Statistical Confidence in Setting and Verifying Requirements

50% statistical confidence may be used if requirements are set at the "worst case" or 99.9 percentile level to compensate.

Some advantages of using 50% statistical confidence are:

1. The 50% confidence value is the best estimate of the actual value.
2. The 50% confidence value is independent of the method of computing confidence.
3. When (series) reliabilities are combined, the 50% confidence values simply multiply.
4. Graphs are less cluttered and simpler to understand without confidence.
5. Requirements are simpler to understand without confidence.

Attribute data is demonstrated by testing a certain quantity of product, typically with 0 failures for the shortest test or smallest sample size. The formula for 0 failures (derived from the first term of the binomial expansion) is:

$$R^n = 1\text{-}C$$

Where **R** is reliability (fraction conforming), **n** is the number of samples (prototypes) tested, and **C** is the statistical confidence. "Reliability raised to the nth power equals one minus the confidence."

When one tests a number of samples without failure, one is simultaneously demonstrating an infinite number of different reliabilities, each at a different statistical confidence. A typical example is demonstrating 0.95 reliability (fraction conforming) at 95% statistical confidence. The formula says to test 59 units.

59 units with 0 failures is:

Statistical Confidence	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%
Reliability	0.95049	0.96172	0.96836	0.97309	0.97678	0.97980	0.98236	0.98459	0.98656	0.98832

There is nothing more or less valid about any of these sets of reliability and confidence; they are equivalent.

Variable data is demonstrated by testing a sample, say 10 units, fitting a distribution to the data pints and then (typically) extrapolating to the required limit (e.g. force, voltage, torque) and reading the reliability (fraction conforming) at the requested statistical confidence.

For example, the following data was taken from an Instron Tensile Tester on force to remove a connector:

Force	5.29	4.57	4.83	5.99	5.31	4.84	4.91	5.18	4.62	4.21

The requirement is for less than 7 pounds with at least 0.99 reliability (fraction conforming) at 95% statistical confidence.

Several distributions were fit to the data with the best fit being a Lognormal. The 95% single-sided upper confidence bound is computed using the Likelihood Ratio method. Different methods of computing confidence would result in different values for the 0.99 reliability force at 95% confidence.

Again an infinite number of reliabilities at 7.0 lb., each at a different confidence, can be presented from these data.

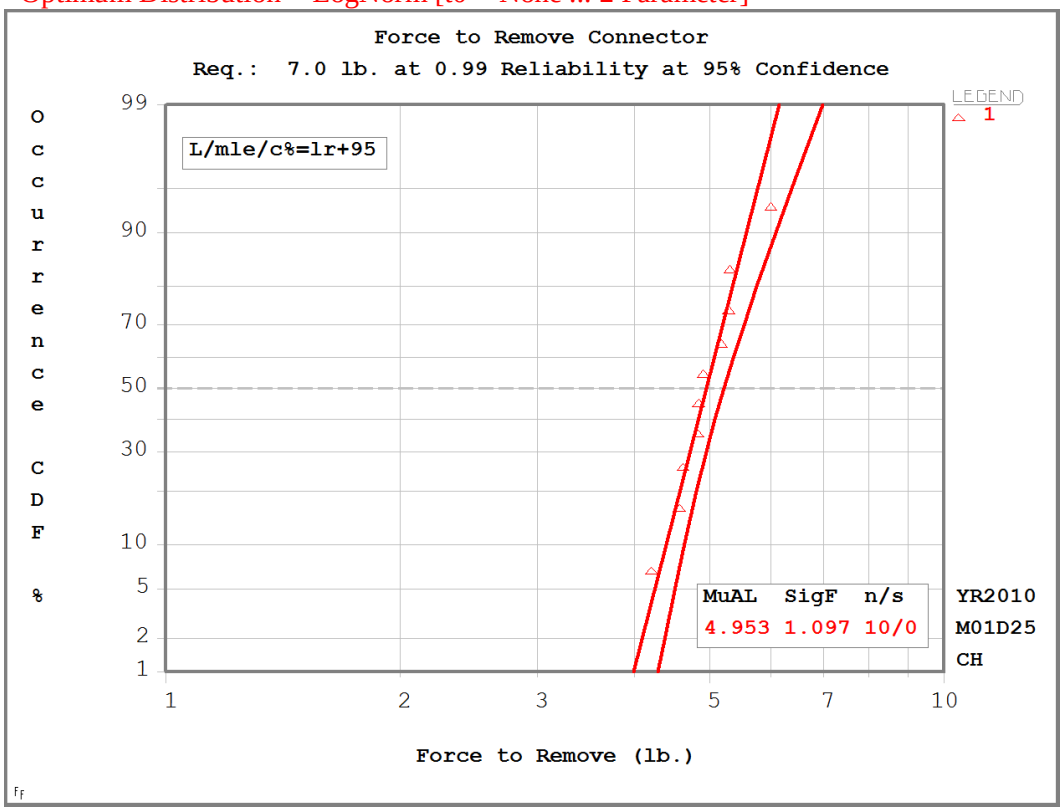
Statistical Confidence	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%
Reliability	0.99033	0.99564	0.99761	0.99856	0.99914	0.99942	0.99962	0.99976	0.99985	0.99990

There is nothing more or less valid about any of these sets of reliability and confidence; they are equivalent.

The fit information, graph, and results are presented on the following two pages with and without using confidence.

