Degradation Model Using the Arrhenius Life-Stress Relationship Applied to Smoke Sensor Detectors

Manuel Ivan Rodriguez¹, Manuel Arnoldo Rodriguez², and Alejandro Alvarado¹

¹Universidad Autonoma de Ciudad Juarez
Av. Del Charro, 450 Norte,
A-P 1594-D, 32310,
Juarez, Chihuahua, Mexico.

²Instituto Tecnologico de Ciudad Juarez
Ave. Tecnologico, 32617
Cd. Juarez Chihuahua, Mexico

Corresponding author's Email: ivan.rodriguez@uacj.mx

Abstract: The accelerated degradation is related to models and data analysis to measure product performance. Degradation is induced over time with overwork of the product. Accelerated degradation tests have some advantages over accelerated life tests. The degradation of the performance data can be analyzed, for example, before the product presents a failure. That is, the extrapolation of the performance degradation to estimate the time when it reaches the level of failure. These extrapolations allow us to examine the effect of life on the various design choices or make inferences about the level of performance resulting in failure. In this paper, a degradation analysis for Arrhenius model is investigated using a Log-Normal life-stress relationship on the study of Accelerated Degradation Testing (ALT) of smoke detector sensors. The investigation consists of doing statistical inference using Bayesian methods and Markov chain Monte Carlo (MCMC) techniques to estimate the parameters involved in the model and predict reliability using degradation of the sensor. Data will be collected from the ADT using a single step stress and its analysis will provide the posterior estimation of parameters and prediction of reliability. Finally, estimation of reliability is presented using the estimated degradation pattern.

Keywords: Accelerated Degradation Testing, Bayesian Analysis, Markov chain Monte Carlo Methods, Arrhenius life-stress relationship.

1. Introduction

The accelerated degradation is related to models and data analysis in order to analyze performance of the degradation over time under design conditions and overwork. Nelson (1990) believes that accelerated degradation tests have some advantages over accelerated life tests. The degradation of the performance data can be analyzed, for example, before the product presents a failure. That is, the extrapolation of the performance degradation to estimate the time when it reaches the level of failure, the test speeds. These extrapolations allow us to examine the effect of life on the various design choices or make inferences about the level of performance resulting in failure. Sometimes degradation data will generate an estimated approximate life accelerated life tests with little flaws. Also, the data signal degradation on the performance shed, which will take improvement actions. However, these advantages can be exploited only if there is a suitable model for extrapolating performance degradation, with great clarity in the definition of failure. Ballado-Perez (1986) suggest, given the little information existing degradation models, treat the data as living to simplify the process of modeling and data analysis. Bayesian statistical inferences in combination with degradation models show a significance advantage related to reliability models. When exact failure data is not present, degradation models can then extrapolate information from a product, with less time consuming. For example, Lu and Meeker (1998) consider the case in which the life distribution of a population of devices is to be computed using degradation information obtained from a randomly selected set of devices. The authors present several random coefficient models and illustrate various methods for computing life distributions with these models. In this work, the combination of Bayesian estimation techniques and a degradation model is presented. The statistical inference obtained by the model is done under a Bayesian frame, with accurate results.

The structure of the work is shown with a motivation, a general explanation of the existing models of degradation and finally the application of the Arrehnius model to smoke sensor detectors, which are being tested, in order to determine the life of the product.