



Standard Guide for Statistical Analysis of Service Life Data¹

This standard is issued under the fixed designation G166; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide presents briefly some generally accepted methods of statistical analyses which are useful in the interpretation of service life data. It is intended to produce a common terminology as well as developing a common methodology and quantitative expressions relating to service life estimation.

1.2 This guide does not cover detailed derivations, or special cases, but rather covers a range of approaches which have found application in service life data analyses.

1.3 Only those statistical methods that have found wide acceptance in service life data analyses have been considered in this guide.

1.4 The Weibull life distribution model is emphasized in this guide and example calculations of situations commonly encountered in analysis of service life data are covered in detail.

1.5 The choice and use of a particular life distribution model should be based primarily on how well it fits the data and whether it leads to reasonable projections when extrapolating beyond the range of data. Further justification for selecting a model should be based on theoretical considerations.

2. Referenced Documents

2.1 ASTM Standards:²

G169 Guide for Application of Basic Statistical Methods to Weathering Tests

3. Terminology

3.1 Definitions:

3.1.1 *material property*—customarily, service life is considered to be the period of time during which a system meets critical specifications. Correct measurements are essential to producing meaningful and accurate service life estimates.

3.1.1.1 *Discussion*—There exists many ASTM recognized and standardized measurement procedures for determining material properties. As these practices have been developed within committees with appropriate expertise, no further elaboration will be provided.

3.1.2 *beginning of life*—this is usually determined to be the time of manufacture. Exceptions may include time of delivery to the end user or installation into field service.

3.1.3 *end of life*—Occasionally this is simple and obvious such as the breaking of a chain or burning out of a light bulb filament. In other instances, the end of life may not be so catastrophic and free from argument. Examples may include fading, yellowing, cracking, crazing, etc. Such cases need quantitative measurements and agreement between evaluator and user as to the precise definition of failure. It is also possible to model more than one failure mode for the same specimen. (for example, The time to produce a given amount of yellowing may be measured on the same specimen that is also tested for cracking.)

3.1.4 $F(t)$ —The probability that a random unit drawn from the population will fail by time (t). Also $F(t)$ = the decimal fraction of units in the population that will fail by time (t). The decimal fraction multiplied by 100 is numerically equal to the percent failure by time (t).

3.1.5 $R(t)$ —The probability that a random unit drawn from the population will survive at least until time (t). Also $R(t)$ = the fraction of units in the population that will survive at least until time (t)

$$R(t) = 1 - F(t) \quad (1)$$

3.1.6 *pdf*—the probability density function (pdf), denoted by $f(t)$, equals the probability of failure between any two points of time $t(1)$ and $t(2)$. Mathematically $f(t) = \frac{dF(t)}{dt}$. For the normal distribution, the pdf is the “bell shape” curve.

3.1.7 *cdf*—the cumulative distribution function (cdf), denoted by $F(t)$, represents the probability of failure (or the population fraction failing) by time = (t). See section 3.1.4.

3.1.8 *weibull distribution*—For the purposes of this guide, the Weibull distribution is represented by the equation:

$$F(t) = 1 - e^{-\left(\frac{t}{c}\right)^b} \quad (2)$$

¹ This guide is under the jurisdiction of ASTM Committee G03 on Weathering and Durability and is the direct responsibility of Subcommittee G03.08 on Service Life Prediction.

Current edition approved July 1, 2011. Published August 2011. Originally approved in 2000. Last previous edition approved in 2005 as G166 – 00(2005). DOI: 10.1520/G0166-00R11.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.