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# THE RCM PERSPECTIVE ON MAINTENANCE

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**ABSTRACT**
This article provides some background on the RCM perspective on maintenance along with a brief introduction to the major principles. The RCM procedure is described for the service brakes of motorcars.
**KEYWORDS**
RCM, failures, maintenance programm

## INTRODUCTIONS

Maintenance has gained momentum and is now at the heart of many companies' activities due to its vital role in the areas of safety, liability, productivity, quality, system reliability, regulatory compliance, profitability and environment preservation. With this new paradigm, new awareness, realities, challenges and opportunities are being presented to maintenance and operations specialists in various industries. In the center-stage spotlight of maintenance, there is a strategy called Reliability Centered Maintenance, or RCM.

## 1. WHAT IS RCM?

Reliability Centered Maintenance (RCM) was first documented in a report written for United Airlines by F.S. Nowlan and H.F. Heap to transform aircraft maintenance as the Boeing 747 was being introduced. The report was published by the U.S. Department of Defense in 1978 and was then adapted to industrial maintenance. RCM is a process used to determine what must be done to ensure that any physical asset continues to do what its users need it for in a certain operating context. RCM analysis provides a structured framework for analyzing the functions and potential failures of physical assets (such as an airplane, a manufacturing/production line, an oil refinery, a telecommunication system, etc.) in order to develop a scheduled maintenance plan that will provide an acceptable level of operability, with an acceptable level of risk, in an efficient and cost-effective manner.

## 2. A FRESH PERSPECTIVE

Traditional thinking holds that the goal of maintenance is to *preserve equipment*. On the surface, we might not see a problem in that mindset, but in fact it has been proven to be flawed at its core. The blind quest to preserve equipment has produced many problems, such as being overly conservative in our maintenance actions (which could cause damage due to intrusive actions and increase the chances of human error), thinking that all failures (or parts) are equal or performing maintenance activities simply because there is an opportunity to do so.

Recent decades have brought in many initiatives and management strategies aimed at reducing cost, optimizing the use of resources and becoming sensible about the effect on the bottom line of any action we take. The *preserve equipment* mentality consumed resources quickly, put maintenance plans behind schedule and overwhelmed even the most experienced maintenance personnel. What is worse, it sometimes caused maintenance actions to become totally reactive. Budget cuts made the scene even uglier and many people simply lost control of their maintenance management.

The development of the Reliability Centered Maintenance approach has provided a fresh perspective in which the purpose of maintenance is not to preserve equipment for the sake of the equipment but rather to *preserve system function*. At first, this might be a difficult concept to accept, because it is contrary to our ingrained mindset that the sole purpose of preventive maintenance is preserving equipment operation. But in fact, in order to develop an effective maintenance strategy, we need to know what the expected output is and the functions that the equipment supports; that is, the real purpose of having the equipment in the first place.

## 3. BASIC STEPS OF APPLYING RELIABILITY CENTERED MAINTENANCE (RCM)

Although there is a great deal of variation in the application of RCM, most procedures include some or all of the seven steps shown below:

1- Prepare for the Analysis
2- Select the Equipment to Be Analyzed
3- Identify Functions
4- Identify Functional Failures
5- Identify and Evaluate (Categorize) the Effects of Failure
6- Identify the Causes of Failure
7- Select Maintenance Tasks

### 3.1. Prepare for the Analysis

**Gathering the team**

As with almost any project, some preliminary work and meticulous planning will be required before beginning an RCM analysis. One of the first steps in the analysis procedure is to assemble the proper team of knowledgeable individuals to perform the analysis. The most efficient and effective analysis teams are cross-functional, with different areas of expertise represented. The size of the team should be adequate (typically 4 or 5 people) but not too large-- "too many cooks spoil the soup." At least one person from maintenance should be part of the group. RCM is a multifaceted process that requires a thorough understanding of the assets being considered for RCM, the purpose of the assets and the impact of their malfunction. The goal is to gather sufficient knowledge/expertise for an effective analysis without wasting valuable resources and/or making meetings unmanageable.

A facilitator is recommended to ensure that the RCM analysis is carried out at the right level, that no important items are overlooked and that the results of the analysis are properly recorded. A facilitator also manages issues among the team members and helps in reaching consensus in an orderly fashion as well as retaining the commitment of the members and keeping them engaged.

**Establishing ground rules and discussing a plan**

Identifying and documenting the ground rules and assumptions that will be followed during the analysis can facilitate the analysis process by making sure that all members of the analysis team understand and accept the conditions of the analysis. Issues to be discussed when preparing for an RCM project may include setting the goals of the RCM project, addressing project management issues and resources required to carry out the project (such as schedule and budget, meeting procedures, reports, how to make recommendations, manpower, tools, consultants, software and meeting rooms) and foreseeing, as much as possible but without getting swamped, the obstacles that lie ahead of the project (company resistance and lack of buy-in, lack of data, bureaucracy, lack of leadership and commitment, etc.). Develop a plan with a viable vision for the future and run with it!

