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Reliability & Variation Research

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A TYPICAL SCENARIO ON THE STEPS TO RELIABILITY

INTRODUCTION

In a previous bulletin we discussed the steps to reliability. In this present bulletin we shall give an actual example of the application of the steps to reliability. This example will illustrate the actual use of the outlined steps in the field of reliability developmental programs. The economic basis of meeting reliability goals after they have been established from cost and profit factors is the main idea pursued in this discussion.

Once these basic concepts are clearly understood and applied it will be seen that the whole idea of reliability goals and their attainment is a totally logical procedure which should always be adopted.

A TYPICAL SCENARIO

ESTABLISHING A RELIABILITY GOAL :

Production Cost of Component : $20

25% Profit Margin (Gain per Good Item) $ 5 = G

Replacement Cost of a Bad Component: $25

Net Loss to Producer per Bad Component : $20 = **L**

WANTED: Profitability Factor = 4 = K_{goal}

∴ if R_{goal} = Reliability Goal to Warranty Target ,

we have $$\frac{G\,R_{goal}}{L(1 - R_{goal})} = K_{goal}$$

or $$\frac{5\,R_{goal}}{20(1 - R_{goal})} = 4 \qquad (1)$$

from (1) : $R_{goal} = .94118$

∴ The Goal Line Entropy at Warranty Target is $-\ln(.94118) = +.06062$ $= \mathcal{E}_{goal}$

For half the desired profitability factor (i.e., k = 2) , the reliability R would be such that $5R/(20(1 - R)) = 2$, or $R = .88889$ and Entropy would be $\mathcal{E} = -\ln(.88889) = +.11778$

COMPONENT FAILURE DATA FROM FIELD

Number of Vehicles sold : (first 200)

Number of Failure Reports on Component : 4

At Mileages : 2601 mi. 4980 mi. 8465 mi. 11,150 mi.

UNFAILED VEHICLES

27	between	0	miles	and	2601 miles
64	between	2601	miles	and	4980 miles
48	between	4980	miles	and	8465 miles
34	between	8465	miles	and	11,150 miles
23	beyond	11,150	miles		

DATA TABULATION

(27 unfailed)

2601 miles ← (1 failed)

(64 unfailed)

4980 miles ← (1 failed)

(48 unfailed)

8465 miles ← (1 failed)

(34 unfailed)

11,150 miles ← (1 failed)

(23 unfailed)

INTERVAL ANALYSIS

INTERVAL	MILEAGE	No. FAILED	NUMBER ACTIVE
1	0 mi. to 2 601 mi.	1	173 + 1/2(27) = 186.5
2	2 601 mi. to 4980 mi.	1	108 + 1/2(64) = 140
3	4980 mi. to 8 465 mi.	1	59 + 1/2(48) = 83
4	8 465 mi. to 11, 150 mi.	1	24 + 1/2(34) = 41

ENTROPY GROWTH VS. MILIAGE

MILEAGE	ENTROPY INCREMENT	CUMULATIVE ENTROPY
2601	1/186.5 = .005362	.005362 failures per vehicle
4980	1/140 = .007143	.012505 failures per vehicle
8465	1/83 = .012048	.024553 failures per vehicle
11, 150	1/41 = .024390	.048943 failures per vehicle

FROM THE ENTROPY PLOT :

