Brief Summary of Reliability Centered Maintenance:[1]
A Business Case for less Preventive Maintenance

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The essence of preventive maintenance (PM) is to achieve the highest possible level of facility availability at the lowest cost. We can use reliability-centered maintenance (RCM) to develop effective PM programs. Availability is the instantaneous probability that a system or component will be available to perform its intended mission or function when called upon to do so at any point in time.

The RCM is a logical, structured framework for determining the optimum mix of applicable and effective maintenance activities needed to sustain the operational reliability of systems and equipment while ensuring their safe and economical operation and support.

We can express operational availability (Ao) mathematically using parameters related to the reliability and maintainability characteristics of the item as well as the support system.

$$A_i = \frac{\text{Mean Time Between Failure (MTBF)}}{\text{Mean Time to Repair} + \text{MTBF}}$$

Inherent availability (Ai) relates only to the maintenance required to correct design failures and ignores the effects of support failures. We can represent it mathematically as:

$$A_o = \frac{\text{Mean Time Between Maintenance (MTBM)}}{\text{Mean Downtime} + \text{MTBM}}$$

The reliability-centered maintenance concept

Before the development of the reliability-centered maintenance methodology, the widely held belief was that everything had a "right" time for some form of PM, usually replacement or overhaul. However, in far too many instances, PM seemed to have no beneficial effects.

Indeed, in many cases, PM made things worse by providing more opportunities for maintenance-induced failures.

Airline companies in the United States observed that PM did not always reduce the probability of failure and that some items did not seem to benefit in any way from the PM.

[1] The summary is from reliability-centered maintenance for command, control, communications, computer, intelligence, surveillance, and reconnaissance (IC4IS) facilities

They formed a task force with the Federal Aviation Administration (FAA) to study the subject of preventive maintenance. The results of the study confirmed that PM was effective only for items having a specific pattern of failures. The study also concluded that PM should be required only when required to ensure safe operation. Otherwise, we should base PM decisions on economics.

Implementing RCM

Define the System

- Identify and document the boundaries of the analysis
- Identify and document equipment included in the analysis
- Identify and document the indenture level the analysis is intended to extend to

Define Ground Rules and Assumptions

- Identify and document ground rules and assumptions used to conduct the analysis

Construct Equipment Tree

- Construct equipment block diagrams to indicate equipment configuration, down to the lowest indenture level intended to be covered by the analysis

Conduct FMECA

- Analyze failure modes, effects, and criticality

Assign Maintenance Focus Levels

- Classify maintenance focus levels based on criticality rankings

Apply RCM Decision Logic

- Apply RCM logic trees for items, especially those identified as being critical

Identify Maintenance Tasks

- Identify maintenance tasks to be performed on the given item

Package Maintenance Program

- Develop a maintenance tasking schedule for the analyzed equipment

Data analysis

Data is the lifeblood of RCM. Data provides the basis for determining the failure characteristics of items. It is also used to evaluate the effectiveness of specific PM tasks used on past systems. Economic data provides the basis for determining whether PM is more economical than running an item to failure (only done when safety is not affected).