### 3.2 Select the Equipment to Be Analyzed

**Scope of analysis**

The RCM team has to reach a decision about the level of the asset at which the analysis should be conducted (e.g. part, component, subsystem, system or plant) and whether the entire plant/facility should be considered for RCM. Consider starting your RCM analysis at the system level, as it is a good, safe and manageable place to start then expand your analysis upward and downward. Typically, systems are a logical starting point for the analysis since they constitute the building blocks for plants/facilities. Because RCM is focused on preserving the function of equipment, performing the analysis at the system level, where functions are usually derived, makes good sense. Focusing on levels below the system level (e.g. components) limits visibility for the analysts and makes them detached from the broad significance of failure, especially when components support multiple functions. Also, comparing failure modes and prioritizing resources become more useful and feasible if the analysis starts at the system level rather than the component level, which might have only a few failure modes. On the other hand, analyzing entire plants in one bite could be overwhelming and might run the whole RCM program to a stall.

The suggestion of starting the analysis at the system level may not work for everyone, of course. Depending on system complexity, constraints and other factors that might be unique to your application and asset, other levels might be more appropriate as a starting point.

**System boundaries**

Selecting the equipment to be analyzed also involves defining system boundaries. Defining system boundaries helps in specifying precisely what is included and not included in the system so that an accurate and complete list of components can be identified and no overlap with component lists of other systems (especially adjacent systems or systems affected by components in other systems) can happen. More importantly, the boundaries help in determining the inputs, outputs and functions of the system.

**System description**

Once the equipment to be analyzed has been selected, it is time to describe it. Identifying and documenting the essential details of the system is necessary in order to perform the remaining steps in a thorough and technically sound manner. Describing the system helps the analysts gather a comprehensive understanding of the system. A well-documented system description will help record an accurate baseline definition of the system as it was at the time of the analysis (this is also useful because systems can be upgraded or modified with time). A system description can also assure that the analysts have identified critical design and operational parameters that play a key role in delineating the degradation or loss of required system functions.

System descriptions may include: Functional block diagrams, component breakdowns and hierarchies, input/output interfaces, electrical schematics, environmental conditions, design specifications, equipment histories (especially information pertaining to failures), the definitions of "failure" that will be followed during the analysis, operation manuals, previous maintenance plans, specifications of the operational environment for the equipment and any assumptions that may affect the analysis.

**Select the equipment**

Once the level of analysis has been established, the candidate systems that would benefit the most from a new maintenance program should be identified and prioritized. Various criteria, such as safety, legal and economic considerations, can be used in determining the benefit obtained from maintenance.

Various equipment selection methods are available. One approach would be to evaluate maintenance records (number of failures, outages hours, loss of productions cost, safety problems, etc.) for a given period (e.g. 1 year or 2 years). The 80/20 rule states that most (80%) of the problems in a plant or system can be attributed to a few (20%) vital players, so it is useful to prioritize the issues in your plant before deciding on a plan of attack.

### 3.3. Identify Functions

Since the ultimate goal of an RCM project is "to preserve system function," it is therefore incumbent upon the team of RCM analysts to define a complete list of system functions. The system functions would then drive the required functions of the equipment supporting the system functions. (Tip: The output of a system typically captures the function of the system; therefore, every output interface could be translated into a function statement.) It is desirable to start function statements with a verb (to pump water, to provide alarm, etc). It is also recommended to specify the acceptable level of performance desired by the user of the asset as opposed to the actual performance that may reflect an operational or maintenance issue.

Keep in mind that function statements are not about what types of equipment are within the system and therefore the use of equipment names to describe system functions should be avoided. Making a mistake about this leads to the common fallacy that the goal of maintenance is protecting equipment. The function definition should be as quantitative as possible. It becomes difficult to decide on maintenance strategies or to hold the people involved in maintenance accountable for not meeting goals of maintenance when the goals are not defined precisely. Qualitative definitions are, however, needed in some circumstances. Some function definitions are absolute (e.g. "To contain liquid," where no leakage is acceptable) while others are variable (e.g. "To remove unwanted particles of 100 microns from air stream."). The RCM team should be careful about using absolute definitions when a variable definition is more appropriate.

### 3.4. Identify Functional Failures

A functional failure is defined as the inability of an asset to fulfill one or more intended function(s) to a standard of performance that is acceptable to the user of the asset. Functional failures may include:

- Complete failure to perform a function
- Poor performance of a function
- Over-performance of a function
- Performing an unintended function, etc.

