

# Considerations Before Investing in Condition-Based Monitoring Technologies for Motor System Reliability

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**Abstract:** The common practice of purchasing Condition-Based Monitoring (CBM) technologies such as Motor Circuit Analysis (MCA), Electrical Signature Analysis (ESA), Vibration, Infrared, etc. often follows the thought process that these technologies are a motor program. This perception often results in frustration and the failure of a motors program. In reality, CBM technologies are tools to be used in a motor management program, which is a management philosophy.

In this paper, we will discuss the preliminary work necessary to specify CBM technology purchases and decisions.

## Introduction

As noted in the Motor Diagnostics and Motor Health Study,<sup>1</sup> 68% of those surveyed felt they had a motor management program in place. In which 72% of programs failed and less than half of the remaining programs were effective. Of the effective programs, 66% of the program recommendations were ignored. Only 7% of the total programs were actually motor management and were effective.

When the data was reviewed further, in particular in the area of the ignored recommendations, some key issues became readily apparent:

1. In a few cases, recommendations were not properly communicated;
2. Frequency of data collected on critical equipment was not effective for planned corrective maintenance; and,
3. Most cases identified that the applied CBM technology did not identify, or correctly identify, critical equipment failure.

In properly applied programs, over 91% identified immediate return on investment through their program(s). These programs were found to be fairly consistent in their outline and implementation. Failed programs were also found to be fairly constant in their attempts.

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<sup>1</sup> Penrose and O'Hanlon, Motor Diagnostics and Motor Health Study, SUCCESS by DESIGN Publishing, 2003.

## Defining Motor Management Programs

“Modern management practices often do not take into account the importance of motor systems maintenance and management requirements. Through efforts in cost control, many industrial and commercial firms will reduce maintenance staffs, take least cost approaches to corrective actions, and sacrifice preventive maintenance programs. The result has been increased energy costs and downtime resulting from equipment not operating to full potential and failing unexpectedly. The problem results in billions of dollars of additional energy consumption and lost revenue.”<sup>2</sup>

There are specific issues with defining the philosophy of motor management. The most important is that many view motor management as energy management, others view it as motor testing, storage, greasing or some other function. These definitions are wrong and will destroy any program before it is started because they are not long-term philosophies. A true motor management program and philosophy will have both immediate impact and long-term results.

Therefore, a more accurate definition of Motor Management is required:

*Motor system maintenance and management is the philosophy of continuous improvement of all aspects of the motor system from incoming power to the driven load. It involves all components of energy, maintenance and reliability from system cradle to grave.*

This provides the outline for any true motor management program which is intended to extend the useful life of the motor system combined with continuous improvement of the system. In addition, the focus is back on a systems approach such that the system includes: Incoming power and distribution; Controls; Motor; Coupling; Load and Process.

Why is this important to our discussion of the proper selection of CBM equipment? Quite simply, understanding the systems in the facility and the potential failures will assist in appropriate selection. For instance, if the greatest

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<sup>2</sup> Penrose, A Novel Approach to Electric Motor System Maintenance and Management for Improved Industrial and Commercial Uptime and Energy Costs, SUCCESS by DESIGN Publishing, 1997.

opportunities are related to the power system, how will the implementation of vibration or MCA be the most effective approach?

The philosophy of motor management requires that certain rules and processes are applied to ensure that the program is a success. A few points in this process include:

1. Identifying the mission of the company;
2. Perform an RCM-Based analysis of the facility and systems in order to determine the systems that will be included in the program and the maintenance practices to be followed;
3. Selection of CBM tools and maintenance practices to meet the analysis;
4. Selection of vendor-partners including discussion of spare parts storage;
5. Selection of personnel to operate the program;
6. Set and communicate the goals and metrics for the program;
7. Periodically review and modify the program as required.

Most of these steps are performed concurrently.

### **Company Mission**

It should also be realized, at this point, that the primary mission of most companies is to make a profit. In other cases, such as with the military, it is still related to performing the primary mission within a budget. Even in commercial buildings, the purpose is to provide the right services, effectively, to maintain residents in order to make a profit.

Any effort which does not impact the mission, safety or environmental considerations, effectively, should not be pursued. Keep in mind that some efforts are performed for appearance (marketing) which will have indirect impacts on the profitability of the company.

### **The RCM-Based Approach for Motor Management**

In the past, I have actually read recommendations that the Original Equipment Manufacturers (OEM) perform the RCM on their equipment then provide that information to the end-user. While this sounds good, it completely misses the point of the concept of RCM which, depending on the flavor, can be streamlined or extremely intense. There is an opposite issue, as well. Many RCM practitioners and consultants consider RCM as the program which is, again, an incorrect direction.

In the first case, the point of RCM is to identify the correct maintenance on the right equipment at the right time for the right reasons. This requires that the RCM analysis is based upon the application and its functions and not the equipment, itself. To consider using the manufacturer's recommendations will usually result in the application of excessive maintenance. One of the key issues that RCM was created to avoid.

OEM practices tend to recommend maintenance based around the most severe application, or a specific intended application, of the equipment. This means that in a majority of cases, the maintenance requirements will be excessive.

