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REVIEW OF RELIABILITY ENGINEERING

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Abstract: Modern systems and devices (electronic systems, electronic devices and components, electrical and mechanical systems) are made to operate under a number of extreme environmental and operating conditions. The resulting stresses can affect the working-life of the components and test their endurance to the limit. Failure of systems and devices can be categorized in a number of ways such that major failures, minor failures, parametric failures, catastrophic failures etc. Increasing the ability of the components and the devices to sustain such stresses, such that they operate for longer periods of time without failure is the goal of reliability engineering. Many systems can be repaired when they fail. This brings into the fore the concepts of maintainability, system availability, time to repair etc. Reliability engineering is engineering that emphasizes dependability in the lifecycle management of a product. Dependability, or reliability, describes the ability of a system or component to function under stated conditions for a specified period of time. Reliability engineering deals with the estimation and management of high levels of "lifetime" engineering uncertainty and risks of failure. Reliability engineering relates closely to safety engineering and to system safety, in that they use common methods for their analysis and may require input from each other. Reliability engineering focuses on costs of failure caused by system downtime, cost of spares, repair equipment, personnel and cost of warranty claims. Safety engineering normally emphasizes not cost, but preserving life and nature, and therefore deals only with particular dangerous system-failure modes. High reliability (safety factor) levels also result from good engineering, from attention to detail and almost never from only re-active failure management.

Keywords: Reliability Engineering, Safety Factor

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INTRODUCTION

Reliability engineering for complex systems requires a different, more elaborate systems approach than for non-complex systems. Reliability engineering may in that case involve:

1.1. System availability and mission readiness analysis and related reliability and maintenance requirement allocation

1.2. Functional System Failure analysis and derived requirements specification

1.3. Inherent (system) Design Reliability Analysis and derived requirements specification: for both Hardware- and Software design

1.4. System Diagnostics design

1.5. Predictive and Preventive maintenance (e.g. Reliability Centered Maintenance)

1.6. Human Factors / Human Interaction / Human Errors

1.7. Manufacturing and Assembly induced failures (non 0-hour Quality)

1.8. Maintenance induced failures

1.9. Transport induced failures

1.10. Storage induced failures

1.11. Software(systematic) failures

1.12. Failure / reliability testing

1. Materials and Methods

Many engineering techniques are used in reliability risk assessments, such as reliability hazard analysis, failure mode and effects analysis (FMEA), fault tree analysis (FTA), Reliability Centered Maintenance, material stress and wear calculations, fatigue and creep analysis, human error analysis, reliability testing, etc. Because of the large number of reliability techniques, their expense, and the varying degrees of reliability required for different situations, most projects develop a reliability program plan to specify the reliability tasks that will be performed for that specific system.

The reason for the priority emphasis is that it is by far the most effective way of working, in terms of minimizing costs and generating reliable products. The primary skills that are required, therefore, are the ability to understand and anticipate the possible causes of failures, and knowledge of how to prevent them. It is also necessary to have knowledge of the methods that can be used for analyzing designs and data.

Reliability and availability program plan

A reliability program plan is used to document exactly what "best practices" (tasks, methods, tools, analysis and tests) are required for a particular (sub)system, as well as clarify customer requirements for reliability assessment. For large scale, complex systems, the reliability program plan should be a separate document. A reliability program plan is essential for achieving high levels of reliability, testability, maintainability and the resulting system Availability and is developed early during system development and refined over the systems life-cycle. It specifies not only what the reliability engineer does, but also the tasks performed by other stakeholders

Reliability requirements

For any system, one of the first tasks of reliability engineering is to adequately specify the reliability and maintainability requirements derived from the overall availability needs and more importantly, from proper design failure analysis or preliminary prototype test results.

2. Reliability culture / Human Errors / Human Factors

Practically, most failures can in the end be traced back to a root causes of the type of human error of any kind. For example, human errors in:

2.1 Management decisions on for example budgeting, timing and required tasks

2.2 Systems Engineering: Use studies (load cases); Requirement analysis / setting; Systems Engineering: Configuration control

2.3 Assumptions

2.4 Calculations / simulations / FEM analysis

2.5 Design and Design drawings

2.6 Testing (incorrect load settings or failure measurement)

2.7 Statistical analysis and Manufacturing

2.8 Quality control and Maintenance

2.9 Maintenance manuals

2.10 Training

2.11 Classifying and Ordering of information

2.12 Feedback of field information (incorrect or vague) etc.

3. Reliability prediction and improvement

Reliability prediction is the combination of the creation of a proper reliability model together with justifying the input parameters like failure rates for a particular failure mode or event and the mean time to repair the system for a particular failure and finally to provide a system (or part) level estimate for the output reliability parameters (system availability or a particular functional failure frequency).

4. Functions of Reliability Engineering

Apply Engineering knowledge with specialized techniques to prevent failures.

This is the function that makes the Reliability Engineer that special member of the team. He has basic knowledge of Instrumentation and Control Engineering, Electrical Engineering and Mechanical Engineering (the three main disciplines). With specialist/specialized techniques, the following is meant:

4.1 The ability to develop and sustain a system to manage the Total Cost of Ownership of specific plant systems.

4.2 The ability to develop and sustain a system to measure the integrity of plant systems. This includes the so-called "ility" measurements and Reliability Modeling.

