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RESISTORS, FIXED FILM TYPE
GENERAL PURPOSE
QUARTERLY PROGRESS REPORT #13

1 July 1962 through 30 September 1962

CONTRACT NO. DA-36-039-SC-81283
ORDER NO. 7630-PP-59-81-81

Prepared for the U. S. Army Signal Agency
by
RESEARCH AND DEVELOPMENT DIVISION
INTERNATIONAL RESISTANCE COMPANY

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Contract. : DA-36-039-SC-81283
Order No. : 7630-PP-59-81-81
Applicable Specifications: SCS-22A
Report Prepared at: International Resistance Co.
401 North Broad Street
Philadelphia 8, Pa.

Written By:

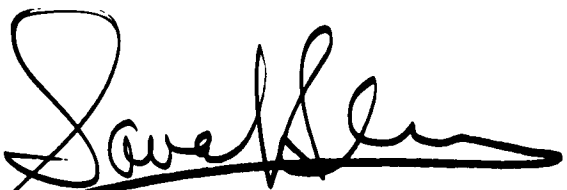


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ABSTRACT

Pre-production shelf life testing has been completed for both RC-07 and RC-20 styles, all ranges. Two marginal failures occurred with the RC-07 style. No failures occurred with the RC-20 style.

Reliability testing has been completed for 175°C no-load but is continuing for 100°C load life. A statistical analysis was performed on the 175°C no-load data. This analysis showed that 175°C no-load performance is dependent on range and that only the lowest ranges have any possibility of passing this test successfully. All other ranges will fail. This analysis is offered as additional evidence to support the previously approved request that the 175°C no-load temperature be reduced to 150°C.

Manufacture of RC-20 resistors for Pilot Plant testing was begun. The first RC-20 range, 50 Ω , has been completed and the next two ranges; 10K and 1/2 megohm are being processed in that sequence. Batch screening tests such as: pull, X-ray and noise have been incorporated into the Pilot Run manufacturing to eliminate "sports" from the process.

BACKGROUND

The purpose of this contract is to establish a production facility with capacity necessary to manufacture a minimum of 35,000 each of 1/4 watt (RC-07) and 1/2 watt (RC-20) resistors per eight (8) hour shift.

The resistors are to have the performance characteristics as set forth in SCS-22A (dated 15 January 1959) as modified by this contract. In addition to other performance tests, the resistors must pass (1) a moisture resistance (10 cycles) test with a performance goal of $\pm 3.0\%$ and (2) a load-life test at 100°C for 2000 hours with a performance goal not to exceed 6% for individual units while the average of the group is not to exceed 3%.

As defined in the contract, the desired maximum failure rate of these resistors shall not be greater than one in one thousand (1 in 1000). The failure rate shall be ascertained during the reliability evaluation and the Pilot Run.

During the period between September 15, 1958 to July 8, 1959, process development work was continued by IRC in an effort to improve the performance characteristics and reliability of the High Stability Resistor beyond the level which was attained at the conclusion of Contract DA-36-039-SC-73235. This work was performed at IRC expense, and

improvements were made in the following areas:

- (1) overcoat materials development for improved moisture resistance.
- (2) contact paint development for improved performance of unspiralled, intermediate range (300 ohm to 0.25 megohm) resistors.
- (3) establishment of processing conditions (specifically arcspiralling parameters) for improvement of short-time overload performance.

Development work was continued at IRC expense on the high-range (above 10 megohm) resistor process.

One of the objectives of this contract is to provide a "high stability," mass-produced resistor at a cost approximately equal to that of the carbon composition resistor. To accomplish this, it will be necessary to set up a highly mechanized operation with a minimum of hand and/or transfer operations. This has already been accomplished with the IRC type BT resistor and will serve as a guide for the contract work.

Resistor element development is being done in three areas: low, intermediate, and high range.

A. Performance & Reliability

1. Pre-Production Testing

Shelf life testing on both RC-07 and RC-20 styles has now been completed. The results are shown in Table I. Two failures (1.12% & 1.06%) were observed, one each for RC-07 ranges 0.29 meg and 0.45 meg. (A failure is defined as anything beyond $\pm 1.0\%$). Visual inspection of the failures after removal of the mold jacket and overcoat revealed nothing significant.

