Statistical Bulletin
Reliability & Variation Research

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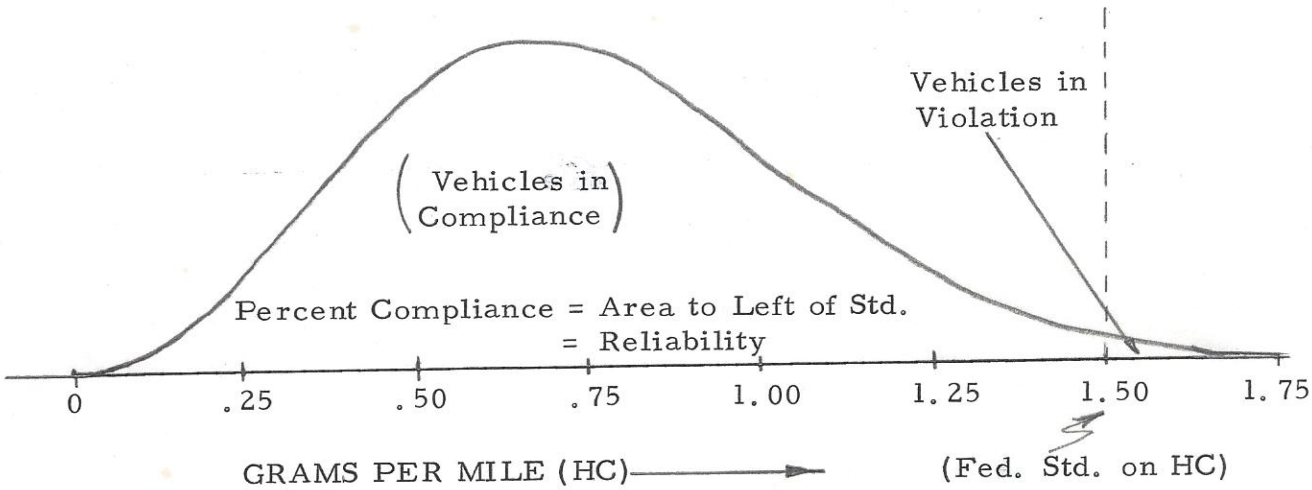
FUNDAMENTALS OF COMPLIANCE RELIABILITY

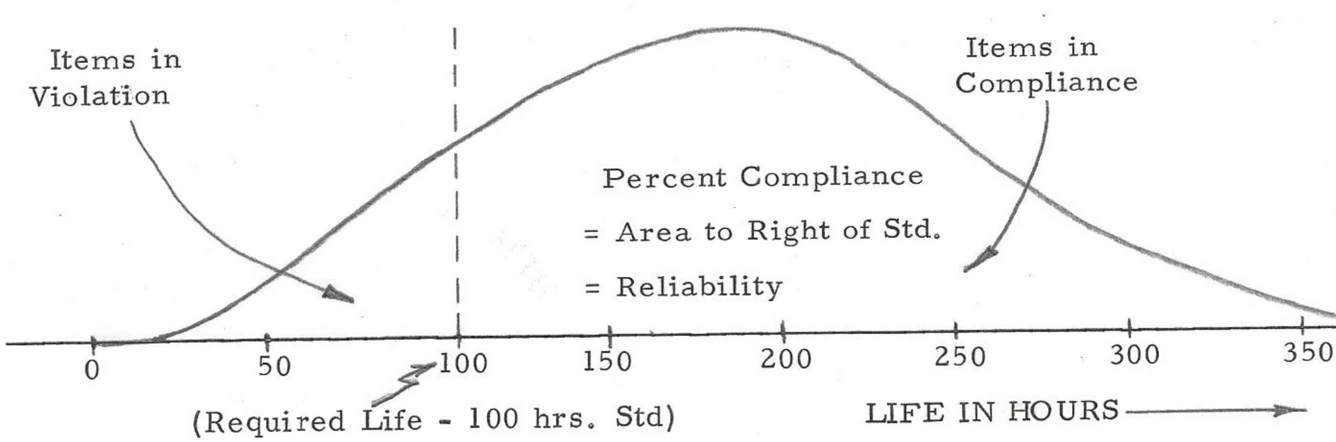
THE MEANING OF RELIABILITY IN COMPLIANCE



NOTE: This is an example of an UPPER standard.

