Reliability Centered Maintenance (RCM): Achieving all your Hopes and Promises

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Introduction

Many engineers and managers are familiar with the history of Reliability Centered Maintenance (RCM) and have been encouraged to implement a reliability-centered maintenance program. RCM was originally developed for the aircraft industry and later migrated to the nuclear power industry. The aim of the process was to avoid failures and the catastrophes that often accompany them. Therefore, the classical RCM process had to be performed perfectly and the results had to be effective to achieve the intended objectives.

In both cases, part of the certification for an airplane or nuclear power plant depended on faithfully performing all the predictive and preventive maintenance recommended by the RCM analysis. Moreover, the brief recommendations made during the analysis were turned into a detailed maintenance program by the same engineers who designed the asset.

In addition to the rigorous application of recommendations during certification, the Classical RCM analysis process used in critical applications was followed by a process that tracked the maintenance programs of aircraft and nuclear plants through their entire lifecycles. This tracking ensured that their maintenance programs remained current and effective in dealing with well-known and newly identified forms of deterioration and failure.

RCM is a form of Failure Modes and Effects Analysis (FMEA). Classical RCM attempts to identify all possible failure modes while streamlined RCM focuses on failures that have happened and are likely to happen again. Streamlined RCM begins with an analysis that identifies the failures that have produced a loss of function for a system or a complete asset. The next step is to identify the Failure Mode that caused them, which is best described by identifying the specific component or sub-component that failed causing the equipment failure and its deteriorated condition. The objective is to identify a method of eliminating the failures, which can take several forms, such as Predictive Maintenance or Preventive Maintenance or both. In some cases, it may be necessary to replace the failed component with one that is more robust or even to replace the entire equipment item or add redundancy.

In a typical plant, there are hundreds or even thousands of items that can be analyzed and performance improved. Therefore, this is a process that requires an organized and structured approach rather than addressing issues one at a time.

After the analysis is complete, the recommendations produced by RCM must be implemented correctly and at an appropriate interval to produce the desired results and prevent failures. To do this, it is essential to identify the Failure Mechanism or the natural process (like corrosion, erosion, fatigue, or overload) that produces the deterioration leading to failure. By identifying the rate at which deterioration is progressing and the conditions at which the component will fail, it is possible to estimate the time of failure. Then by intervening before the time of failure, replacing the component or repairing deterioration, it is possible to avoid failure.

While both classical and streamlined RCM attempt to identify the entire population of failures that may occur or are likely to occur, it is important to follow the two steps described above by implementing a Living Program that continues to track reliability and availability of the asset and the effectiveness and cost of the maintenance program and prompts action to be taken when a new opportunity is identified.

In recent years, RCM has been applied in situations where all failures were no longer catastrophic, and recommendations no longer needed to be perfect. This led to the introduction of streamlined RCM processes, which made the process practical for far more users. However, the end results were not always as effective or absolute as they had been with aircraft or nuclear power plants. In this course, I will answer why that is and provide ways to deliver on your original expectations.

In the sections below, I will describe the hopes and promises that were used to initially sell many streamlined RCM programs. Then, I will describe how those programs were implemented and why they might have failed. Finally, I will describe the methods that can be used to transform a failed effort into an effective and valuable program that delivers on all the hopes and promises that were initially made.

Managing Initial Expectations: The Promises and Realities of Streamlined RCM

Like Classical RCM, Streamlined RCM aims to improve the reliability of an asset by preventing equipment failures that are critical to its intended function. The streamlined approach focuses only on equipment items that cause most of the failures and the Dominant Failure Mode, i.e., the most frequent cause of outages. Despite addressing only a small portion of the equipment and possibly only one failure mode for those items, the principal hope of Streamlined RCM is to significantly improve the asset's reliability.

Another hope of Streamlined RCM is to shift the balance from reactive maintenance (80% or more) to proactive maintenance (80% or more). Proactive work is non-invasive, determines if further work is needed, and is repeated in the same manner, requiring less planning. This results in a better and more accurate daily schedule, less wasted time between jobs, and significantly more useful life for assets. Reactive work, on the other hand, is completed after deterioration or failure and is quite invasive and expensive. The overall cost of reactive maintenance is also higher due to the direct cost and the multiple costs incurred due to outages or reduction in throughput.

In summary, the hopes and promises of Streamlined RCM are much improved reliability, significantly reduced costs, and improved income from both sources.

Common Weaknesses in Streamlined RCM Implementations

Pareto's rule of achieving 80% of the results with 20% of the effort is a useful principle, but it may not apply to all situations. When it comes to assets, meeting the expected production level may require addressing more than just the 20% of the asset causing 80% of the downtime. In transitioning from Classical RCM to Streamlined RCM, it is crucial to have a clear idea of the expected outcome. For instance, if the objective is to achieve the nameplate capacity, the number of equipment items and the reliability needed to produce that level of performance must be addressed.