Force to Remove Connector

Life Data Distribution Analysis (Likelihood)
W:Weibull [t0 = None ... 2 Parameter]
W: Log Likelihood (LL)= -7.541119
W: Characteristic Value=5.196 Weibull Slope=10.42 Method=mle
3:Weibull [t0 = 3.699579 ... 3 Parameter] [Scale As Recorded]
3: Log Likelihood (LL)= -6.662878
3: Characteristic Value=5.053 Weibull Slope=3 Method=mle/t0^
L:LogNorm [t0 = None ... 2 Parameter]
L: Log Likelihood (LL)= -6.427567
L: Log-Mean Antilog=4.953 Std. Dev. Factor=1.097 Method=mle
Optimum Distribution = LogNorm [t0 = None ... 2 Parameter]



Set 1 - 1 ... SigF = 1.09735 MuAL = 4.953385

At Force to Remove = 6.988255 (lb.)
  > .99 (99%) Will Occur
  < 9.99999E-03 (1%) Will NOT Occur
[Confidence = 95%]

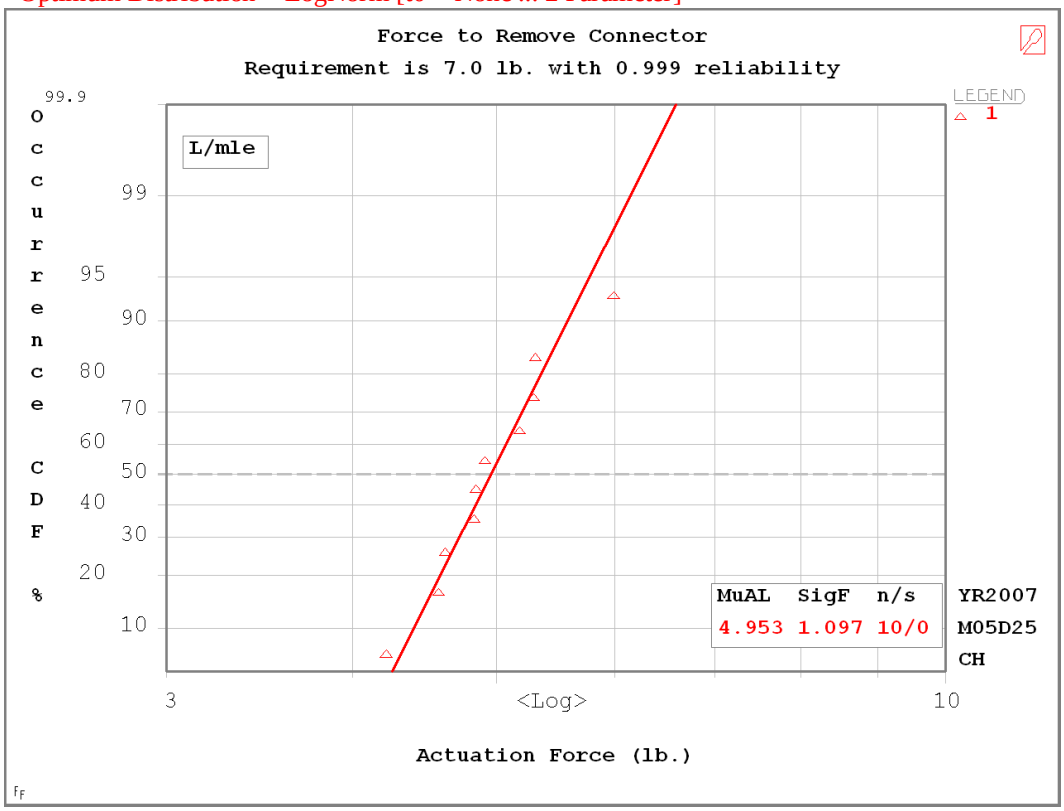
The force is 6.99 lb. at 0.99 reliability at 95% statistical confidence.

At Force to Remove = 7 (lb.)
  > .9903338 (99.03%) Will Occur
  < 9.666204E-03 (.97%) Will NOT Occur
[Confidence = 95%]

The reliability at 7.0 lb. is 0.9903 at 95% statistical confidence.

Force to Remove Connector

Life Data Distribution Analysis (Likelihood)
W:Weibull [t0 = None ... 2 Parameter]
W: Log Likelihood (LL)= -7.537253
W: Characteristic Value=5.195 Weibull Slope=10.42 Method=mle
3:Weibull [t0 = 3.703365 ... 3 Parameter] [Scale Not As Recorded]
3: Log Likelihood (LL)= -6.651657
3: Characteristic Value=1.348 Weibull Slope=3 Method=mle/t0^
L:LogNorm [t0 = None ... 2 Parameter]
L: Log Likelihood (LL)= -6.411047
L: Log-Mean Antilog=4.953 Std. Dev. Factor=1.097 Method=mle
Optimum Distribution = LogNorm [t0 = None ... 2 Parameter]



Set 1 - 1 ... SigF = 1.097198 MuAL = 4.952575
At Actuation Force = 6.596476 (lb.) (Z-Value = 3.09)
  .999000015258789 (99.9%) Will Occur (Will Be <)
  9.99984741210991E-04 (.1%) Will NOT Occur (Will Be >)
[Confidence = 50%]

The force is 6.6 lb. with 0.9990 reliability.

Set 1 - 1 ... SigF = 1.097198 MuAL = 4.952575
At Actuation Force = 7 (lb.) (Z-Value = 3.730088)
  .999904274940491 (99.99043%) Will Occur (Will Be <)
  9.57250595092773E-05 (9.572506E-03%) Will NOT Occur (Will Be >)
[Confidence = 50%]

The reliability at 7.0 lb. is 0.9999.