(We call this an UPPER limit problem.)

In an upper limit problem the product must be kept to the left of (i.e., less than) the upper limit (std.) in order to comply.



NOTE: This is an example of a LOWER limit (std.) problem.

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In a Lower Limit problem the product must be kept to the right of (i.e., greater than) the Lower Limit (STD.) in order to comply.

THE NON-VIOLATION POLICY IN COMPLIANCE TESTING

RULE:

Regardless of the number of items tested in a sampling check, all the items in the sample must pass (i.e., comply with the standard).

This is also known as the Zero Defects Principle in sampling checks.

Only fully complying samples possess Legal Validity for defense purposes.

EVEN THE WORST ITEMS IN A SAMPLE MUST BE A NON-VIOLATOR !

GIVEN: TOTAL PRODUCTION PLANNED = T (POPULATION)

THEN: FOR FULL COMPLIANCE: (In population of T)
NO VIOLATORS UNTIL ITEM (T + 1).

THIS MEANS:

A PASSING RATE (i.e., A RELIABILITY) OF AT LEAST $\left(\frac{T}{T+1}\right)$.

FOR UPPER LIMIT COMPLIANCE

Let X_o = the Standard

Then $\boxed{B_{(T/T+1)} \leq X_o}$ is the Hypothesis to be tested.

OR

the Equivalent Hypothesis $\boxed{R(X_o) \geq \frac{T}{T+1}}$

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Suppose we test a sample of N items and suppose we obtain N measurements -- X_1 , X_2 , X_3 , ... , X_N . (arranged in order of magnitude)

In accordance with the Non-Violation Policy of Compliance Testing , all N values must be less than the Upper Standard X_o. Hence, the worst item (which measured X_N) must be less than X_o. Thus ,

