F1/8	27184	
90 - 9	F1/7	28884	
90 - 9	F1/53	23493	
60 - 6	F1/10	85533	
60 - 6	F2/9	84160	
60 - 6	F3/3	74083	
60 - 6	F2/2	62794	
60 - 6	F3/7	96349	
60 - 6	F4/2	1000000	NOT BROKEN

LOAD, S kN	LUG ID.	NO. CYCLES TO FAILURE, N	FAILURE MODE & COMMENTS
60 - 6	F1/68	85067	
55 - 5.5	F4/12	163703	
55 - 5.5	F4/14	177295	
55 - 5.5	F4/15	177170	
55 - 5.5	F4/16	1000000	NOT BROKEN
50 - 5	F4/5	1000000	NOT BROKEN

TABLE 2. FATIGUE RESULTS FOR A STRESS RATIO OF R = 0.6

LOAD, S kN	LUG ID.	NO. CYCLES TO FAILURE, N	FAILURE MODE & COMMENTS
210 - 126	F1/2	14693	
210 - 126	F2/7	21084	
210 - 126	F3/4	15671	
210 - 126	F4/9	15576	
210 - 126	F3/2	16694	
180 - 108	F1/14	14446	CENTRE OF BAIL
180 - 108	F1/6	23388	CENTRE OF BAIL
180 - 108	F4/17	28976	
180 - 108	F4/8	26031	
150 - 90	F1/1	22029	CENTRE OF BAIL
150 - 90	F3/6	45451	CENTRE OF BAIL
150 - 90	F4/10	35168	
150 - 90	F2/1	53062	
120 - 72	F3/8	89100	
120 - 72	F1/3	79184	CENTRE OF BAIL
120 - 72	F4/6	121828	
120 - 72	F2/4	145346	
90 - 54	F1/9	192731	
90 - 54	F2/8	228300	
90 - 54	F3/9	396006	
90 - 54	F4/4	405788	
80 - 48	F1/23	235612	
80 - 48	F1/24	290562	
70 - 42	F2/6	551698	
70 - 42	F1/20	357666	
70 - 42	F1/21	558290	
60 - 36	F1/22	737156	

6.0 REFERENCES

6.1 Kerrison, R. Fatigue test on No. 51 Mk 1 suspension lugs. Warwick: Cape Engineering Co. Ltd., Report No.480/TD/73, Dec. 1972

6.2 NATO suspension lug evaluation program for 1000 pound class and 2000 to 3500 pound class stores. New York: Dayton T. Brown Inc., Engineering and Test Division, Report No. DTB02R83-1408, 15 Dec. 1983.

