

STATISTICAL BULLETIN

Reliability & Variation Research

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DESIGNING ADEQUATE LIFE TESTS IN RESTRICTED LEAD TIMES

**A Discussion Between a Businessman and a Test Engineer
Concerning This Most Critical Problem in Product Design**

AN INTERESTING CONVERSATION

PARTICIPANTS: BUSINESSMAN & TEST ENGINEER

BUSINESSMAN: Sir, what is your job, and what kind of work do you do?

TEST ENGINEER: My job is to test the products produced by my employer in order to be assured that such products will perform properly for a sufficiently long service period in the hands of the customer.

BUSINESSMAN: It's been said that the customer himself is the real testing instrument for a product.

TEST ENGINEER: That's very true, but if there is something defective in a product, we can't let the customer get burned and, as a result, cause a financial set-back plus great embarrassment and inconvenience to the manufacturer.

BUSINESSMAN: What special difficulties do you encounter in testing a product in advance of releasing it for sale to the public?

TEST ENGINEER: Limited lead time is the greatest difficulty. This is because of the fact that in so many instances those who make contracts to purchase a particular design are in a great hurry to get it done and released for use ahead of competitors. Furthermore an upcoming model year might be just a short time away, and this forces rapid approval and quick testing.

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BUSINESSMAN: If you can't take your time in testing, how in the world can you develop any kind of assurance of product reliability?

TEST ENGINEER: Now you've hit upon the crux of this whole matter of testing for product reliability in advance of selling to the public.

BUSINESSMAN: What do you mean by this statement?

TEST ENGINEER: What I'm saying is that quick approval on a product in a limited time frame necessitates the development of what is known as *Accelerated Testing*.

BUSINESSMAN: Oh, I see! You are telling me that there must be a quick way, that is, a speeded-up way of getting to the acceptance point for a design, and you call this *Accelerated Testing*. I'm curious as to how you can do such an accelerated program to shorten your investigation.

TEST ENGINEER: Well, for one thing, in order to make a product fail sooner, we can put extra stress on it, over and above what it would experience in service. This type of accelerated testing is what is called overload testing. By this technique we can make comparisons between a new design and some older design in order to claim that the new design is superior when it outlasts the old design under the increased stress to which we subject both of the designs. We then conclude that the new design would outlast the old design under standard service loads in the hands of the customer. The same idea applies when we have a specific required service life desired into a corresponding required life goal at the higher stress level used in the accelerated test.

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BUSINESSMAN: But, what can you do about shortening test time when somebody doesn't trust putting extra stress on a product because it might change the entire nature of the failure due to bad side effects caused by loads not compatible with those encountered in service?

TEST ENGINEER: That's a good question. In case we don't dare increase the stress load on our product, we can resort to special time shortening techniques, such as *Sudden Death Testing*. In sudden death testing we run many specimens simultaneously and wait only until the first failure is encountered.. This can shorten test time quite a bit if there is a great spread between the weakest and the strongest item in the sample tested. The weak ones will fail quite early compared to the average life of such items. We can repeat the sudden death process with as many samples as needed in order to get enough first failures to make a sufficiently accurate *Weibull Plot*.

BUSINESSMAN: How do you convert a sudden death Weibull plot into a picture of the life distribution for the population of the product you are testing?

TEST ENGINEER: At any quantile level (say B-10) on a sudden death Weibull line we simply multiply the sudden death life by the factor $K^{(1/b)}$, where

$$K = \text{Number of specimens run simultaneously}$$
$$b = \text{Weibull slope of sudden death line.}$$

BUSINESSMAN: That's interesting. What other techniques are there in your collection of time shortening methods for accelerated testing?

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TEST ENGINEER: Well, there is what is called *Sequential Testing* of small samples with a build-up of *Confidence* as we succeed in proving that each small sample is a winner versus some *Goal (Bogey)*. The more small winning samples we get, the greater our resulting confidence becomes. This sequential procedure uses less test time and fewer specimens than the large single sample required for the same final *Desired Level of Confidence*.

BUSINESSMAN: Suppose there is a desired life to which you test a whole bunch of items and they all succeed, i.e., survive to the desired life. Is there any way of avoiding the large sample size required by the classical *Binomial Probability theory*?

TEST ENGINEER: There is a way of relying on *Past Experience* about *Minimum Reliability* by using what is called the *Compressed Success Run Theorem*. For example, in order to demonstrate 99% reliability with 90% Confidence, classical theory requires us to run 229 consecutive successes to the desired life. However, if we can guarantee at least 50% reliability to desired life, then we can get by with one half of the 229, i.e., 115 successes. If we know from past experience that the reliability cannot go below 90%, then we can get by with one tenth of the classical 229, i.e., 23 successes.
How's that for accelerating a testing program?

BUSINESSMAN: I can see where it takes special training in order to get anything accomplished in an orderly and logical fashion in your accelerated testing programs which must be designed to meet approval deadlines.
Where can I tell any of my engineers to go for such up-to-date training?

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TEST ENGINEER: Tell them to attend the special seminar put on by *Detroit Research Institute* on the topic of *Accelerated Testing*.

That's where I've learned so many of these useful techniques on shortening the testing time for a product which must get early approval of being reliable enough to sell to the public without serious repercussions.

BUSINESSMAN: Thank you, sir. This has been a most useful discussion.

CONCLUSION

From the discussion which took place between the businessman and the test engineer, we can see that the problem of product life testing can get so involved that it requires special training in the proper techniques required in order to get valid results and valid life predictions which do not end up disappointingly false and misleading. It behooves everyone concerned with product compliance to customer demands, as well as to legal responsibilities of the seller of a product, to make sure that all personnel involved in a testing program, are fully educated in designing of tests, including accelerated testing, sample size requirements, confidence levels needed, and all other criteria about evidence of product compliance to what is demanded in service.