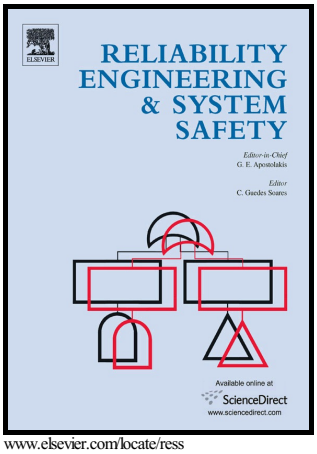

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Reliability Assessment Model Considering Heterogeneous Population in a Multiple Stresses Accelerated Test

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Abstract

Heterogeneous population, a mixture of weak and strong subpopulations, is inevitable in some multiple stresses accelerated tests. Modeling the reliability of heterogeneous population in an accelerated test differs dramatically from that for a homogeneous setting. In this paper, a multiple stress reliability assessment model with heterogeneous populations is proposed, which includes verifying the presence of heterogeneous population, determining the number of subpopulations and separating populations based on Bayes classifier. The acceleration model structure is then specified, and the effects of different accelerating stresses are analyzed. A practical example is used to demonstrate the accuracy and flexibility of the proposed method. It is shown that reliability assessment without considering heterogeneity is heavily biased, and the sequences of stress sensitivity to different subpopulations are different. We also explain the phenomenon that the pseudo lifetime of smart electricity meter under some milder stress is shorter than that in harsher condition due to opposite effects on degradation characteristics among different stresses, and verify the phenomenon by the enhancement test.

Keywords: heterogeneous populations, multiple stresses accelerated test, subpopulation separation, mixture distribution, reliability assessment

1. Introduction

Engineering and industrial applications are presently facing a big challenge regarding the development and the design with higher reliability and longer lifetime [1]. It is necessary to perform accelerated tests to assess the reliability of the product due to limitations of acceptable cost and time. Besides, the product may be sensitive to multiple accelerating stresses due to multiple failure mechanisms. For example, Lipscomb et al. evaluated the effect of humidity, temperature and electrical field on the electrical resistance of soft PZT ceramics [2]. Therefore, acceleration tests using two or more potential accelerating stresses might be suggested when the product works in complex environments and working conditions [3].

The existence of heterogeneous populations, a mixture of weak items and normal (or strong) items,