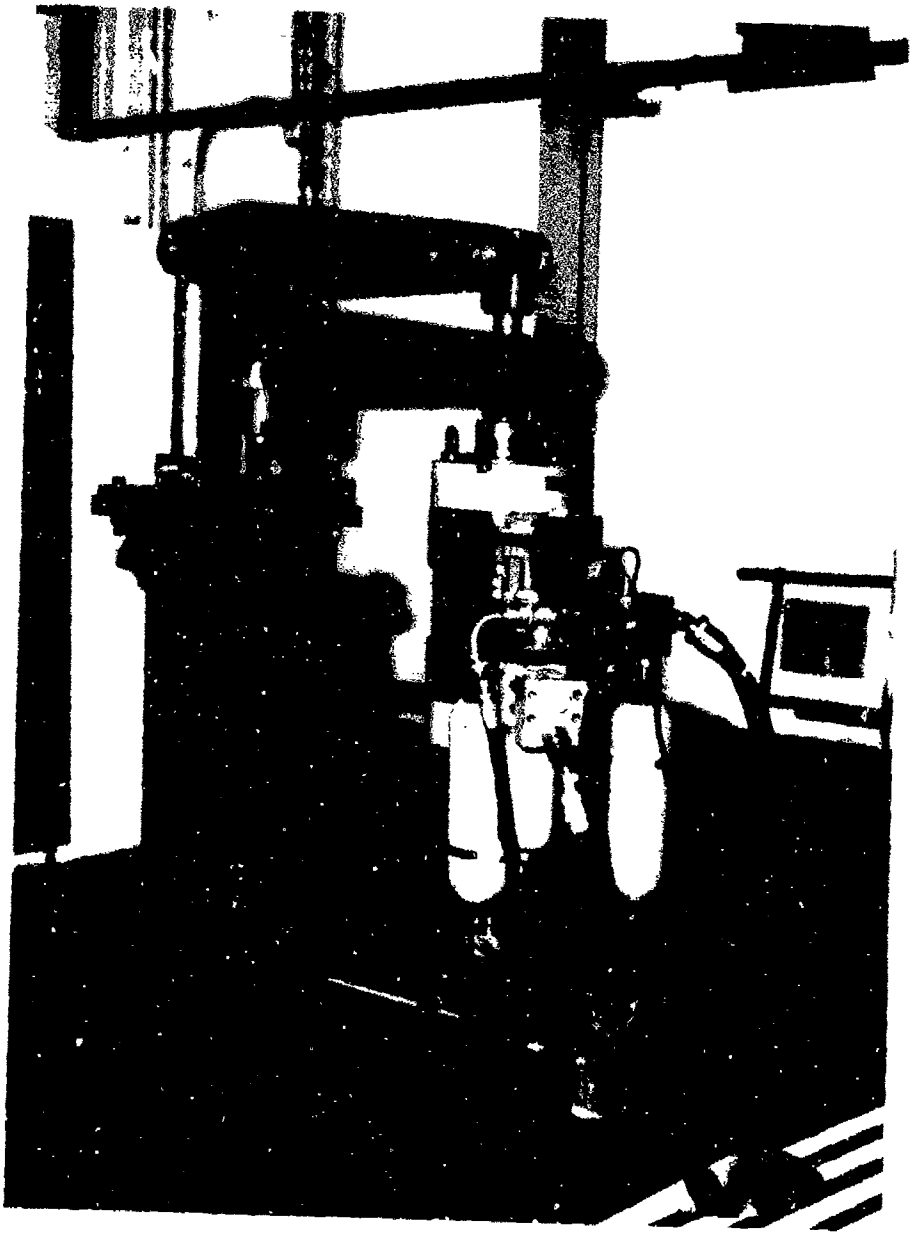

FIGURE 1: FATIGUE TESTING RIG

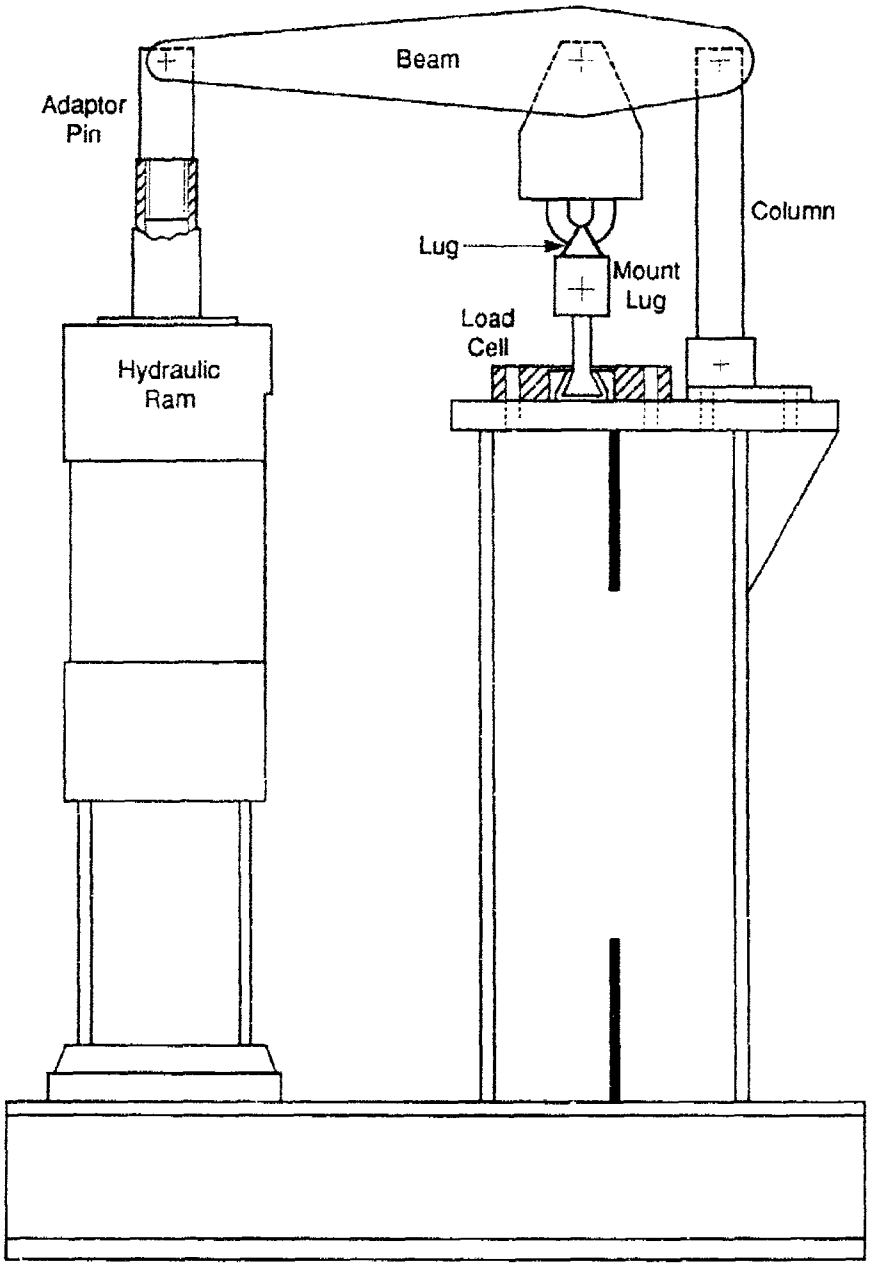

