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MEDIAN ENTROPY COMPUTER PROGRAM FOR ANALYZING GROUPED FIELD DATA

INTRODUCTION

Field failure data (as well as test data) are often given in grouped form. Wherein a list is given of the number suspended (unfailed) and the number failed in specific life intervals (such as mileage intervals) on the items under study. For example, we might be told how many vehicles are survivors and how many are failures in the first 10,000 miles without being told where in the first 10,000 miles each one is at the moment. Then, continuing in the list, we would be told how many are survivors and how many are failures between 10,000 miles and 20,000 miles without giving specific mileages at the moment of data collection. Such listings can be given for any number of intervals until the entire sample under study is accounted for.

In treating such grouped data it is most convenient to use the MEDIAN ENTROPY approach (with Benard Corrections) to estimate the Weibull parameters for the type of failure under investigation. In this bulletin we present an outline for using a computer program to arrive at such Weibull parameters via MEDIAN ENTROPY.

A TYPICAL FIELD DATA PROBLEM

LIFE INTERVAL	NO. UNFAILED	NO. FAILED
0 to 100 Hrs.	2	3
100 Hrs. to 250 Hrs.	4	2
250 Hrs. to 600 Hrs.	1	4
600 Hrs. to 1050 Hrs.	3	5
Beyond 1050 Hrs.	2	0

THE ENTROPY METHOD OF ANALYSIS FOR THE EXAMPLE

There are four relevant time intervals. These have the following end points:

100 Hrs., 250 Hrs., 600 Hrs., and 1050 Hrs.

In the first 100 Hrs. There are 21 items (fully active) which have gone all the way to 100 Hrs., namely, the total 26 minus the 2 unfailed and the 3 failed in the first life interval (0 to 100 Hrs.). 2 unfailed and 3 unfailed have unknown times in the first 100 hours, so we simply assume they have an average of 50 hours of service, i.e., that they are 1/2 active. 5 half active items yields 5 x 1/2 = 2.5 active items in addition to the 21 fully active to the end point (100 Hrs.) of the first interval. Thus, in the first 100 Hrs. we have a total of 21 + 2.5 = 23.5 active items. AVERAGE ENTROPY in an interval is defined as the QUOTIENT

$$\frac{\text{NO. FAILED}}{\text{NO. ACTIVE}} = \frac{3}{23.5}$$

To convert this to MEDIAN ENTROPY we use BENARD'S MODIFIED FORMULA

$$\frac{\text{NO. FAILED} - .3}{\text{NO. ACTIVE} + .4} \quad \text{FOR THE FIRST INTERVAL}$$

and the formula

$$\frac{\text{NO. FAILED}}{\text{NO. ACTIVE} + .4} \quad \text{FOR INTERVALS AFTER THE FIRST}$$

In each interval we assume the failed and unfailed are half active, i.e., that they have an average time of service midway in the interval, while the subsequent items (beyond the interval) are fully active, since they have gone all the way to the interval end point. The total number active in each interval is then given by the formula

$$\text{NO. ACTIVE} = \underset{\text{(BEYOND END PT.)}}{\text{NO. FULLY ACTIVE}} + 1/2 \left[\underset{\text{(IN THE INTERVAL)}}{\text{NON-FAILURES PLUS FAILURES}}\right]$$

PREPARING THE DATA FOR LOGARITHMIC REGRESSION

With BENARD MODIFICATIONS we calculate the MEDIAN ENTROPY for each interval , as well as the CUMULATIVE ENTROPY , as shown in Table 1 below:

TABLE 1

INTERVAL END PT.	NO.FULLY ACTIVE	PARTIAL ACTIVITY	TOTAL ACTIVITY	NUMBER FAILED	INTERVAL MED.ENTROPY	CUMULATIVE MED.ENTROPY
100 Hrs.	21	2.5	23.5	3	.11297	.11297
250 Hrs.	15	3	18	2	.10870	.22167
600 Hrs.	10	2.5	12.5	4	.31008	.53175
1050 Hrs.	2	4	6	5	.78125	1.31300

LOGARITHMIC REGRESSION ANALYSIS FOR FITTING THE DATA

We fit the data in Table 1 with the best linear fit on log(CUMULATIVE MEDIAN ENTROPY) versus log(INTERVAL END PT.). This is done on ENTROPY PAPER (Fig. 1). The resulting straight line from the logarithms yields

B = SLOPE = 1.021 (i.e. , WEIBULL SLOPE)

A = INTERCEPT = -7.005

In such a log-log fit we calculate the Characteristic Life Value in a Weibull line by the formula

θ = EXP(-INTERCEPT/SLOPE) = EXP(-(-7.005/1.021)) = 954 Hours
(at cum.Entropy=1)

The B-10 LIFE is then

B-10 = θ(ln(1/1 - .1))^1/b = 954 (ln(1/.9))^1/1.021 = 105 Hours

The raw data points and the fitted line are shown in Figure 1.

