Step-Stress Models

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Life testing is a major issue in reliability analysis, with applications in diverse fields, ranging from material sciences and quality control to biomedical sciences and ecology statistics. In all these fields acceleration of life testing procedures is important. Step-stress models form an essential part of accelerated life testing (ALT). Under a step-stress ALT (SSALT) model, the test units are exposed to stress levels that increase at intermediate time points of the experiment. Statistical inference is then developed for, e.g., the mean lifetime under each stress level, targeting to the extrapolation under normal operating conditions. This is achieved through an appropriate link function that connects the stress level to the associated mean lifetime. The assumptions made about the time points of stress level change, the termination point of the experiment, the underlying lifetime distributions, the type of censoring, if present, and the way of monitoring, lead to respective models. A SSALT model is introduced that considers a general scale family of distributions, which allows for flexible modeling. It is based on a failure rate approach and leads to explicit expressions for parameters' maximum likelihood estimators and their conditional density functions, for underlying lifetime distributions out of this family. The approach is presented for Type-I censored experiments, under continuous and interval monitoring of the tested items. Results under interval censoring are illustrated and compared to those derived under the corresponding continuous monitoring set-up in terms of characteristic examples. Finally, the issue of optimal designing a SSALT experiment is briefly discussed.