Sources for RCM analysis

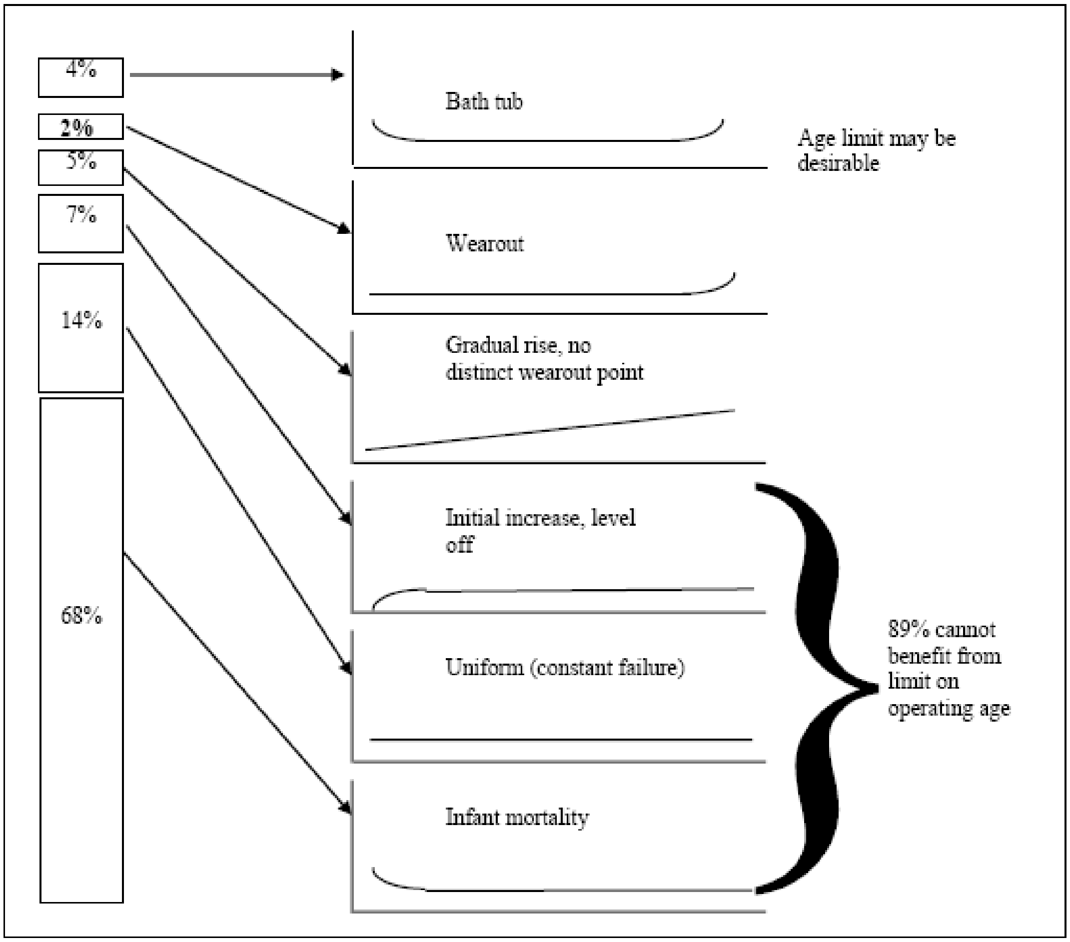
Data Source	Comment
Lubrication requirements	Determined by designer. For off-the-shelf items being integrated into the product, lubrication requirements and instructions may be available.
Repair manuals	For off-the-shelf items being integrated into the product.
Engineering drawings	For new and off-the-shelf items being integrated into the product.
Repair parts lists	
Quality deficiency reports	For off-the-shelf items being integrated into the product.
Other technical documentation	For new and off-the-shelf items being integrated into the product.
PREP Database	For new and off-the-shelf items being integrated into the product.
Recorded observations	From test of new items and field use of off-the-shelf items being integrated into the product.
Hardware block diagrams	For new and off-the-shelf items being integrated into the product.
Bill of Materials	For new and off-the-shelf items being integrated into the product.
Functional block diagrams	For new and off-the-shelf items being integrated into the product.
Existing maintenance plans	For off-the-shelf items being integrated into the product. Also may be useful if the new product is a small evolutionary improvement of a previous product.
Maintenance technical orders/manuals	For off-the-shelf items being integrated into the product.
Discussions with maintenance personnel and field operators	For off-the-shelf items being integrated into the product. Also may be useful if the new product is a small evolutionary improvement of a previous product.
Results of FMEA, FTA, and other reliability analyses	For new and off-the-shelf items being integrated into the product. Results may not be readily available for the latter.
Results of Maintenance task analysis	For new and off-the-shelf items being integrated into the product. Results may not be readily available for the latter.

RCM as a component of the design

It is essential to incorporate RCM into the conceptual stages of the design and development of a new system to develop a maintenance program. Applying the four Ws to the design process will reduce life cycle cost, increase assets' reliability and availability. The four Ws are:

1. What can fail?
2. Why does it fail?
3. When will it fail?
4. And what are the consequences of failure?

Only a small percentage of items can benefit from PM, see figure below. Knowing the underlying distribution of times to failure is essential in determining if PM is applicable.



Applicability of age limit depending on failure pattern

Studies on civil aircraft showed that 4% of the items conform to the bathtub pattern, 2% to the wear out pattern, 5% to the gradual rise without any distinct wear out pattern, 7% to an initial increase and level off pattern, 14% to uniform constant failure pattern and no fewer than 68% to infant mortality pattern.

However, the distribution of these patterns in aircraft is not necessarily the same as in industry. Still, as equipment grows more complex, more and more items conform to the uniform constant failure and infant mortality patterns.

Moubray[2] notes that these findings contradict the belief that there is always a connection between reliability and operating age. This knowledge led to the idea that the more often an item is overhauled, the less likely it is to fail. In practice, this is hardly ever true. Unless there is a dominant age-related failure mode, fixed interval overhauls or replacements do little or nothing to improve the reliability of complex items.

2 Moubray, J. (2001). Maintenance Management – A new paradigm. CIM Bulletin, Issue 1055, 78-86.

Conclusion

The bathtub curve approach to maintenance is still prevalent in many maintenance operations. This mystical faith that many organization continues to place in the relationship between age and failure is unfortunate and wasteful. According to Moubray, in practice, this faith has two serious drawbacks. It leads to the belief that if we don't have any hard evidence at all about the existence of an age-related failure mode, it is wise to overhaul the item anyway from time to time "just-in-case" such a failure mode does exist. This action ignores the fact that overhauls are extraordinarily invasive undertakings that massively upset stable systems. As such, they are highly likely to induce infant mortality and so cause the very failures which they seek to prevent.