Improve Your Knowledge

- A Summary About Reliability -

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Reliability, known more popularly by the letter **R** (Ing.: Reliability), is a complementary function of a cumulative distribution of probability, known by the acronym CDF (Cumulative Distribution Function) called Unreliability, represented by the letter **F** (from the term "failure").

F points to the time interval **t** the probability of an item[1] fails in such interval. **R**, as its complementary function, indicates the probability of the item does not fail in that time range.

The CDF more utilized in aviation follows the negative exponential function, given by:

$$R = e^{-\lambda t} \qquad (1)$$

that results of

$$\mathbf{R} = 1 - \mathbf{F} = 1 - (1 - e^{-\lambda t}), \qquad (2)$$

and t is a continuous random variable[2].

λ is a constant named failure rate.

(1) and (2) tells us that for t = 0, **R** = 1 and **F** = 0. For very large t, R tends to zero and F tends to 1.

The negative exponential has an interesting property, known as Property of forgetting or memory loss. With this we mean that when the item that follows this function is turned off and turned back on, everything happens as if it was starting to operate for the first time, i.e., the item does not "remember" having operated before.

In practice the CDF (1) applies, with good approximation, to the electrical and electronic items, because the failure rate of these items is approximately constant in the operational phase, after the project of these items are already mature. After a certain time, which varies from item to item, the failure rate is not more approximately constant and begins to grow quickly. It is the so called phase of wear.

It is important to note that the reliability depends on the item and the conditions of the event that is submitted. For this reason is that in the reliability requirements of a project item is not sufficient to quote a value of reliability. You must specify the conditions under which the event occurs.

This is very important to avoid sterile discussions, after the item enters the operational phase. A civil aircraft, follows more or less well-defined events, flying always in the same configuration, i.e. rolling on the runway, takeoff, climb, cruise, descent, landing and rolling. Military aircraft have different missions and it is common during the training at Air Bases, the pilot range settings. Thus, it is also common for military operators complain about the reliability of the aircraft, almost always below that of requirement. Typically, what takes place in military design is to establish a requirement of reliability for the most common mission.

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[1] In this MSC, we follow the nomenclature adopted by brazilian standard NBR 5462 – **Reliability and maintainability** that defines *Item as any part, component, device, subsystem functional unit, equipment or system that can be considered individually (Note: eventually, an item may be one person).* Therefore, an airplane or any of its equipment, for example, is an item.

[2] A random variable is infact a function. In the case of the CDF F and R, it is the function that associates to every event a time value. With regard to an aircraft, the events are in the operation of the aircraft.

What we do so, in military practice, is seeking to improve the reliability, in operational phase, adopting processes for its improvement, as for example the reliability improve method of Duane

For repairable electrical and electronic items, the inverse of λ is another constant named MTBF (Mean Time Between Failures)..

There is by someone a misunderstanding about the parameters MTBF and MTBUR (Mean Time Between Unscheduled Removal). The MTBUR includes all removals of the item, with failure detected or supposedly with failure, while the MTBF refers only to removals of items indeed in failure. It is common to the maintenance personnel, at the start of the operation, that is, without practice with the system (and this already we have seen enough), remove items, supposing that they were in failure. Of course, the MTBUR is less than the MTBF, i.e. the removal rate is greater than the failure rate and, almost always, this difference is large, especially at the beginning of operations. Obviously, the MTBUR is variable, tending, over time, to be equal to MTBF.

Figure 1 presents the famous curves of Reliability and Unreliability. It is easy to see that when we maximize **R**, we minimize **F**. It is what we try to do in a design. But this process has limits dictated by cost, space and weight. A centesimal improves in reliability can mean an extra of million dollars in cost.

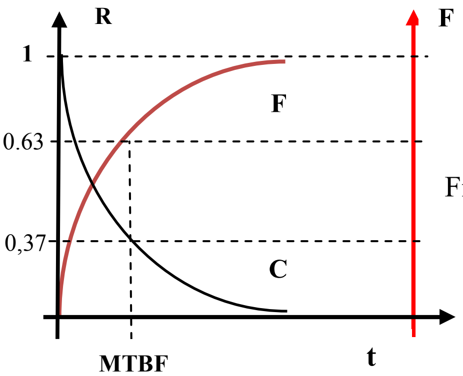

Fig. 1

Note that the MTBF is the instant that sets the time interval in which the probability of fail is 0.63 and not to fail is 0.37.

Of course, if we know λ for a particular item, we will have the expression (1) for the such item
λ é obtido por meio de testes cujos resultados são inseridos na expressão (3).

λ is obtained by means of tests whose results are inserted in the expression (3).

$$\lambda = \frac{\text{Number of Failures}}{\text{Total Operating Hours}} \qquad (3)$$

The problem is to determine the total time of operation. This is because we can do tests with a single item or with multiple items; with or without replacement of failed items. Here is a quick example with a single item.

Suppose that the operating cycle (one year) for a given electronic item is 187.5 hours, as shown in Figure 2. During this time, failures occur at times indicated in Figure 2.

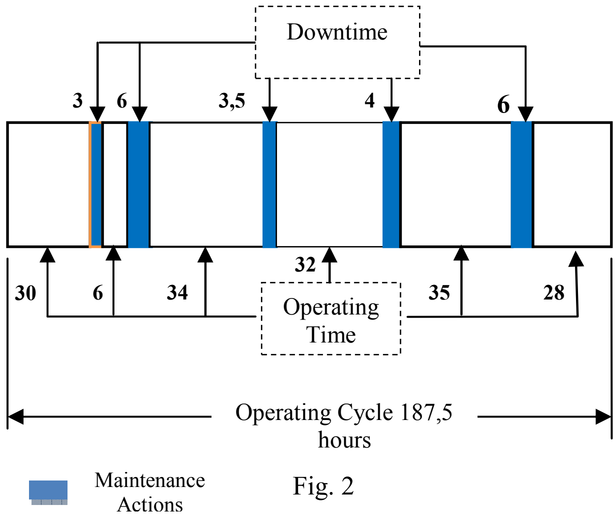

Fig. 2

- Operation Cycle: 187,5 hours.
- Operating Time: 165 hours.
- Downtime: 22,5 hours.

Therefore, it is a test of 165 hours with 5 failures. Thus, the expression (3) becomes:

$$\lambda = \frac{5}{165} = 0{,}03\ h^{-1} \qquad (4)$$

Then, the amount found in (4) applied to the expression (1) would give us:

$$\boldsymbol{\lambda = e^{-0{,}03t}}$$

See you.

References:

(1) *MODARRES, M. Reliability and Risk Analysis. Marcek Dekker, Inc. Cincinnati (Ohio), USA, 1993.*

(2) *BLANCHARD, Benjamin. S - FABRICKY, Wolter J. Systems Engineering and Analysis. 4. Ed. USA*

(3) *DoD: MIL-STD-785B,Reliability Program for Systems and Equipment, EUA Department of Defense, Washington, D.C. USA.*

(4) *O'CONNOR, P.D.T. Practical Reliability Engineering. John Wiley & Sons, Inc., New York, USA, 1991.*