Subject-Reliability Engineering

BE 8th Semester EE Department

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Chapter 1 – Introduction to Reliability Engineering

1.1 Definition of reliability

Reliability of a unit or a product is the probability that the unit performs its intended function adequately for a given period of time under the stated operating conditions or environment. By a unit we mean an element, a system or a part of a system. The reliability definition stresses four elements namely - probability, intended function, time and operating conditions.

If T is the time till the failure of the unit (a random variable) occurs, then the probability that it will not fall in a given environment before time t is

$$R(t) = P(T>t)$$

(1.1)

Thus, reliability is always a function of time. It also depends on environmental conditions which may or may not vary with time. Since it is a probability, the numerical value of reliability always lies between one and zero i.e.

$$R(0) = 1 , \quad R(\infty) = 0$$

(1.2)

and $R(t)$ is a non-increasing function between these limits.

1.2 Differentiate between Reliability and Quality

Quality of a device or a product is the degree of conformance to applicable specifications and workmanship standards. It is not concerned with the elements of time and environment.

1. Quality is associated with the manufacture whereas reliability is primarily associated with the design.
2. Reliability is the ability of a unit to maintain its quality under specified conditions for a specified time.
3. One can build a reliable complex system using less reliable elements but it is impossible to construct a “good” quality system from a “poor” quality elements.

1.3 Reasons for reliability engineering

Reliability engineering is a very important field in some of the industries like consumer and capital goods industries and in space like NASA agencies and defence agencies. No such industry in any country can progress effectively without the knowledge and implementation of reliability engineering. In simple words, reliability is the best quantitative measure of the integrity of designed part, component or a product. So, here the reliability engineering comes, to design, to manufacture the designed required parts to the users in respective to their demands at competitive costs.

1. In the near future, the only companies left in the business will be those who know and are able to control reliability of their products. So as to stay ahead of world competition, all industries need to be knowledgeable of reliability engineering programs.
2. The complexity of most of the products is increasing continuously. In order to maintain the present reliability levels, higher reliabilities have to be designed and built into components of new models of the same product.
3. The customers and the public are becoming more and more reliability conscious every day. Their demand for higher standards and more comfortable modes of living in a complex and automated world make it imperative to make them understand and know how to apply reliability engineering principles in daily lives.

4. More and more products are being advertised by their reliability ratings, such as their failure rate, mean time between failures (MTBF) and reliability. This practices forces competition-
   a) To know about reliability of their own products
   b) To find out how to generate and obtain data for their own products
   c) To learn how to remove their failure rates and to calculate MTBF.

1.4 Applications and Benefits

The important applications and benefits of reliability engineering may be summarized as follows:

1. Implement an integrated reliability engineering and product assurance program in-purchasing, engineering, research, development, manufacturing, quality control, testing, packaging, shipping, installation, start up, operation, field service or inspection, and performance feedback.
2. Obtain the required data and prepare reliability bathtub curves as in Fig. 1.1, where the failure rate for that part or equipment is plotted versus its age or accumulated hours of operation. These curves enables us to determine- optimum breaking in period, burn-in time, warranty period and cost, preventive replacement time of parts, spare part requirements and their production rate.
3. Study the consequences of failures as to the following:
   3.1 Loss of adjacent parts, whole equipment, production and revenue, human life and resources etc.
   3.2 Damage to the environment, ecology and competitive posture of the company.
4. Study the types of failures and determine the time-to-failure distribution of parts, components, products and systems in order to minimize failures and be prepared to cope up with them.

5. Study the effects of age, mission duration and operation stress levels on reliability to see if the established goals can be met.
6. Indicate areas in which design changes would be most beneficial from the reliability improvement and cost reduction point of view. Provide a basis for comparing two or more designs and choosing the best one from the reliability point of view.
7. Predict at the design stage the reliability being designed into parts and components via the stress/strength interference approach and thereby optimize the designed in reliability.
8. Establish a failure reporting system to determine who is responsible for occurring failures from engineering, manufacturing, purchasing, testing, packaging, shipping, storage to maintenance. Guide corrective action decisions to minimize failures and reduce repair and maintenance to eliminate overdesign as well as under design.
9. Optimize the reliability goal that should be deigned into products and systems for minimum total cost to own, operate and maintain for their lifetime. Also prepare the product reliability growth curves to see if the target is obtained by the time full production starts.
10. Some of the benefits are as follows:
    a) Reduce warranty costs and reduce inventory costs through correct prediction of spare parts requirements.
    b) It helps in increase of sales as result of increased customer satisfaction and promote them on the basis of reliability indexes and view-points through the sales and marketing departments.
    c) Increase profits or for the same profit we can get more reliable products and systems.
    d) It helps to establish important guidelines for evaluating suppliers and provide engineering and management inputs into all company operations and maintenance manuals.

1.5 Maintainability and Availability

Maintainability can be defined as the probability that a failed equipment is restored to operable condition in a specified time when a maintenance is performed under stated conditions. The more reliable and equipment and better its maintainability, the rarer it fails and the shorter its down-time.

Availability is another measure of performance of maintained equipment. It integrates both reliability and maintainability parameters and depends on the number of failures that occur and on how quickly any faults are rectified. The long- run or steady state availability is defined as the proportion of the time during which an equipment is available for use. It can be expressed as:

$$\text{Availability} = \frac{\text{Up}-\text{time}}{\text{Up}-\text{time}+\text{Down}-\text{time}}$$

where, up-time is the actual period for which the equipment is available to use and the down time includes active repair-time, administrative, and other delays related to repair. The denominator is equal to the total time for which the equipment is required to function.