4.3 The ability to develop and sustain a system to measure physical conditions of plant equipment.

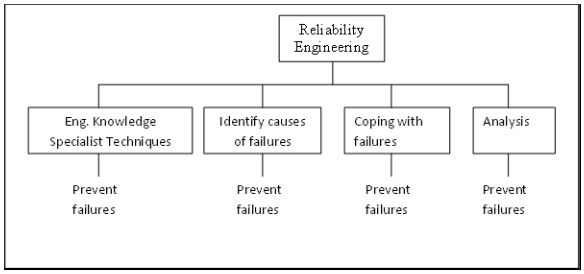
4.4 A basic knowledge of the following CBM (Condition Based Maintenance) techniques:

- Vibration analysis

– Tribology

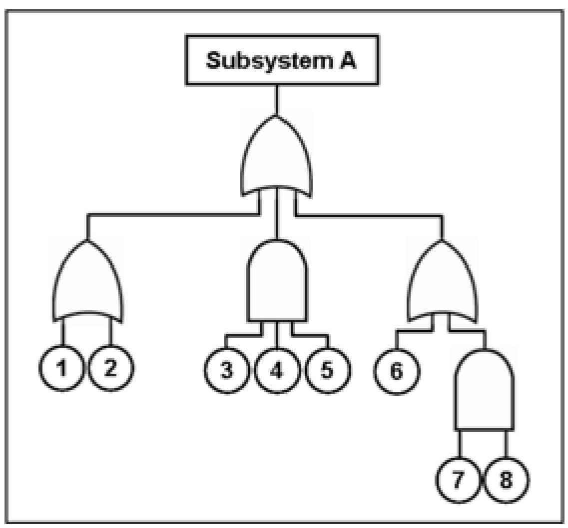
– Thermography

– Other (where necessary and required)



5. Design for reliability

A. Reliability design begins with the development of a (system) model. Reliability and availability models use block diagrams and Fault Tree Analysis to provide a graphical means of evaluating the relationships between different parts of the system. These models may incorporate predictions based on failure rates taken from historical data.



A Fault Tree Diagram

Many designing tools are given few of them are: redundancy, to prevent failures physics of failure, component derating.

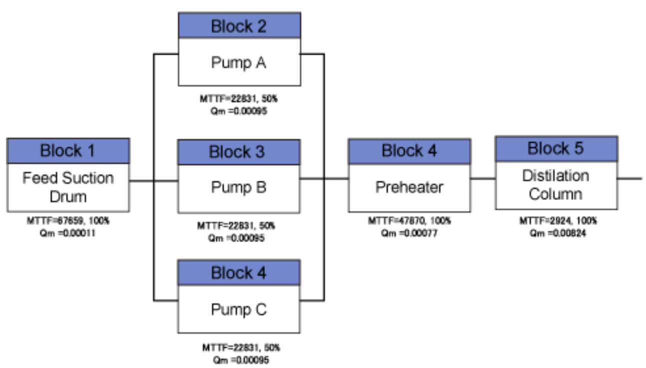
6. Reliability modeling

Reliability modeling is the process of predicting or understanding the reliability of a component or system prior to its implementation. Two types of analysis that are often used to model a complete system availability (including effects fromlogistics issues like spare part provisioning, transport and manpower) behavior are Fault Tree Analysis and reliability block diagrams. On component level the same type of analysis can be used together with others. The input for the models can come from many sources: Testing, Earlier operational experience field data or data handbooks from the same or mixed industries can be used. In all cases, the data must be used with great caution as predictions are only valid in case the same product in the same context is used.

For part level predictions, two separate fields of investigation are common:

1. The physics of failure approach uses an understanding of physical failure mechanisms involved, such as mechanical crack propagation or chemical corrosion degradation or failure;

2. The parts stress modeling approach is an empirical method for prediction based on counting the number and type of components of the system, and the stress they undergo during operation.



Reliability block diagram

7. Reliability theory

Main articles: Reliability theory, Failure rate and Survival analysis

Reliability is defined as the probability that a device will perform its intended function during a specified period of time under stated conditions. Mathematically, this may be expressed as,

$$R(t) = Pr\{T > t\} = \int_t^{\infty} f(x)\, dx,$$

where $f(x)$ is the failure probability density function and t is the length of the period of time (which is assumed to start from time zero).

There are a few key elements of this definition:

1. Reliability is predicated on "intended function:" Generally, this is taken to mean operation without failure. However, even if no individual part of the system fails, but the system as a whole does not do what was intended, then it is still charged against the system reliability. The system requirements specification is the criterion against which reliability is measured.

2. Reliability applies to a specified period of time. In practical terms, this means that a system has a specified chance that it will operate without failure before time t. Reliability engineering ensures that components and materials will meet the requirements during the specified time. Units other than time may sometimes be used.

3. Reliability is restricted to operation under stated (or explicitly defined) conditions. This constraint is necessary because it is impossible to design a system for unlimited conditions. A Mars Rover will have different specified conditions than a family car. The operating environment must be addressed during design and testing. That same rover may be required to operate in varying conditions requiring additional scrutiny.

8. Quantitative system reliability parameters

Quantitative Requirements are specified using reliability parameters. The most common reliability parameter is the mean time to failure (MTTF), which can also be specified as the failure rate (this is expressed as a frequency or conditional probability density function (PDF)) or the number of failures during a given period. These parameters may be useful for higher system levels and systems that are operated frequently, such as most vehicles, machinery, and electronic equipment. Reliability increases as the MTTF increases. The MTTF is usually specified in hours, but can also be used with other units of measurement, such as miles or cycles.

CONCLUSION

Reliability Engineering is a multidisciplinary field of engineering. It involves techniques and procedures to analyze the performance of the equipment, and the reasons for failures and downtime.

Reliability Engineering tends to become a more and more important part of the engineering team and failure prediction as well as failure identification

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