B. Reliability Evaluation

One objective of the reliability phase was to estimate the shape of the failure distribution or life characteristic curve for 175° no-load and 100° load life. The 100° load life is still continuing after 6500 hours, see Table (II), but the 175° no-load has now been completed for all ranges. Even though the 175° no-load has been changed to 150°C, the following information is being offered for the record and as additional evidence for having requested the no-load requirement changed to 150°C.

Cumulative per cent failure when plotted against time to failure on Weibull probability paper should approximate a straight line of a particular slope. See Figures I and II for Weibull plots of 175° no-load test results. The slope of the line establishes the failure rate as,

increasing, decreasing, or constant. An increasing failure rate indicates a degradation or wear-out effect; a decreasing failure rate indicates a high number of early failures with a tapering off; and a constant failure rate indicates that failures are occurring randomly over time. In addition to establishing the failure distributions as normal, (increasing failure rate), exponential (constant failure rate) and Weibull with the shape parameter less than (1), (decreasing failure rate), certain other distribution parameters are readily estimated from the Weibull plot. They are the population mean time to failure, standard deviation, median, and reliability function or probability of survival to various times.

The following life estimates were obtained from the 175° no load data plotted in figs. I and II.

	RC-07		175°C No-Load	
	24Ω	3000Ω	.27Meg	.48Meg
m-(Shape parameter)	4.5	3.8	3.9	6.8
mean time to failure.	2600 Hrs	1490 Hrs	780 Hrs	735 Hrs
-Standard deviation	655 Hrs	430 Hrs	225 Hrs	130 Hrs
median	2650 Hrs	1500Hrs	780 Hrs	750 Hrs
Rx-prob. of surviving 2000 Hrs.	0.81	0.12	0.00	0.00

	RC-20		175°C No-Load	
	38Ω	2800Ω	.24Meg	.48Meg
m-(Shape parameter)	3.1	6.8	5.8	5.0
-mean time to failure	1390 Hrs	3400 Hrs	1060 Hrs	680 Hrs
-Standard deviation	495 Hrs	430 Hrs	210 Hrs	155 Hrs
median	1350 Hrs	3400 Hrs	1080 Hrs	680 Hrs
Rx-prob. of surviving 2000 Hrs.	0.10	.99	0.00	0.00

The shape parameter (m) in all cases being greater than 1, indicates that the failure rate per time is increasing due to a degradation or wear-out effect. A value of (3.3) or greater for (m) indicates a normal probability failure distribution. The greater the (m) value beyond (3.3), the more peaked is the normal distribution.

The mean time to failure for RC-07 ranges decreases as the range increases verifying what had been reported previously, that the 175° no-load ΔR's are a function of range (film thickness).

For a normal distribution the mean time to failure and median should be approximately the same, and they are.

The probability of survival or reliability function shows that the High Stability unit has a 99% to 0.0% chance of surviving 2000 hours at 175°C no-load depending on the range.

A similar analysis of the 100° load life data will be performed when complete test results for all ranges have been received.

C. Pilot Plant - Phase II

Manufacture of RC-20 units for Pilot Plant testing was begun during this quarterly period. Some initial difficulties were encountered in trying to manicure the sub-assembly machine to produce consistent sized Cp Beads with equally consistent pull and twist strengths. This problem has since been resolved and processing of the first RC-20 range 50Ω has now been completed. The next two ranges 10KΩ and 0.5 megohm are now being processed through the pilot line.

In order to eliminate the so called "sports" or earlier failures from the process, a number of screening tests have been incorporated into the process. All sub-assemblies are being pulled with a 5# pull tester, and completed units are being 100% X-rayed, noise tested, and rotated in a clamping fixture to detect instability.

CONCLUSIONS

1. Two failures occurred in the RC-07 style during pre-production shelf life testing. These failures are within the number allowable.
2. A statistical analysis of the 175°C no-load data, collected from reliability testing, shows that this resistor cannot pass 175°C no-load testing successfully.
3. Pilot run manufacturing has begun and the RC-20 50Ω units have been completed. The 10KΩ and 1/2 megohm units are in process.