In the Computer Program "MEDENT" (abbreviation for Median Entropy) we put the data into STATEMENT 110 as follows:

```
110 DATA  26, 4, 2, 3, 100, 4, 2, 250, 1, 4, 600, 3, 5, 1050

110 DATA sample size,# of end pts,# unfailed,# failed,end pt(1),
# unfailed,# failed,end pt(2),# unfailed,# failed,end pt (3),
# unfailed,# failed,end pt(4),...# unfailed,#failed,end pt(N).
```

CONCLUSION

It can be seen that this Computer Program "MEDENT" is very handy to use in the analysis of grouped data sets involving both survivors and failures for several intervals of service time .

MEDIAN ENTROPY COMPUTER PRINTOUT

MEDENT PROGRAM

END PT.= 100
CUM.ENTROPY= .1129707

END PT.= 250
CUM.ENTROPY= .2216664

END PT.= 600
CUM.ENTROPY= .5317439

END PT.= 1050
CUM.ENTROPY= 1.312994

WEIBULL SLOPE= 1.021034

B-10= 105.2988

CHAR. VALUE= 954.1399

CORR. COEFF.= .9867269

LOG - LOG ENTROPY PLOT

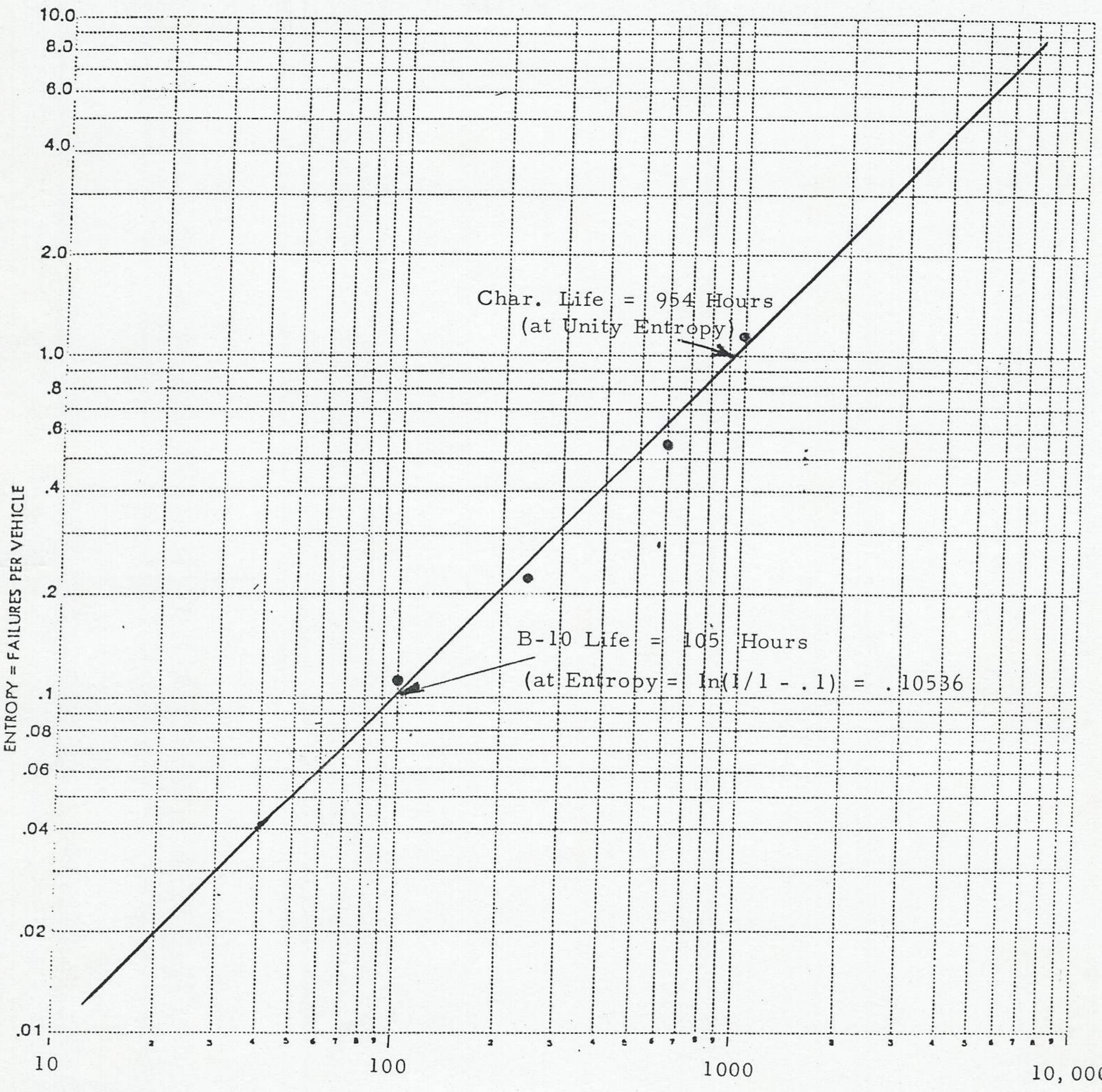

FIGURE 1