Chapter 7
Introduction to System Reliability Evaluation through Bayesian Approach

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ABSTRACT

Consider a parallel system with \( n \) independent components. Assume that lifetime of \( i \)-th component follows exponential distribution with unknown parameter \( \lambda_i, \ 1 \leq i \leq n \). We assume each \( \lambda_i, \ 1 \leq i \leq n \), is distinct and the priori information can be modeled by quasi-density function given by

\[
g(\lambda_i) = \frac{1}{\lambda_i^k}, \quad k \geq 1, \quad \lambda_i \leq u_i, \text{where } u_i \text{ is a predefined upper bound.}
\]

A Bayesian estimator for \( \lambda_i, \ 1 \leq i \leq n \), based on type-I censoring is used to get an estimate of system reliability. Optimal reliability test plan is designed, and an optimization problem is formulated satisfying usual probability requirements. Several numerical examples are considered to illustrate the Bayesian approach of obtaining optimal reliability test plan for a parallel system.

INTRODUCTION TO LIFE TESTING

The expected lifetime and failure rate of units or products are of great significant for any manufacturing industry. If a statistically significant sample is selected randomly from a lot of similar units and if the selected units are tested till all units fail, then enough data will get generated for confidently predicting the life expectancy of any unit contained in the lot. Life testing is carried out for estimating the mean time to failure and the expected life of units.

When units are produced in the manufacturing industry, the manufacturer would like to study the exact behavior of the unit under the normal working environment. For that he needs the data and evaluates
the life and reliability of the units produced. By studying this, he can improve the design, manufacturing, and other related goals. This will improve the confidence of the manufacturer and thus to provide higher guarantee periods and better service facilities. In addition, he can plan maintenance schedules, replacements of parts, warranty policies, etc.

**Life Testing Methods**

Some of the important life testing methods are briefly discussed below:

**Life Test with Censoring**

The procedure adopted for terminating a life test is called censoring. Censoring of data arises when exact lifetimes are known only for a portion of the individuals under study. A life test will get terminated when all units undergoing a test fail. However, it might take lot of time and immense effort for this to happen in practice, and sometimes it is even not possible to attain failures of all units under the specified test. Therefore censoring methods are developed for terminating life tests, and thereby to study the lifetime characteristics of units.

**Life Test with Replacement**

In tests with replacement, life testing is started with \( n \) units. Whenever a unit fails, it is replaced with a new unit and the testing is continued without any halt. The test is terminated either after the pre-decided time or after the occurrence of the \( r \)-th failure. Test with replacement will generate more data over a period of time as compared to the data generated by tests without replacement over the same time period.

**Simulated Life Tests**

In this procedure units are tested in simulated operating conditions; equipment such as test chambers are used for obtaining the simulated operating conditions. Some of the factors that significantly influence the operating conditions are temperature, humidity, pressure, etc. The actual tests are carried out with various combinations of these factors. Best results are achieved through the proper control of simulated test conditions.

**Accelerated Life Testing**

Most of the highly reliable products manufactured in industry do not fail very easily. To obtain failure data of such products further techniques are required. Accelerated life testing is one such technique to obtain faster failures. A variety of procedures is used to accelerate failures due to the difficulties encountered in performing life tests with time deadlines. Accelerated tests are designed and carried out for accelerating failures so that more number of units fail in a short test duration. Compressed-time test and advanced stress tests are two different types of accelerated life tests. In compressed-time testing, loads and environmental stresses on the product are maintained at the same level as in normal use but
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