### 3.5. Identify and Evaluate (Categorize) the Effects of Failure

Failure effects analysis is concerned with what happens when a failure mode occurs. Revealing the effects of failure involves asking questions such as:

- What will be observed when the failure occurs?
- What is the impact on operations/production?
- What is the impact on the environment/safety?
- What physical change will occur to the equipment or adjacent equipment?
- What alarms or indications will be observed?

Effects can be defined at three different levels:

- Local Effect - What is observed at the individual component?
- Next Level Effect – What is observed at the sub-system level?

- End Effect – What will be observed at the system level?

For example, if you run out of gas in your car, then:

- Local Effect: Fuel injectors fail to supply gas to the engine.
- Next Level Effect: Engine stops working.
- End Effect: Car stops, you are late to work.

Many RCM references contain logic diagrams that can be used to evaluate and categorize the effects of failure. For example, the following logic diagram is provided as an example in [5], figure 1.

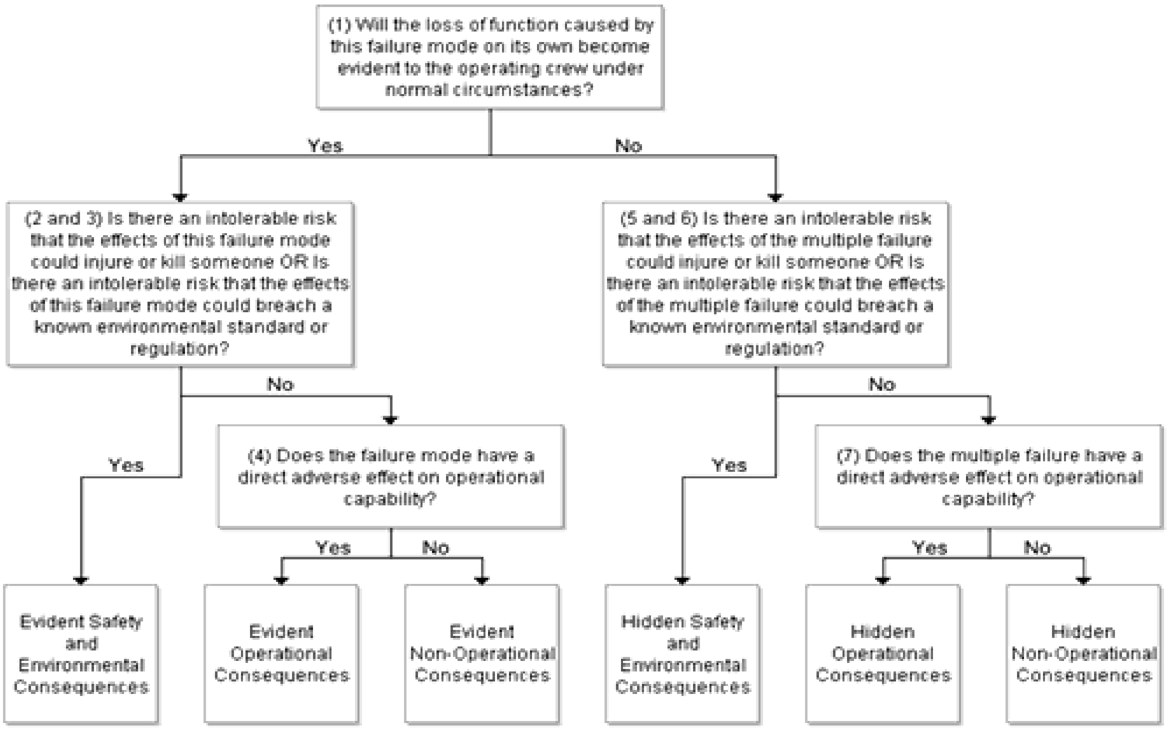


Figure 1. RCM logic diagram

### 3.5. Identify the Causes of Failure (Failure Modes)

The cause of failure (failure mode) represents the specific cause of the functional failure at the actionable level (*i.e.* the level at which it will be possible to apply a maintenance strategy to address the potential failure). Identifying causes (failure modes) is of paramount importance. It is a time- and effort-intensive step, but it is well worth it! The day-to-day issues of maintenance are mostly managed at the failure mode level (*e.g.* work orders issued to deal with specific failure modes, maintenance plans designed to deal with failure modes, product recalls due to a certain unexpected failure mode or frequent failure mode, emergency design or maintenance meetings triggered because of an occurrence of a failure mode, etc.) Extensive discussions about failure mode identification in this step of the RCM process will have a great beneficial impact on the success of the RCM project. It is what could make a difference between a reactive and a proactive maintenance management plan.