SLOPE OF TEST ENTROPY LINE = 1.46

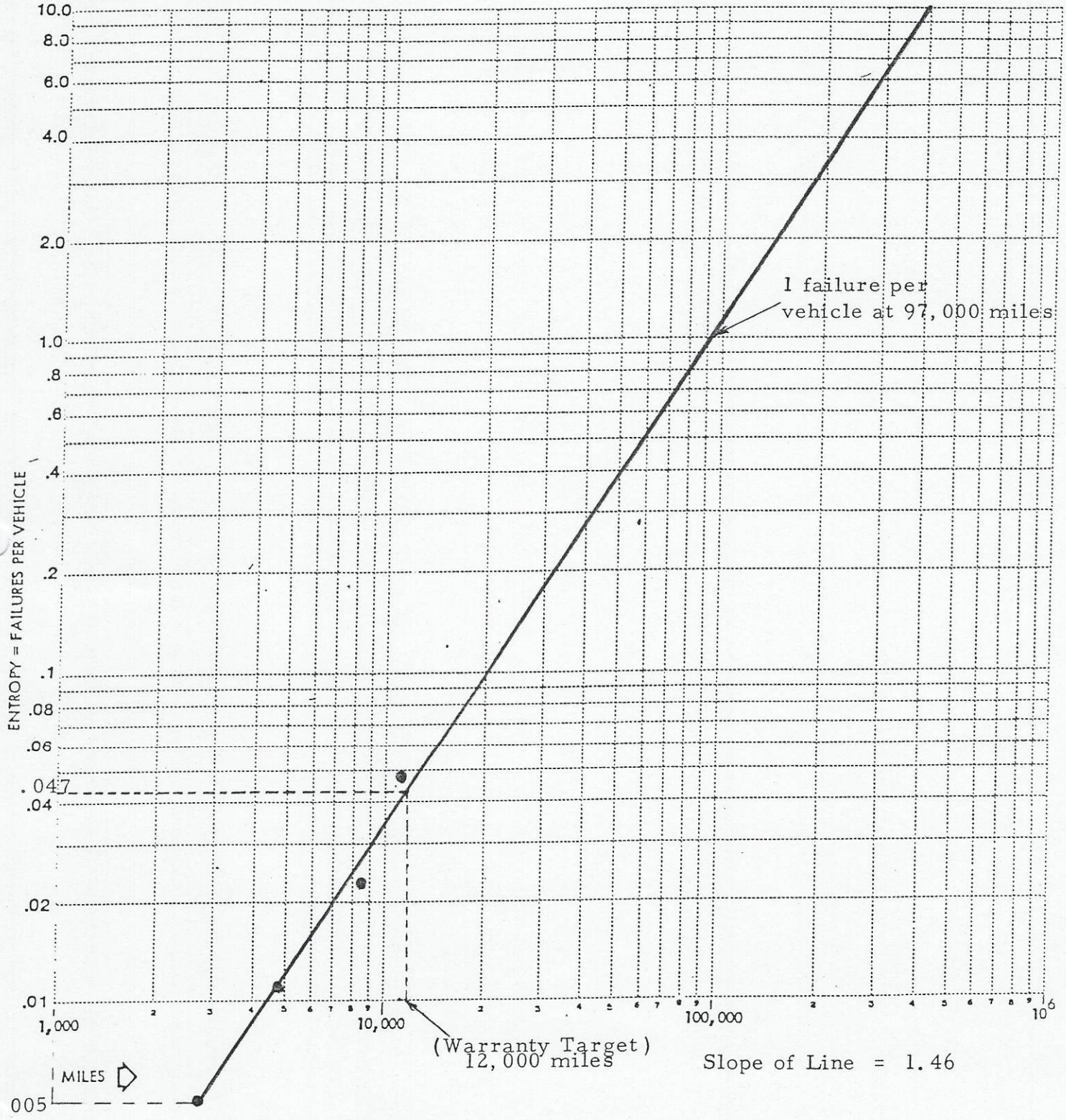
1 FAILURE PER VEHICLE AT 97, 000 MILES

TEST ENTROPY AT WARRANTY TARGET (12, 000 MILES) = .04731

TEST RELIABILITY TO WARRANTY TARGET EQUALS

$$R_{TEST} = e^{-.04731} = .95379$$

ENTROPY PLOT OF THE FIELD DATA



CHECK ON THE TEST ADEQUACY

At 12,000 miles (warranty target)

$\mathcal{E}_{goal} = +.06062$ (for K = 4)

$\mathcal{E}_{test} = +.04731$

$\mathcal{E}_{(for\ K = 2)} = +.11778$

Sigma of $\ln \mathcal{E}_{test}$ at 12,000 miles $= \frac{1}{\sqrt{\text{sample size at 12,000 mi.}}} = \frac{1}{\sqrt{27}} = .19245$

3 Sigma = 3(.19245) = .57735

Test is adequate as long as

$$\ln \mathcal{E}_{test} + 3 \text{ sigma} < \ln \mathcal{E}_{(for\ K = 2)}$$

$$\ln (.04731) + .57735 < \ln (.11778)$$

$$-2.47368 < -2.13894 \quad \text{(o.k.)}$$

ODDS IN FAVOR OF BEATING THE GOAL

$$\text{ODDS} = (\mathcal{E}_{goal}/\mathcal{E}_{test})^{(\pi\sqrt{N/3})}$$

N = test sample size at warranty target

In this case, $\mathcal{E}_{goal} = .06062$ N = 27

$\mathcal{E}_{test} = .04731$

So $\text{ODDS} = (.06062/.04731)^{\pi\sqrt{9}} = (1.28134)^{9.42478} = 10.34459$

Confidence of beating the goal = ODDS/1 + ODDS = 10.34459/11.34459 = .91

91 % confidence of making at least 4 times as much money from good items as we lose from bad items.

We have 50% confidence that the profitability factor is at least

$$5 R_{test}/20(1 - R_{test}) = 5.16$$

100 % confidence that profitability factor is at least 2.84 .

CONFIDENCE INTERPOLATION DIAGRAM FOR PROFITABILITY