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Reliability & Variation Research

LEONARD G. JOHNSON
EDITOR

DETROIT RESEARCH INSTITUTE
P.O. Box 36504 • Grosse Pointe, MI 48236 • (313) 886-8435

WANG H. YEE
DIRECTOR

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USING CONCEPTS OF STRENGTH AND WEAKNESS IN THE STUDY OF THE STATISTICS OF RELIABILITY AND CONFIDENCE IN LIFE TESTS

INTRODUCTION

In any quantitative scientific system there are certain basic concepts and their definitions, which form the underlying base for the entire structure of the system. This is certainly the case in the scientific approach to the statistical study of product reliability as predicted from life testing data. Furthermore, when making a prediction from a sample of items tested for length of life under specified conditions, we are faced with the question of confidence for any claimed level of reliability as indicated by test samples.

In this bulletin we introduce the basic concepts upon which statistical studies of reliability are based. These basic concepts are

(1) ENTROPY --- The destroyer of life

(2) POTENCY --- The preserver of life

(3) EVIDENCE --- Which must be added up in order to come to any conclusion about the reliability of a product and how confident we can be about promising such a reliability.

Note: Evidence is such an important concept due to the fact that it enables us to combine several test data conclusions by simple addition of their Evidence Indices.

For Any Life There Are 2 Basic Factors:

Factor #1 : Destroyer of Life (ENTROPY)

Factor #2 : The Preserver of Life (POTENCY)

Every life belongs to a population (DISTRIBUTION)

Within Any Class (population) There Are Different Life Expectations.

(Some are short, some are in-between, and some are long.)

In any class (population), we can look at any age (usage time) and calculate the **Entropy** (or statistical weakness), as well as the **Potency** (or statistical strength).

Let R(x) be the reliability, or probability of survival, to any age x. Then the Statistical Weakness **(Entropy)** at age x is **-ln R(x) .**

When survival is sure (with its probability = 1), there is Zero Statistical Weakness **(Entropy = 0) .**

When survival probability is Zero, there is infinite Statistical Weakness **(Infinite Entropy) .**

For all survival probabilities between 0 and 1, there is Statistical Weakness **(Entropy) between 0 and ∞ .**

Let F(x) be the probability of failure by age x. Then, the Statistical Strength **(Potency)** at any age x is **-ln F(x) .**

When the failure probability = 1, there is Zero Statistical Strength **(Potency = 0) .**

When the failure probability is Zero, there is infinite Statistical Strength **(Infinite Potency) .**

For all failure probabilities between 0 and 1, there is Statistical Strength **(Potency) between 0 and ∞ .**

Definition of Survival Evidence

The Difference

Statistical Strength - Statistical Weakness is known as the **Evidence of Survival.**

Thus, at any age x,

$$\textbf{Evidence of Survival} = \textbf{Potency - Entropy}$$

$$= -\ln F(x) - [-\ln R(x)]$$

$$= \ln R(x) - \ln F(x)$$

$$= \ln [R(x) / F(x)]$$

but, $F(x) = 1 - R(x)$

So, **Evidence of Survival** at x $= \ln \dfrac{R(x)}{1 - R(x)}$

The Meaning of Confidence

When we speak of **Confidence,** we are generally referring to some **Hypothesis**, such as a claim that Reliability to survive to a specific age is some percentage (such as 99% Reliability). The confidence we have in the hypothesis is then actually the faith (or, we could say, the reliability) we have regarding then claim.

Because of the above analogy, we can state that **Evidence of the Hypothesis** is defined (mathematically) as

$$\ln \frac{C}{1 - C} .$$

where C = Confidence

Conclusion

We have defined and discussed the basic concepts regarding **Reliability** as indicated by life test data, and how it is all knit together by **Entropy, Potency,** and **Evidence** as **fundamental factors** for arriving at predictions about product service life and the **Confidence** we can probabilistically express as our **Assurance** about the required performance of the product which has been tested.