FIGURE:2 SKETCH OF FATIGUE TESTING RIG GIVING LOAD CELL DETAIL

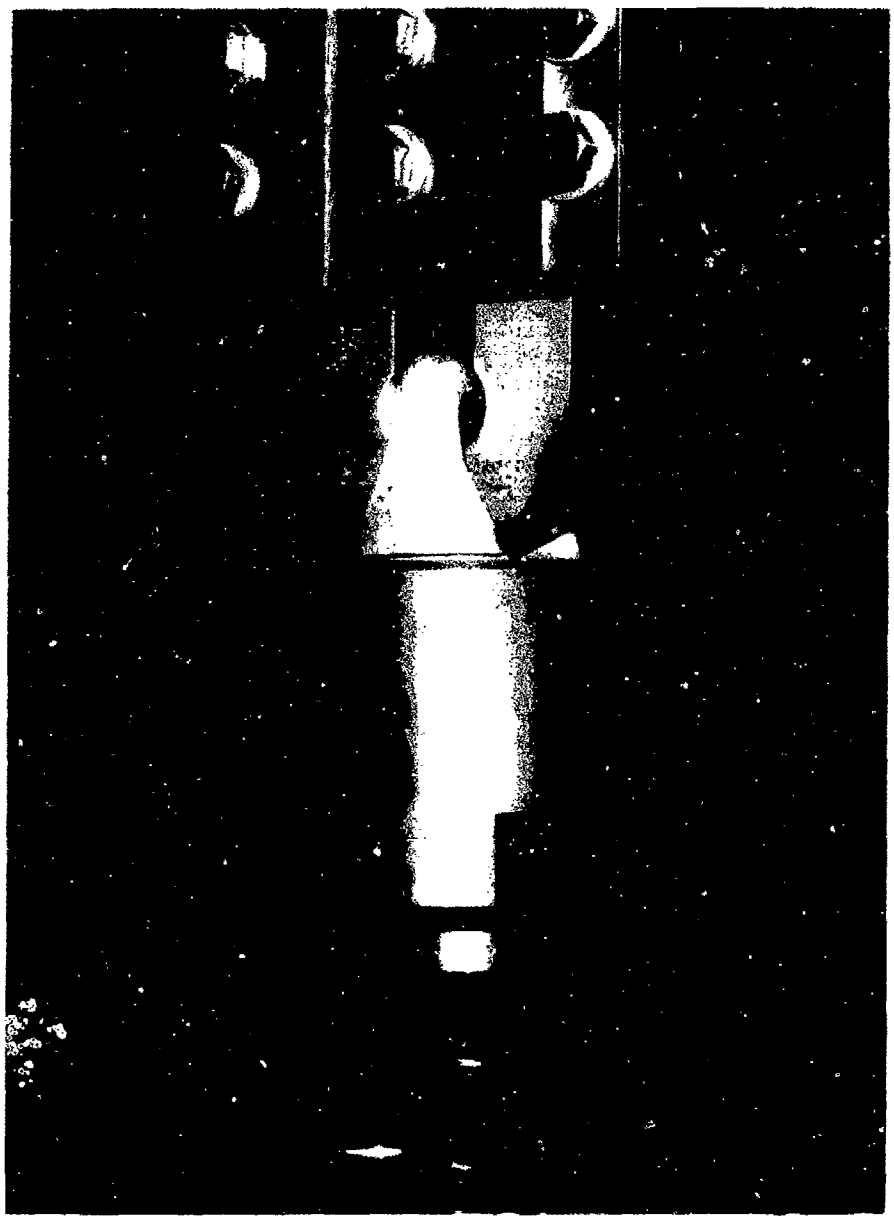

