Optimal Designs of Partially Accelerated Life Tests for Weibull Lifetime Distributions

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Abstract

When life testing of items at the specified use condition requires a long time to acquire the test data, accelerated life tests (ALTs) or partially accelerated life tests (PALTs) are often used to shorten the lives of test items. In an ALT test items are run only at higher-than-usual levels of stress, and in a PALT at both accelerated and use conditions. The test data obtained at the accelerated conditions are analyzed in terms of a model, and then extrapolated to the specified design stress to estimate the life distribution.

In a PALT a test item is first run at use condition and, if it does not fail for a specified time τ, then it is run at accelerated condition until failure. There are two models for analyzing the data from a PALT. One is the tampered random variable model in which $Y = T$ if $T \leq \tau$, and $Y = \tau + (T - \tau)/\beta$ if $T > \tau$, where T is the lifetime of an item at use condition and Y its total lifetime. The other is the tampered failure rate model in which, if $h_T(\cdot)$ and $h_Y(\cdot)$ are the failure rate functions of T and Y, respectively, then $h_Y(y) = h_T(y)$ if $y \leq \tau$ and $h_Y(y) = \beta h_T(y)$ if $y > \tau$. When T follows an exponential distribution, the two models are equivalent to each other.

The problem of optimally designing PALTs for the tampered random variable model has been considered for items with exponentially distributed lifetimes and and for items with lognormally distributed lifetimes. This paper considers designing two modes of PALTs for the tampered random variable model, the use-to-accelerated and accelerated-to-use modes. In the use-to-accelerated mode, each test item is first run at use condition and, if it does not fail for a specified time, then it is run at accelerated condition until a predetermined censoring time. In the accelerated-to-use mode, however, each one is first run at accelerated condition and, then it is run at use condition. For items having Weibull lifetime distributions, the shape and scale parameters of the lifetime distribution at use condition, and the 'acceleration factor', which is defined as the ratio of the scale parameter of the use-condition distribution to that of the accelerated-condition distribution, are estimated by the method of maximum likelihood. The condition change time for each mode is determined to minimize the asymptotic variance of the acceleration factor. For selected combinations of the design parameters the optimum plans are obtained, and the effects of using the incorrect pre-estimates of the design parameters on the variances are investigated. Minimizing the generalized asymptotic variance of MLEs of the model parameters is also considered as an optimality criterion.