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THE COMPRESSED SEMI-PARAMETRIC SINGLE DEFECT COMPUTER PROGRAM AND ITS APPLICATIONS

INTRODUCTION

Whenever the question of sample sizes in attribute life tests is brought up for discussion among test engineers we are always faced with a multitude of possible sample sizes, mostly depending upon who is in control of the decisions about the sizes of the test samples. This can be a frustrating experience to any honest investigator who would like to have a firm scientific basis for the choice of sample size. For example, suppose there is a situation in which a **Reliability** of 99% is being demanded with 90% **Confidence** to some required life under specific operating conditions, such as survival to 2,000,000 bending cycles for a bending specimen. The classical **Binomial Probability Theory** demands that we test 229 such bending specimens for the 2,000,000 cycles without a single failure. However, if it is known that the specimen design is at least good enough to have no more than 5% of them failing in the 2,000,000 cycles, then a **Success Run** of one dozen to 2,000,000 cycles would be sufficient to demonstrate **99% Reliability** with **90% Confidence**. This is a dramatic illustration of the importance of knowing what **Proper Initial Assumptions** can be made before we begin to design a testing experiment on the product being studied. The **Classical Binomial Theory** involves the pessimistic assumption that the **True Population Reliability** could be **as low as zero**. It is no wonder that it demands 229 consecutive successes in order to assert that the true reliability of the product is at least 99% with a confidence of 90%. Now, suppose one of the test specimens in the sample was defective (i.e., did not last 2,000,000 cycles), how many more must be run successfully to 2,000,000 cycles in order to allow us to claim at least 99% **Reliability** with **90% Confidence**?

This last question (about having 1 defective in a life test sample) is one of the most annoying trouble makers for those who are involved in attribute life tests to required life targets. In the case being illustrated here, anyone following the **Classical Binomial** approach would have to end up testing a total of 387 specimens with only 1 defective allowed. It can be seen that the classical approach is totally impractical for such single defect attribute testing programs.

In this bulletin we introduce a new and practical computer program which allows the user to make an appropriate realistic assumption about the **Known Minimum Reliability** of the item being tested when 1 defective is permitted in an **Attribute Test** run on a total on N items to a life target. Furthermore, we will make use of **Semi-Parametric Ranks** in our mathematical formulation for the required sample size with 1 defective allowed. By using this computer program (called "**COMSEMSD**") the sample sizes required for such **Single Defect Tests** it will be found that we can come up with very reasonable sample sizes, which will make it possible to run such tests with the confidence demanded for any required reliability level without such outlandish sample sizes as the one required in the example (i.e., 1 defective in 387). The examples we give in applying the program "**COMSEMSD**" will dramatically illustrate the fact that it truly is a neat way of designing attribute life tests where 1 defective is allowed in the test sample. For the case of **no defectives** the reader should make use of the **Compressed Success Run Theorem** discussed in Volume 19, Bulletin 7 (January 1990).

THE MATHEMATICAL BASIS FOR THE PROGRAM "COMSEMSD"

This new and useful computer program for the **Compressed Semi-Parametric Single Defect ("COMSEMSD")** method of treating problem in **Attribute** testing programs with 1 defective item in a total of N tested to a specific life goal is based on the so-called **Universal Law of Odds** discovered by **Leonard G. Johnson** of **Detroit Research Institute** in the mid-nineteen eighties. This particular law states that the **Odds** in favor of compliance to a required life can be determined from the following formula:

$$\textbf{ODDS} = (\textbf{ENTROPY RATIO})^{(\textbf{ODDS EXPONENT})}$$

where ENTROPY RATIO is the ratio of $\dfrac{\log R_C}{\log R_{.50}}$

and ODDS EXPONENT $= \left(\dfrac{\pi}{\sqrt{3}}\right)\left(\sqrt{\dfrac{N}{2}}\right)$

{C = Confidence , N = Sample Size}

This happens to be **Semi-Parametric** formulation for those cases in which the population failure rate is low.

R_C is the **Reliability** with **Confidence** C.

$R_{.50}$ is the **Reliability** with **50% Confidence.**

ACTUAL EXAMPLES OF THE USE OF COMSEMSD

PART 1--- COMPRESSED SEMI-PARAMETRIC SINGLE DEFECT PROGRAM

PROGRAM NAME IS COMSEMSD
NO. OF TRIALS = 31 AND CONFIDENCE = .9
ASSUMED MINIMUM RELIABILITY = .85
RELIABILITY WITH CONFIDENCE .9 = .9895305

THE EXAMPLE BELOW SHOWS HOW A MINIMUM RELIABILITY IS REJECTED WHEN TOO LARGE

SAMPLE SIZE PROGRAM WITH SINGLE DEFECTIVE
THIS IS PROGRAM #2 IN COMSEMSD

DESIRED RELIABILITY = .99
DESIRED CONFIDENCE = .9
MINIMUM RELIABILITY TAKEN AS .95

DESIRED SAMPLE SIZE = 12
MINIMUM RELIABILITY TOO LARGE FOR 1 BAD IN 12
RERUN WITH NEW MINIMUM RELIABILITY

BELOW IS A RE-RUN OF THE PREVIOUS CASE WITH A REASONABLE MINIMUM RELIABILITY

SAMPLE SIZE PROGRAM WITH SINGLE DEFECTIVE
THIS IS PROGRAM #2 IN COMSEMSD

DESIRED RELIABILITY = .99
DESIRED CONFIDENCE = .9
MINIMUM RELIABILITY TAKEN AS .85

DESIRED SAMPLE SIZE = 31

CONCLUSION

It can be seen from the example, which is analyzed by our computer program "COMSEMSD" (Compressed Semi-Parametric Single Defect) on Page 4 of this bulletin, that we can get by with much smaller total sample sizes (even with one defective) than we could even hope to be able to do by the standard classical approach. As things turned out, we were able to prove 99% reliability with 90% confidence by testing 31 items to target life with 1 defective allowed. On the other hand, the classical approach would have required 387 items with one defective allowed in order to prove the same reliability and confidence levels. Furthermore, the computer program "COMSEMSD" is so smart that it will tell us when we have assumed an unreasonably high minimum reliability, so that we can then make another run with a properly reduced minimum reliability assumption (e.g., the minimum reliability of 85% in the example). Also, it should be pointed out that the use of **Semi-Parametric** rankings for confidence levels still further reduces sample size requirements when compared to classical **Non-Parametric** rankings for the same confidence levels.