PROGRAM FOR NEXT QUARTER

(October, November, December, 1962)

1. Write and submit RC-07 and RC-20 pre-production Shelf Life report.
2. Perform a statistical analysis on the 100°C load life reliability test data when available.
3. Write and submit a pre-production report on the RC-20 and RC-07 styles, critical ranges, for informational purposes only.
4. Continue Pilot Run production for the RC-20 style 10K Ω , 1/2 megohm, 300 Ω and 100K Ω ranges.

PERSONNEL

Time Spent on Contract - (1 July through 30 September 1962)

PRODUCT AND PROCESS

H. Agatone	24.5
J. Burns	152.0
J. Koszarek	1.0
W. Ogden	105.0
D. Osborne	400.5
M. Packer	12.0
H. Pugh	110.5
D. Williams	17.0

PERFORMANCE AND RELIABILITY REVIEW

O. Johnson	166.0
J. Saboe	253.5

TEST SECTION

307.8

TOTAL

1,549.8

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TABLE I

PRE - PRODUCTION SHELF LIFE-DATA SUMMARY

51%RH - 6 MONTHS --SPEC. LIMITS=+1.0%

	AVERAGE	MAX.	MIN.	NO. FAILURES
RC- 20 STYLE				
40Ω	+ 0.11	+ 0.21	- 0.05	0
490Ω	+ 0.07	+ 0.14	0.00	0
1100Ω	+ 0.15	+ 0.26	+ 0.05	0
3200Ω	+ 0.16	+ 0.36	+ 0.08	0
5000Ω	+ 0.09	+ 0.11	+ 0.05	0
.46 Meg	+ 0.28	+ 0.39	+ 0.18	0
.20Meg	+ 0.22	+ 0.43	+ 0.15	0
RC-07 STYLE				
40Ω	+ 0.05	+ 0.19	- 0.08	0
400Ω	+ 0.14	+ 0.39	- 0.05	0
770Ω	+ 0.06	+ 0.11	+ 0.02	0
3000Ω	+ 0.14	+ 0.27	- 0.01	0
5500Ω	+ 0.06	+ 0.54	0.00	0
0.29Meg	+ 0.35	+ 1.12	+ 0.07	1
0.45Meg	+ 0.41	+ 1.06	+ 0.16	1

