

APPENDIX L- STATISTICAL CONFIDENCE

Description

Statistical confidence is a measure of the accuracy of a sample statistic in estimating a true population value. For example, an estimate of the mean life of a population of parts can be made using a test of a few samples or through sample field data collection. If very few samples are used, the mean life estimate may not be a very good estimator of the mean life of the entire population. In fact, it is expected that each such sample would produce a different mean life estimate. The calculation of confidence limits enables us to quantify the certainty (or uncertainty) of any decisions made based on the sample statistic.

Purpose

When a population parameter such as mean life, mean time between failure, Weibull B_{10} life, etc. is estimated based on a test or field sample, the statistical certainty of the estimate in representing the true population value can be calculated. This is accomplished by calculating a confidence interval, an upper confidence limit, or a lower confidence limit at a predetermined confidence level based on the sample data. In the case of a confidence interval, the likelihood that the true population value exists between the upper and lower confidence limits is termed the confidence level. In the case of an upper or lower confidence limit, the confidence level is the likelihood that the true population value is less than the upper limit or exceeds the lower limit.

For example, we might obtain sample values that indicate that a component has a mean life of 12,000 hours. After calculating a 90% confidence interval, we would state that the mean life, at 90 percent confidence, is between 10,250 hours and 13,750 hours. This can be interpreted as the following:

- 90 percent likelihood that the population mean life is between 10,250 and 13,750, and
- 5 percent likelihood that the population mean life is less than 10,250, and
- 5 percent likelihood that the population mean life is greater than 13,750.

If we make a business decision (for example, a warranty commitment) based on the lower confidence limit, we have a 5 percent chance that the decision will be wrong. It should be noted that, while we can calculate the probability that a given sample will contain the population mean, we cannot estimate the likelihood that the population mean exists between specific limits. Since the population mean is a constant, it is either in the interval or not.

An illustration of the concept of confidence intervals is shown in **Figure 1**. A total of ten samples has been taken from a population, and the mean (\bar{X}) and 90 percent upper and lower confidence limits (U_{CL} , L_{CL}) have been calculated for each sample. As shown, the true population mean (μ) is between the upper and lower confidence limits in nine of the ten samples. In other words, for any given sample, there is a 10 percent chance that the true population mean is not contained by the confidence interval.

If we had instead calculated the upper and lower confidence limits at a 99 percent confidence level, then the upper and lower bounds would be further from the mean of each sample and would therefore be much more likely to contain the true population mean.

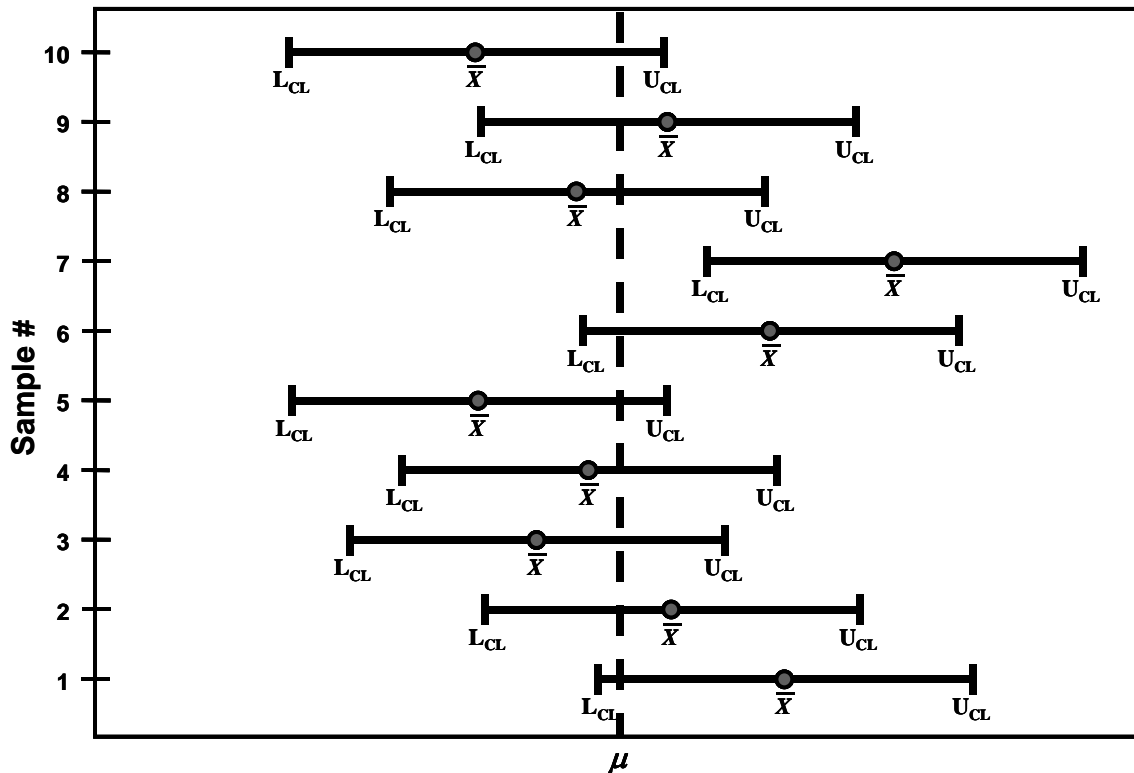


Figure L.1: Example of Samples and Confidence Limits Relative to the True Population Mean

Benefits

The calculation of statistical confidence is a critical element of any reliability program since it quantifies the uncertainty associated with any sample-based reliability measurement. This allows you, for example, to quantify the increased uncertainty (and risk) associated with reduced sample size and to express to management, in quantitative terms, the relative risk associated with any reliability measurement.

Implementation

Statistical confidence plays an important role in virtually the entire product development cycle.

- **During Product Design & Development:** Confidence levels are used to determine the sample sizes required for product validation tests.
- **During Product & Process Validation:** Confidence levels are used during validation to measure the uncertainty associated with reliability measurements taken during validation testing.
- **During Production & Field Use:** Statistical confidence is applied to any sample observations taken from the field.

General Comments

The concept of statistical confidence is central to the meaningful interpretation of sample statistics.

References

Bain and Engelhardt. *Introduction to Probability and Mathematical Statistics*, PWS-Kent, 1989.

Lipson and Sheth. *Statistical Design and Analysis of Engineering Experiments*, McGraw Hill, 1983 .

