Can You Use Weibull Analysis On Repairable Items?

Can you use Weibull analysis on both new components and repaired components? The short answer is **yes**. The longer answer follows below.

In a perfect world, the Weibull analysis would only apply to new parts. As a pragmatist, I know I'll never see this condition as I live in a "sinful" world devoid of perfection. Therefore I must make the best use of imperfect data to say something to meet never ending time and cost constraints.

Weibull analysis is described in IEC 61649-2008, second edition. By the way, IEC does not restrict Weibull analysis to either new or reconditioned components. IEC's second edition closely follows Dr. Bob Abernethy's book The New Weibull Handbook, 5th edition. You can also read the bio of both Dr. Abernethy and Dr. Weibull on this website.

Repair conditions-

We have these practical conditions of repairing things:

a) Repaired to good as new
b) Repaired to good as old
c) Repaired to something in between good as new or good as old
d) Repaired to better than new

For condition a)-

If the parts are repaired to **good as new**, then the repaired Weibull trend line should lie near the original Weibull line for new parts (you can validate the "sameness" by use of the likelihood ratio test described in The New Weibull Handbook and built into SuperSMITH Weibull and displayed in SuperSMITH Visual).

For condition b)-

If the parts are repaired to **good as old**, then the Weibull line should be displaced to the left (shorter characteristic life, eta) by a significant amount.

For condition c)-

If the parts are repaired to the in between case, **something between good as new or good as old** then you should see displacement between the old and new Weibull lines with the "goodness" of the repair manifest by the "how much displacement" and is the displacement significant.

For condition d)-

Of course we optimistic folks always want to think we can make improvements over the base line new parts. We believe we can repair them to a condition which is **better than new.** If so, then test results should show a displacement of the Weibull trend to the right of the as new Weibull line when repaired to better than new. This translation of the Weibull trend line would then demonstrate a significantly improved eta value.

Location of Weibull characteristic life eta and Weibull slope beta-

We can change the Weibull eta value for characteristic life which demonstrates the grade of the product. Low grade products will have shorter life (smaller eta). High grade products will have longer characteristic life. The Weibull characteristic life is identified by a single point on the Weibull trend line at 62.3% which is a mathematical property of the Weibull distribution where for a given eta value, all trend line slopes will pass through the same point. Translation of the Weibull line to the right or left is driven by the inherent strength condition. However, the Weibull line slope beta is driven by the physics of failure. Usually we do not get the opportunity to simply "dial up the value" for Weibull line slope beta. Typical values for beta are listed in Weibull databases and the eta values are determined by the grade of the material strengths. Knowing typical beta values from test results is a method of reducing variability in small sample test data, for example a typical beta value for **rubber belts is β = 2.5** defines the amount of scatter expected in the data and when imposed on test results (Weibayes method) can reduce uncertainty in Weibull analysis of small datasets.

How much data do you need to prove your repair condition?

We rarely have large datasets of new and repaired data. More data suggest more failures. How many more failures would you like to purchase?—the answer to this basic question is most often zero.

Usually more test data reduces the zone of ignorance by reducing uncertainty. Often arguments between right and wrong Weibull's are wrapped up in the uncertainty of the test results. We can have wonderful wars and arguments over test results. Usually the arguments are driven by "my test data is better than your test data". The likelihood ratio tests put these arguments to bed. The likelihood ratio test settles arguments by demonstrating if two or more test results are significantly different and provides the clarity between night and day. By the way, if no significant differences result from the likelihood ratio test, then the test results can be pooled for a single, larger dataset which usually reduces uncertainty in the statistical results.

Purist may look at data from repaired components as a "sinful practice". The practical issue is how much do we sin? Some sins are slaps on the hand where we knowing take risks. Other sins are capital crimes and you don't want to go there (particularly here in Texas where we believe in flushing the toilets regularly with the death penalty). As a practical issue Weibull analysis is used for both new parts and repaired parts without splitting hairs. However the issue is getting the age-to-failure identified correctly and addressing the a) through d) issues listed above.

I decided a long time ago that a practical and workable answer obtained quickly is better than a perfect answer obtained 50 to 100 years into the future. So label me as a pragmatist rather than a perfectionist as tempus fugits and costs accumulate. I use the tool that produces useful results PDQ—so if Weibull analysis works OK for repaired parts, I will use it. Of course, you can always use Crow-AMSAA plots which aren't as smart as Weibull plots but are more forgiving of mixed failure modes, etc.

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