TABLE II

HIGH STABILITY - RELIABILITY EVALUATION SUMMARY

TEST 100° Load Life Spec. Limit - 6.0%

RUN NO. - RANGE	HOURS										TOTAL NO. FAILS	
	3500	4000	4500	5000	5500	6000	6500					
24Ω	AV	0.55	+ 0.93	1.83	+ 4.08	+ 0.89	+ 1.48					
	SPRN	+ 2.03	+ 2.61	3.73	+ 6.60	+ 2.80	+ 7.84					
	FAIL	- 0.63	+ 0.34	1.01	+ 3.36	+ 0.17	- 0.29					
	AV	0	0	0	1	1	1					
3000Ω	AV	0.95	+ 1.17	1.27	+ 1.50	+ 1.59	+ 1.84					
	SPRN	+ 1.82	+ 2.06	2.25	+ 2.52	+ 2.61	+ 2.90					
	FAIL	- 0.42	+ 0.57	0.64	+ 0.78	+ 0.86	+ 1.05					
	AV	0	0	0	0	0	0					
.27Meg	AV	4.69	+ 4.36	5.63	+ 5.29	+ 6.49	+ 6.87					
	SPRN	+ 7.23	+ 7.97	7.56	+ 8.15	+ 10.03	+ 10.56					
	FAIL	+ 2.10	+ 2.36	2.67	+ 1.57	+ 2.99	+ 3.41					
	AV	5	6	7	9	10	12					
.48Meg	AV	1.64	+ 1.85	2.04	+ 2.25	+ 2.37	+ 2.47					
	SPRN	+ 2.49	+ 2.73	3.04	+ 3.14	+ 3.27	+ 3.37					
	FAIL	- 1.09	+ 1.24	1.42	+ 1.57	+ 1.68	+ 1.75					
	AV	0	0	0	0	0	0					
TOTAL NO. FAILS	5	6	7	10	11	13						
38Ω	AV	1.07	+ 1.18	1.66	+ 1.25	+ 1.77	+ 1.55	+ 1.96				
	SPRN	+ 2.22	+ 2.66	4.12	+ 4.65	+ 4.70	+ 7.14	+ 5.27				
	FAIL	- 0.24	+ 0.21	1.90	- 0.13	+ 0.49	- 0.14	+ 0.14				
	AV	0	0	0	0	1	1	1				
2800Ω	AV	1.58	+ 1.75	1.96	+ 2.11	+ 2.30	+ 2.44	+ 2.75				
	SPRN	+ 2.76	+ 3.02	3.31	+ 3.48	+ 2.77	+ 3.88	+ 4.10				
	FAIL	- 0.78	+ 2.10	- 1.01	+ 1.11	+ 0.24	+ 1.33	+ 1.50				
	AV	0	0	0	0	0	0	0				
.24Meg	AV	4.96	+ 5.55	6.49	+ 7.51	+ 8.47	+ 9.51					
	SPRN	+ 8.27	+ 9.57	9.61	+ 13.11	+ 13.55	+ 17.29	+ 3.50				
	FAIL	- 0.67	+ 0.89	2.82	+ 1.41	+ 1.72	+ 4.87	+ 4.90				
	AV	8	11	10	13	16	18	18				
.48Meg	AV	2.27	+ 2.49	2.71	+ 2.99	+ 3.14	+ 3.32	+ 3.50				
	SPRN	+ 3.45	+ 3.76	4.09	+ 4.46	+ 4.77	+ 5.02	+ 5.20				
	FAIL	- 0.55	+ 1.26	0.77	+ 0.91	+ 0.99	+ 1.07	+ 1.10				
	AV	1	1	1	0	1	1	1				
TOTAL NO. FAILS	8	13	10	13	17	19	19					

