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Page 1

**THE RE-EDUCATION OF MR. JIMMY BIG SAMPLE
(OR THE EFFECTIVENESS OF SEQUENTIAL TESTING)**

A TYPICAL RELIABILITY PROBLEM FACED BY A PRODUCT SUPPLIER

A certain machine manufacturer told a potential customer "We promise you that not more than 1 machine in 100 will give you any trouble in 2000 hours of operation." . The customer then reasoned that this means at most 1/100th of a failure per machine in 2000 hours. The fancy name for failure per machine is ENTROPY. So, according to the promise made by the machine manufacturer, the ENTROPY at 2000 hours will not exceed $1/100 = .01$. Then the following conversation took place between Mr. Manufacturer and Mr. Customer :

Mr. Customer : "Before I buy your machines I want a test demonstration which verifies your claim."

Mr. Manufacturer: "I'll go and tell my test engineer, Mr. Jimmy Big Sample, to run a sufficient number of these machines to prove my point -- i.e., that not more than 1 in 100 will fail in the first 2000 hours of use."

Mr. Customer : "OK, you go ahead with your testing. When you have all things ready, let me know."

Mr. Manufacturer: "Yes, Sir! I'll call you when we're ready. So long!"

Then Mr. Manufacturer went directly to Mr. Jimmy Big Sample and told him to come up with a test plan to prove with sufficient confidence that the machines had no more than an ENTROPY of .01 at 2000 hours.

SPECIAL QUESTIONS RELEVANT TO THE PROBLEM

What do we lose dollar-wise in case our machines do not live up to the 2000 hour requirement of having no more than 1 bad one in 100 sold?, asked Mr. Big Sample. Mr. Manufacturer replied "Mr. Customer has informed me that a serious breakdown prior to 2000 hours could mean a loss to them of \$1,000,000 due to delays and I can say our replacement expense would be as much as \$2,000,000 , making a total loss of \$3,000,000 , for which we would be responsible." . "On the other hand," added Mr. Manufacturer , "Should we succeed in keeping our promise, we would have a net profit of \$200,000." . "In any case," added Mr. Manufacturer , "On repeated sets of 100 machines, we want to retain at least 2/3 of the possible net profit."

Then Mr. Big Sample reasoned that in order to realize at least 2/3 of the possible net profit even in the case of non-compliance to our promise, the ODDS in favor of not exceeding the ENTROPY level of .01 at 2000 hours, must be set at

$3 \times 3,000,000 / 200,000 = 45 \text{ to } 1$, which
implies a CONFIDENCE = $45/46 = .97826 = 97.826\%$

Mr. Jimmy Big Sample looked in his files and found that similar machines had shown .75% failed in 2000 hours. So, he figured that he must construct a Weibull plot of 53 machines and get a Weibull line showing at most .75% failed at 2000 hours. He told Mr. Manufacturer that he wanted to test 53 machines to failure to construct a Weibull plot.

"We don't have 53 machines available to test", replied Mr. Manufacturer.

"Why don't we just test 6 machines and let's see what we get" replied Mr. Manufacturer.

So, Jimmy ran a life test on 6 machines to failure and constructed a Weibull plot which crossed 2000 hours at .62% failed. From this, Jimmy calculated the ODDS of staying below 1% failed at 2000 hours to be 8.41 to 1 . Jimmy then told Mr. Manufacturer that the 6 machines tested did not give the required ODDS of 45 to 1 , but only 8.41 to 1 .

"OK", replied Mr. Manufacturer, "Go ahead and test 6 more to see what happens."

Jimmy did as he was told, and found from the second set of 6 machines that their Weibull plot crossed 2000 hours at .68% failed. Then Jimmy calculated the ODDS of staying below 1% failed at 2000 hours to be 5.57 to 1 . He conveyed this information to his boss, Mr. Manufacturer.

"Fine", replied Mr. Manufacturer, "We're all set." "I'll call Mr. Customer and tell him to come and look at our test results". He told Mr. Customer to come to the testing lab the next day.

Jimmy asked Mr. Manufacturer how it could be concluded that they were all set as a result of two test samples of 6 each, thus making for a total of 12 test machines.

"That's simple", replied Mr. Manufacturer, "Just multiply the two ODDS you obtained, i.e. , $8.41 \times 5.57 = 46.8$. You can see that this exceeds the required 45 to 1 ODDS."

"Oh, I see", said Jimmy. "It's perfectly logical to multiply two INDEPENDENT ODDS to obtain the RESULTANT ODDS."

So, as a result, it turned out that all that was needed was 12 test machines instead of the 53 which Mr. Jimmy Big Sample originally proposed. Thus, Jimmy got a good lesson on the effectiveness of SEQUENTIAL TESTS (in this case, two separate independent tests each test having 6 machines).

Incidentally, Mr. Customer was fully convinced that he could safely buy the 100 machines which Mr. Manufacturer would supply.

CONCLUSION

This story on the re-education of Mr. Jimmy Big Sample illustrates the effectiveness of SEQUENTIAL TESTING. Those who are interested in all the mathematical formulas involved in such problems should attend DETROIT RESEARCH INSTITUTE'S special seminar entitled "NEW AND EFFECTIVE METHODS IN STATISTICAL RELIABILITY", with emphasis on practical problems.