It is essential to understand that availability is the difference between 1 and total unavailability, which comprises total unavailability caused by planned outages and reliability-related downtime. Total unavailability caused by planned outages is determined by run limiters and duration setters, while total unavailability caused by reliability-related downtime is based on the number of failures that might cause unplanned outages and the time needed to recover from those instances. Working on only 20% of the equipment may not guarantee that the plant fulfills its requirements.

In RCM, identifying the failure mechanisms causing the deterioration that leads to the failure is more likely to prevent outages than focusing on failure modes. Common failure mechanisms include corrosion, erosion, fatigue, and overload. Monitoring the progress of these mechanisms and intervening before failure and outage of a plant is a more effective approach.

When Streamlined RCM analysis is conducted, the tasks needed to prevent failures are typically described briefly and estimated for effectiveness based solely on a guess. In contrast, the predictive and preventive tasks recommended for Jumbo-Jets by the same engineers who designed the plane were far more detailed, with identified parts, materials, tools, and special equipment, and training. Furthermore, the frequency and duration of most tasks were based on the assumption that the plane would be on the ground and close to a hangar numerous times per day, allowing for health checks to be performed frequently.

Continuous assessment following the initial analysis is crucial for ensuring the safety and operability of assets like aircraft or nuclear power plants. However, no such absolute standard exists for operating plants, and corrective steps are only taken in instances where catastrophic events occur. Even then, changes are not mandatory for operators of similar kinds of plants or for designers to modify all future facilities or maintenance programs.

Key Components for Building a Successful Streamlined RCM Program

This section will describe the steps required for a successful RCM program, which consist of three major categories of work: Analysis, Implementation of Recommendations, and the Living Program. While these categories are accomplished by different people and done differently, an RCM program will not be successful without all three. Therefore, it is necessary to have a single leader who understands the effort invested and knows that effort will be wasted without continuing support for the program.

1. Analysis

The first category of work is the activity that many people identify most closely with RCM. While these steps need to be done correctly, it is important for the next two steps to be performed equally well. There are several steps associated with the analysis that should be kept in mind:

- Clearly identify and understand all the effort and desired outcomes from your RCM program.

- Select a program leader who understands RCM, proactive and reactive tasks, how to create a plan for a program and a schedule, how to obtain and lead resources, and how to get results.
- Select and procure software that can perform the functions you need.
- Learn how to perform all the activities you envision using the software.
- Design your workshop format, including structure, location, participants, duration, and schedule.
- Conduct a pilot exercise using an observer who is not a participant. Modify your workshop to address weaknesses.
- Create a complete written procedure for your workshop that future participants can use when training.
- If possible, create a training video that participants can use when convenient and can be repeated later if needed.

2. Implementation of Proactive Maintenance

This is the piece that is most frequently missing from RCM programs. The following steps are useful:

- Identify the individual who will lead implementation of all recommendations starting with interpreting the recommendations and ending with a complete program of predictive and preventive maintenance.
- The implementation leader should observe the initial analysis being performed and be invited to make comments on the format and clarity of RCM recommendations.
- The first implementation should be viewed as a pilot and should be evaluated and modified as needed.
- Using the same format as the assessment process, the procedure needed to implement the predictive and preventive tasks should be written into a procedure that can be used for training others.
- Invite individuals who will perform the new tasks to participate in their development.
- If new forms of predictive technology are being introduced to the plant, technical experts should be invited to participate in their selection and application.
- All individuals who are being asked to perform a task or deal with new technology will need training.
- As part of implementing new predictive and preventive tasks, look for tasks where the objectives can be achieved in simpler ways.

3. Living Program

The effectiveness of the Living Program is another element of RCM that is frequently missing. It is important to identify and quantify the outcomes you expect from the RCM program and create measures that will tell you if you are seeing those outcomes. The following should be elements of your Living Program:

- View the successful implementation of RCM as an instance of change that will cause significant changes to your plant's performance, increasing profit, CIBT, and net throughput or production.
- Add Key Performance Indicators (KPIs) and increase focus on KPIs that describe outcomes affected by RCM products.
- Measure RCM related outcomes monthly and include crafts persons, foremen, maintenance leaders, and engineers in reviewing those outcomes.
- Explain the relationship between increased proactivity, improved productivity, reliability, and availability and the work they do and the way they do it.
- Make changes when things are not working as you hoped.
- Celebrate improvements with small rewards for employees.