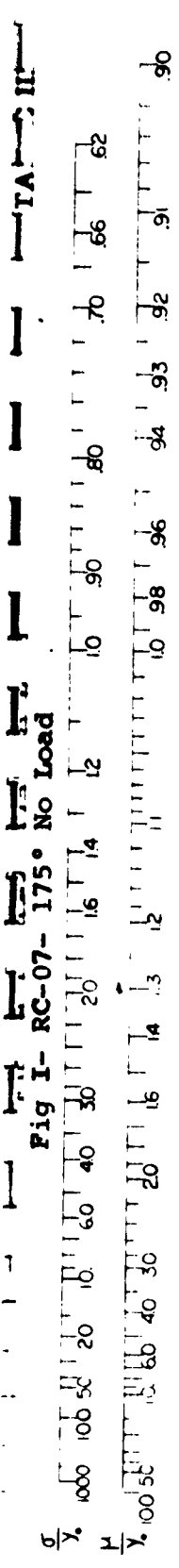


Fig I- RC-07- 175° No Load

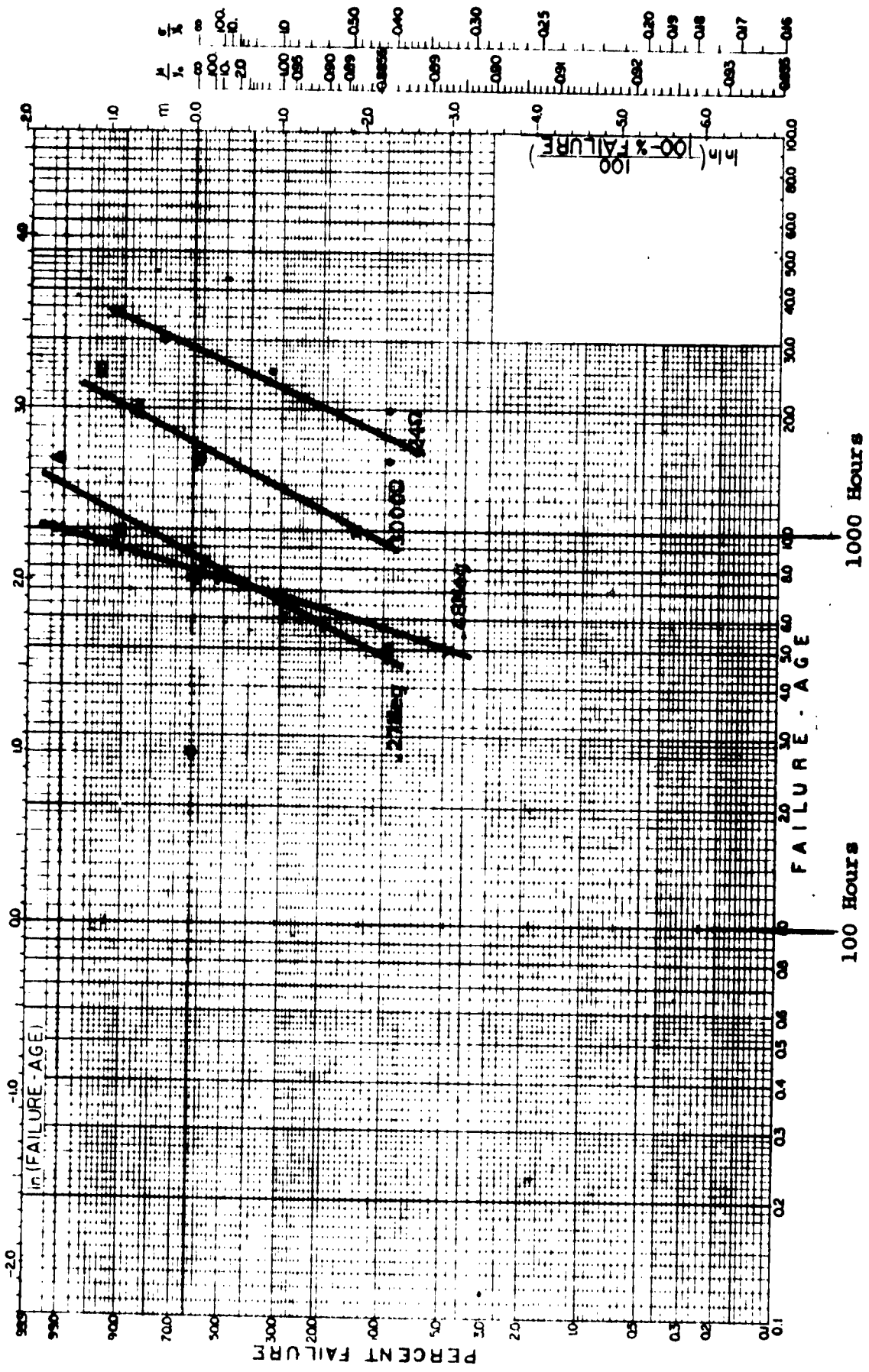