## 4. PRACTICAL DEMONSTRATION OF THE MAINTENANCE PROGRAMM

The RCM procedure is described for one of the most important safety system, i.e. for the service brakes of motorcars. The analysis procedure has been demonstrated just with the brake segment example (fig.2)

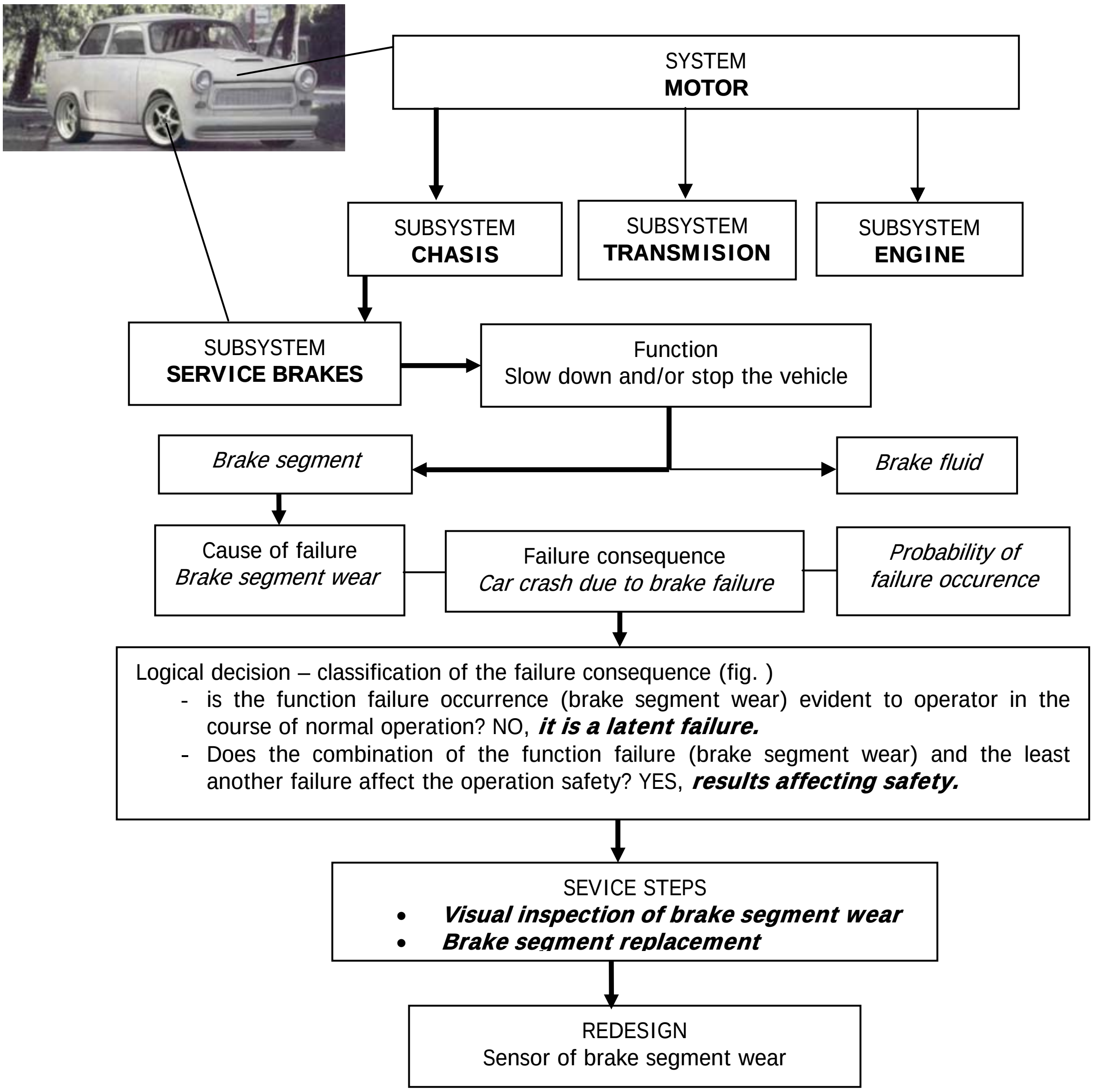


Figure 2. RCM application for vehicle service brakes

## 5. CONCLUSION

The article summarized the "analysis" or "investigative" steps in the RCM process of vehicle safety elements, in which functional failures, the failure modes and their effect and causes are explored for the brake segment. The methods and procedures applied are general and can bhe applied where the dynamic maintenance programme should be introduced.

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