Methods for Achieving Desired Results through Corrective Action

This section will discuss the most common kinds of problems encountered with streamlined RCM programs that fail to achieve anticipated results. By far, the most common problem is inadequate implementation of the recommendations made during the analysis. The Predictive Maintenance and Preventive Maintenance contained in the RCM implementations are not implemented by magic. In most cases, the new recommendations are not the same as tasks that currently exist in a plant. As a result, implementation may require:

- New tasks
- New training
- New tools
- New parts
- New materials
- New CMMS plans
- New CMMS schedules

- More robust equipment
- Redundant equipment

Considering that a single streamlined RCM analysis produces tens to hundreds of new tasks, it is useful to assign a capable Project Manager to implement this new proactive program. Expecting the same mechanics who are currently engaged in maintaining the facility is a mistake. They will need help.

The second most common problem is associated with selecting either the 20 problems or 20% of all problems that produce the largest part of the downtime. Somehow, the items selected are the ones that managers have developed a vendetta against. Individuals can recall the problems that have caused them the most pain in the past. While regrettable, it may not be one of the failures that has cost the most downtime or the most money. It is important to select the first items to address based on how they will improve the Return on Investment for the plant.

The third problem results from looking for Failure Modes rather than Failure Mechanisms. For instance, if the Failure Mechanism, corrosion, is the source of the deterioration leading to the failure, it is important to identify when the deterioration starts, how fast it is progressing, and when a failure should be expected. That way, failure and associated downtime can be avoided. The Failure Mode will be a specific component that has corroded to failure. Finding that Failure Mode after the failure happens will still result in undesired downtime.

It is important to view every failure as an opportunity to learn and avoid future failures. For instance, viewing the other three Failure Mechanisms:

- If a component fails from fatigue, calculate the number of cycles to failure and the associated time. Next time, intervene at an appropriate time interval before failure and replace the component with a new one. As an alternative, replace the failed component with one that is not subject to fatigue.
- If a component fails from thinning resulting from erosion, once the source of erosion is identified (erosive particles and velocity):
- Install a filter to remove the particles.
- Install pressure gauges on both sides of filters so you can see pressure loss when it is increasing.
- Make the deteriorated component of harder or more durable material.

- Replace the deteriorated part at a reasonable interval before the time it is expected to fail.
- If the component fails from overload:
- Manage the load.
- Increase the load capacity of the failed component.

The fourth problem results from either a non-existent or ineffective Living Program. An effective Living Program is a mandatory part of any streamlined RCM program. The following are several reasons:

- If the streamlined RCM program being used focuses on finding and addressing the Dominant Failure Mode, there is no certainty that another Failure Mode is not operating close behind the DFM. If so, past repairs made to address the DFM may simply have eclipsed the secondary (or even a tertiary) failure mode. Correcting the DFM without an effective Living Program will simply make the MTBF a little longer and not produce the expected results.
- If the RCM recommendations produced new and unfamiliar maintenance activities, those activities may not produce the anticipated results. If not, they need to be updated to produce the desired results.
- One of the ultimate promises of RCM is the ability to flip maintenance from being 20% proactive and 80% reactive to 80% proactive and 20% reactive. That is a realistic promise, and it will result in an entirely different way of doing business. Proactive work is far less costly. A significant portion of proactive work may be integrated in structured operator rounds. Proactive work can be accurately scheduled far in advance and accomplished as scheduled. Conversion to proactivity eliminates the need for "firefighting," both illustrative and real.
- Finally, it is important to perform the form of Lifecycle Cost Analysis included in many of the forms of RCM software on the market and then use those results to justify taking the recommended steps. It is important to avoid understating the complexity or cost of the Predictive and Preventive Maintenance recommended during the analysis because that will understate the costs and therefore overstate the benefits.

CONCLUSIONS

There is a saying that it is important to "start with the end in mind." If we applied this principle to either classical RCM or streamlined RCM, we would recognize that both processes aim to improve the reliability of an asset by identifying and intervening before failure and downtime occur. While this objective can be achieved without RCM, the steps needed to produce the improvement may not be apparent to everyone. Moreover, even with knowledge of these steps, achieving this objective for hundreds or thousands of equipment items in a plant would require more time and expertise than most individuals or organizations possess.

Therefore, RCM provides a tool for making this objective achievable. In some cases, those who perform and implement RCM understand all the necessary steps to make it work and enjoy a comfortable work life. Unfortunately, this is not always the case. Some people have never heard of RCM, while others have tried to apply it but given up after failing to achieve the desired results.

To the third group of people, I would like to remind them that they are on the right track. They have already invested a significant amount of effort in achieving success. By rethinking the steps needed to produce success and redoubling their efforts, they can achieve the desired results.

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