FIGURE: 3 BAIL LUG LOAD TRAIN

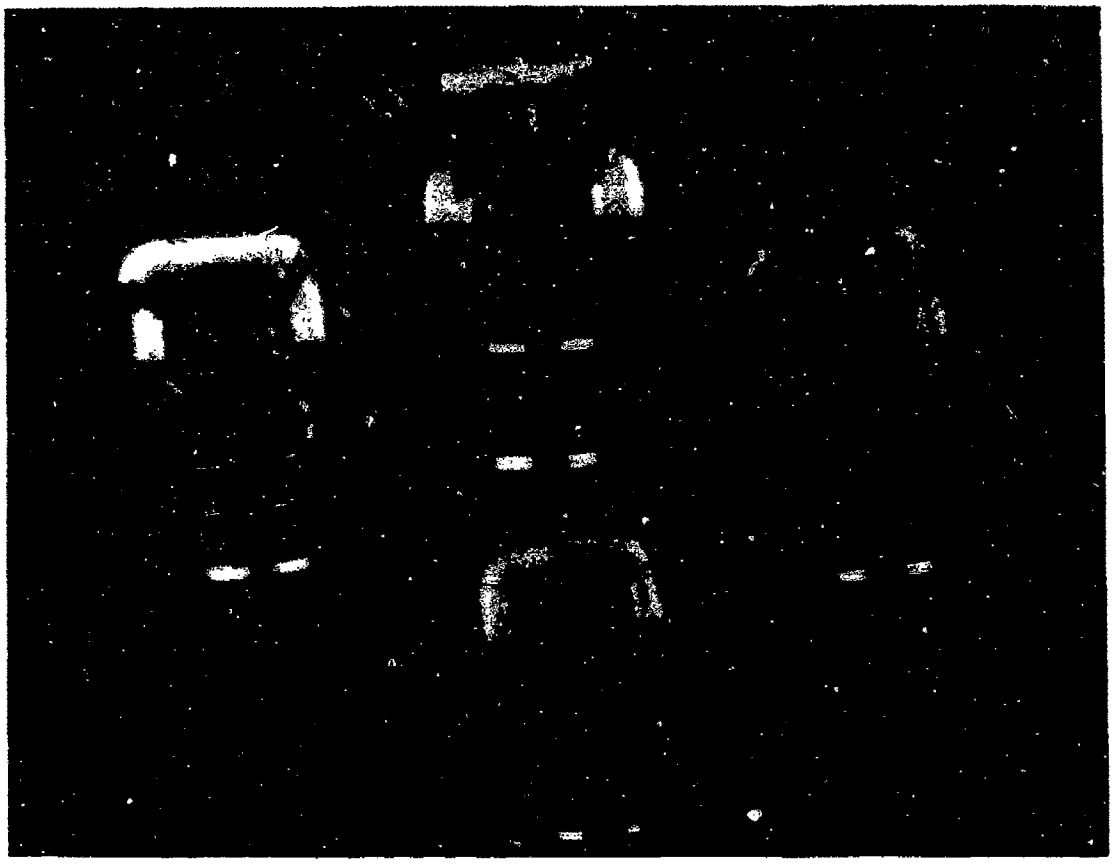

FIGURE 4: LUG FAILURE MODES

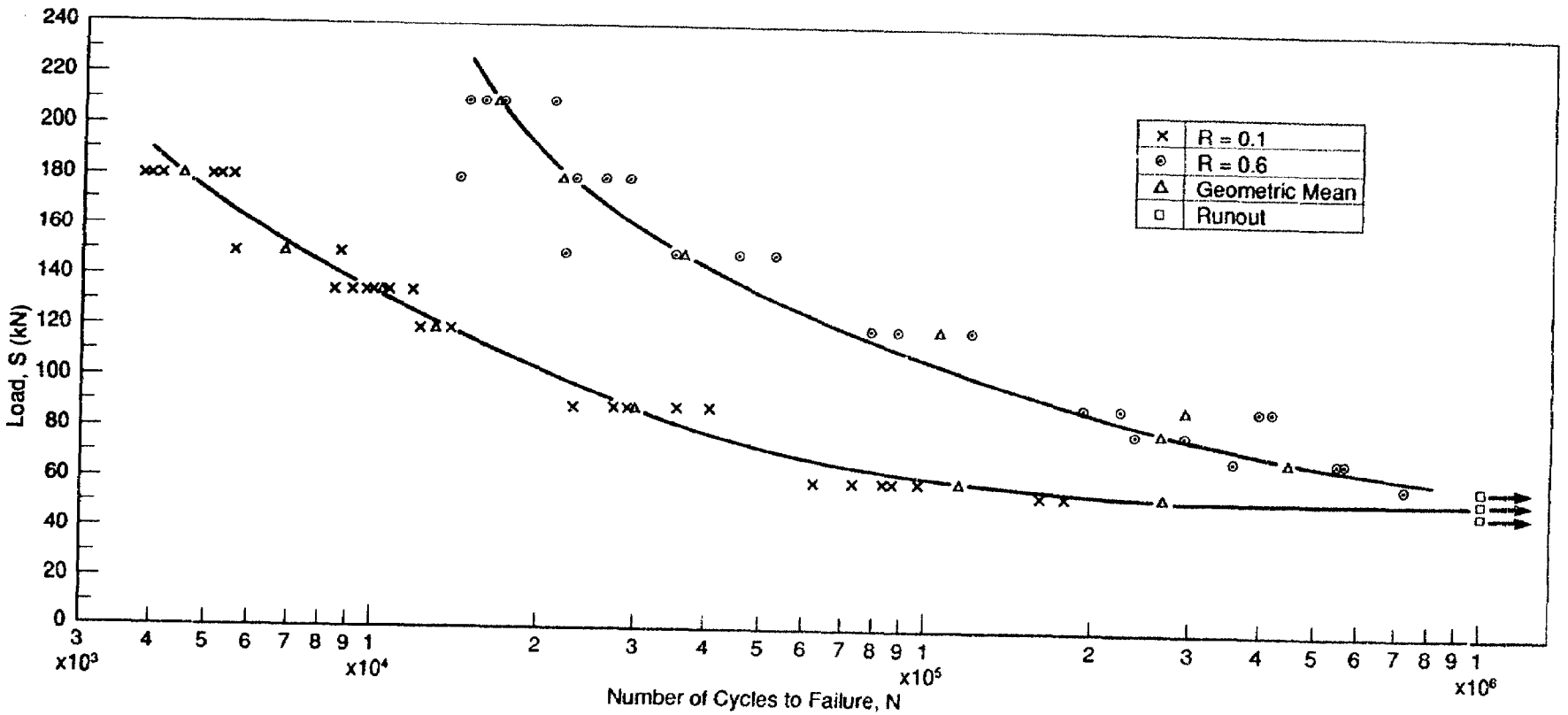

FIGURE 5: MAXIMUM LOAD vs NUMBER OF CYCLES TO FAILURE

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