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# Standard Guide for Statistical Analysis of Accelerated Service Life Data[1]

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## 1. Scope

1.1 This guide briefly presents some generally accepted methods of statistical analyses that are useful in the interpretation of accelerated 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 covers the application of the Arrhenius equation to service life data. It serves as a general model for determining rates at usage conditions, such as temperature. It serves as a general guide for determining service life distribution at usage condition. It also covers applications where more than one variable act simultaneously to affect the service life. For the purposes of this guide, the acceleration model used for multiple stress variables is the Eyring Model. This model was derived from the fundamental laws of thermodynamics and has been shown to be useful for modeling some two variable accelerated service life data. It can be extended to more than two variables.

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 is emphasized in this guide and example calculations of situations commonly encountered in analysis of service life data are covered in detail. It is the intention of this guide that it be used in conjunction with Guide G 166.

1.5 The accuracy of the model becomes more critical as the number of variables increases and/or the extent of extrapolation from the accelerated stress levels to the usage level increases. The models and methodology used in this guide are shown for the purpose of data analysis techniques only. The fundamental requirements of proper variable selection and measurement must still be met for a meaningful model to result.

## 2. Referenced Documents

2.1 *ASTM Standards:*

G 166 Guide for Statistical Analysis of Service Life Data[2]

G 169 Guide for the Application of Basic Statistical Methods to Weathering Tests[2]

## 3. Terminology

3.1 *Terms Commonly Used in Service Life Estimation:*

3.1.1 *accelerated stress*—that experimental variable, such as temperature, which is applied to the test material at levels higher than encountered in normal use.

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

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

3.1.4 *complete data*—a complete data set is one where all of the specimens placed on test fail by the end of the allocated test time.

3.1.5 *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 or obvious. 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. For example, when some critical physical parameter (such as yellowing) reaches a pre-defined level. It is also possible to model more than one failure mode for the same specimen (that is, the time to reach a specified level of yellowing may be measured on the same specimen that is also tested for cracking).

3.1.6 *f(t)*—the probability density function (pdf), equals the probability of failure between any two points of time $t_{(1)}$ and $t_{(2)}$; $f(t) = dF(t) / dt$ . For the normal distribution, the pdf is the "bell shape" curve.

3.1.7 *F(t)*—the probability that a random unit drawn from the population will fail by time ($t$). Also $F(t)$ = the decimal

[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.

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[2] *Annual Book of ASTM Standards*, Vol 14.04.

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