$$X_N < X_o$$

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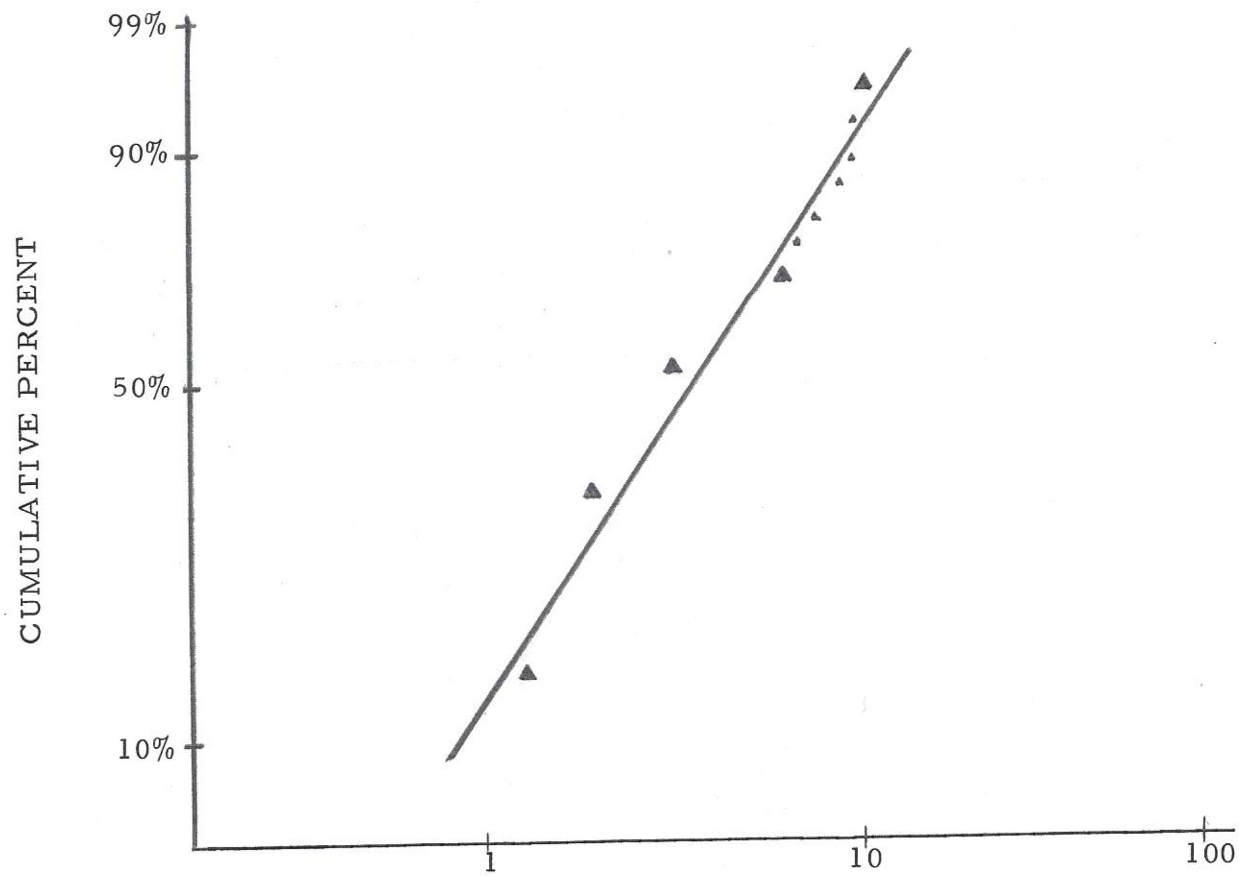
Suppose we construct a Weibull Plot from the N observations (X_1 , X_2 , X_3 , ... , X_N) , and suppose the Weibull Slope comes out to a value b .



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Let the symbol ρ_N denote the ratio

$$\left(\frac{X_N}{X_o}\right) < 1 .$$

Then , if a Reliability $R(X_o)$ to the standard X_o is desired , it follows that the CONFIDENCE that such a desired reliability will be realized is

$$C = 1 - \left(1 - \left[1 - R(X_o)\right]^{\rho_N^b}\right)^N$$

X_o = Standard (upper limit confidence)

$$\rho_N = \left(\frac{\text{Maximum Measurement in Sample of } N}{\text{Standard}}\right)$$

N = Sample Size

b = Weibull Slope .

- -

NUMERICAL EXAMPLE

Seven vehicles were measured for HC emission levels. The results were as follows :

X_1 = .75 g/mi.
X_2 = .86 g/mi.
X_3 = .93 g/mi.
X_4 = 1.00 g/mi.
X_5 = 1.04 g/mi.
X_6 = 1.10 g/mi.
X_7 = 1.21 g/mi.

Plotting these values on Weibull paper yields a Weibull Slope of

$$b = 6.76 .$$

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$$\theta = e^{-\frac{INTCP}{SLOPE}} = e^{.0487} = 1.05 \text{ g/mi.}$$

(NOTE: INTCP = −.3291)

We are going to produce 1000 of these vehicles (over a given time period). Hence , the desired reliability level is

$$R = \frac{1000}{1001} = .999 \quad ,$$

from the seven test results , how confident are we that this reliability level will be realized ? (Standard = 1.5 g/mi. for HC)

SOLUTION (UPPER STANDARD TESTING)

$R = .999$; $N = 7$; $\rho_N = \frac{1.21}{1.50} = .80667$

$\rho_N^b = .23402$; $b = 6.76$

Hence ,

$$C = 1 - \left[1 - (1-R)^{\rho_N^b}\right]^N$$

$$C = 1 - \left[1 - (.001)^{.23402}\right]^7 = .7877$$

Thus , we are 78.77% confident that the desired reliability will be realized. (This is called the NON-PARAMETRIC CONFIDENCE).

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