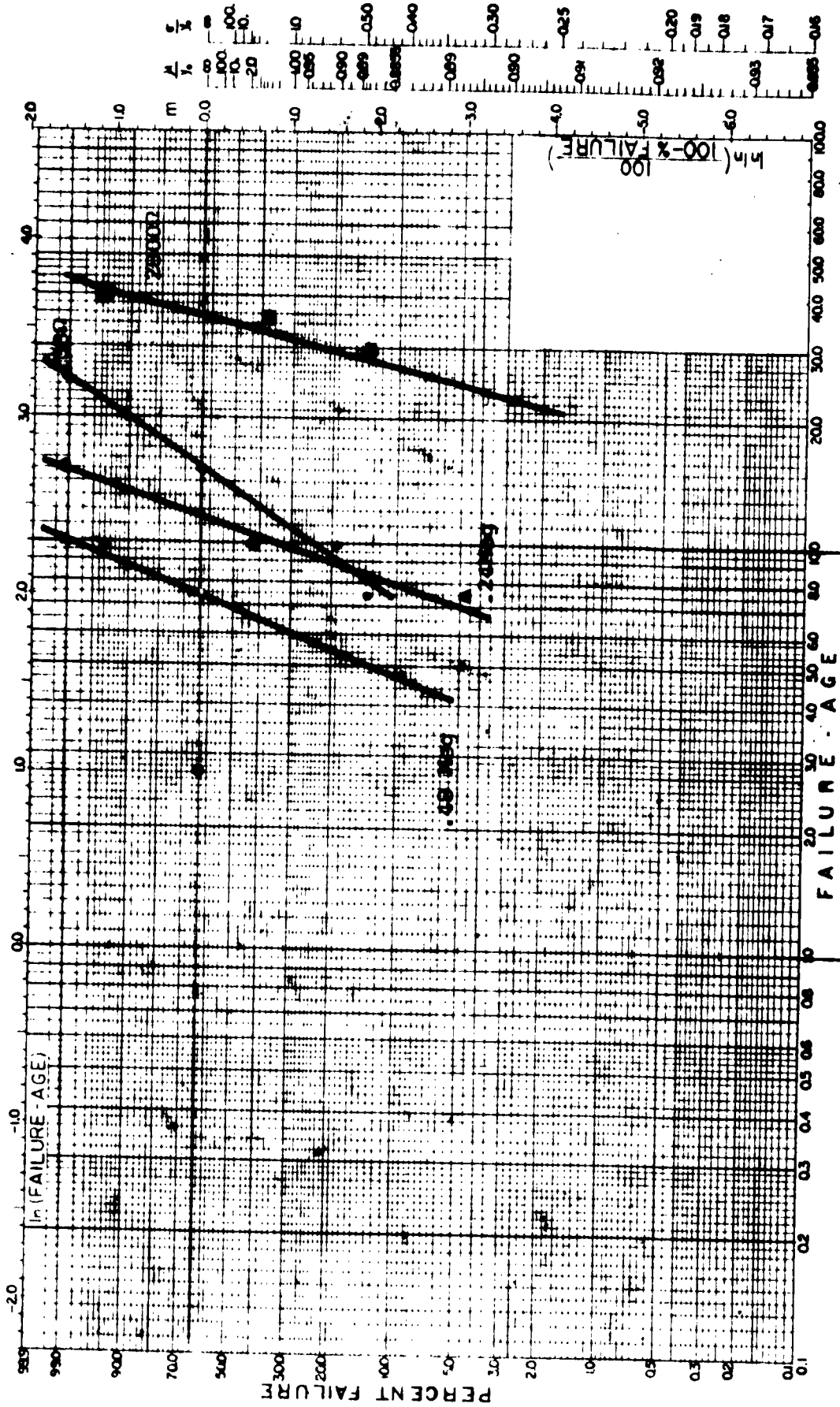
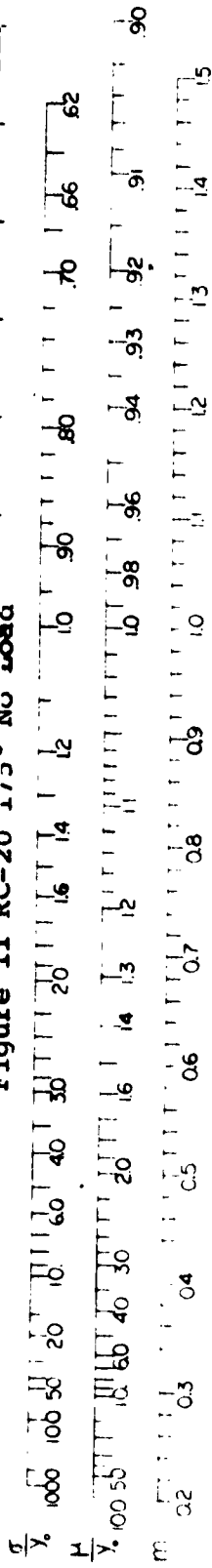


Figure 11 R-20 1/3 No load

BLF 27



100 Hours

1000 Hours