Excessive maintenance has both the impact that it is not effective and can actually reduce the reliability of the equipment. For instance, we all know that too little or too much grease will have a negative effect on bearings. Too frequent greasing will also have a negative effect on bearing life, such as increasing the risk of introducing contaminants, mixing incorrect greases or excessively greasing the bearing.

In the second case, the purpose of RCM is to develop tasks that are based on condition which allows us to capture the maximum useful life of a component regardless of its initial condition or stresses. In a standard industrial environment, by performing excessive RCM, valuable resources can be drawn upon, reducing the effectiveness of the involved parties. The fact is simple: Just as with CBM technology, or a screwdriver, RCM is a tool which should be used effectively. When incorrectly applied, it can be the same as trying to put in a finishing nail with a sledgehammer.

Instead, the program should be focused on identifying, first, equipment that affects safety, regulatory conditions, production then other applications (ie: maintenance of costly equipment).

The types of maintenance that can be applied to these systems include:

1. Corrective Maintenance: Maintenance used to return the condition of equipment following failure;
2. Alternative Maintenance: Maintenance involving re-designing the equipment to correct a design problem with the application; and,
3. Preventive Maintenance:
  - o Lubrication
  - o Time Directed – Maintenance performed by hours or calendar
  - o Condition Directed – Maintenance performed where the condition can be evaluated prior to failure. May include inspection or CBM.

In order to identify the types of tasks, an RCM approach is used. The key is to ensure that the most effective method is used as each has their strengths and weaknesses for different types of applications. The types and processes are outside the scope of this particular paper. However, the basic steps include:

1. Set boundaries and create a functional block diagram with partitioning of the system under review;
2. Determine functional failures;
3. Determine functionally significant items of the system;

4. Perform a Failure Modes and Effects Analysis (FMEA);
5. Perform a logic tree analysis in order to determine the effectiveness of maintenance tasks for the FMEA;
6. Determine servicing and lubrication tasks;
7. Set maintenance requirements for the system;
8. Draft and evaluate maintenance procedures;
9. Determine tasks for inactive equipment; and,
10. Develop corrective maintenance processes, procedures and specifications.

It is also important to understand, through this process, that not all failures can, or should, be avoided. There will be equipment in which time involved in maintenance will not be effective and others where the Risk<sup>3</sup> is not great enough to make maintenance effective.

Other considerations that, more or less, fits into the realm of the RCM process are Root-Cause-Failure-Analysis (RCFA) and Repetitive Failure Analysis (RFA). Rules need to be applied for the application of both, and both may require the use of CBM technologies for issue identification.

For instance, in a starch and gluten packing plant<sup>4</sup>, compressed air systems are required for the packaging equipment in order to reduce an explosive hazard. A maintenance assessment identified that there was an air pressure drop in the system from 110 psi to 45 psi from the compressors to the end of the packaging line. The losses created two conditions:

1. There were process issues with packaging. It was determined that potential production levels were not being met due to the loss of air pressure at the end of the production line;
2. There was a 60.5 kW demand loss due to the pressure drop. At \$16 per kW demand charge, \$0.12 per kWh usage, and 6,000 operating hours per year, the cost for the leak was \$55,176 per year.

Following a relatively simple RCFA, it was determined that the use of Ultrasonics for fault detection would be effective and monitoring and recording of pressure gauges by operators during the normal course of operating the equipment, and the production manager monitoring production levels, would be the most cost effective approach. Traditionally, the company may have run out and purchased an ultrasonic device and added a routine analysis route to the maintenance staff. The device was purchased, but manhours used more effectively.

The effectiveness of the solution would be evaluated during a routine analysis of the effectiveness of the program, known as Backfit RCM. This process allows the analyst, or group, to periodically review the effectiveness of the program and make adjustments as necessary. For instance, if it was determined

that there were issues with the operators monitoring the equipment, then it may be added to the CBM schedule.

In effect, the RCM-Based approach to motor management will assist in the identification of:

1. The equipment that needs to be monitored;
2. The conditions that need to be monitored;
3. The limits and fault conditions to be monitored; and,
4. The frequency of testing.

### Selecting CBM Equipment

Now, armed with a more accurate understanding of the needs for effective maintenance, the correct technologies can be selected. This information can be used to compare to the capabilities of each type of technology<sup>5</sup> and instrument vendor.

For example: In the case of a critical pumping system, it is determined that infrared, vibration, MCA and ESA technologies are to be used.<sup>6</sup> The need for these technologies is identified elsewhere, in similar applications, within the plant.

Using the information from all of the RCM analysis, a specification for the required CBM equipment can be generated. This also allows for the development of a series of questions for the vendors. The result is the purchase of an instrument that meets the needs of the program and not necessarily an instrument with bells and whistles that will not be used in the normal course of the program.

In the case above, we have selected four different technologies to cover the program. In the case that there is a limited budget, we can compare the abilities of each of the instrument vendors against the actual needs of the program. With the diversity of costs, we have the ability to determine if we need : A \$10,000 camera or a \$60,000 camera; A \$1500 MCA device or a \$35,000 MCA device; etc. The specification should also extend to the supporting software.

The evaluation of the technologies will also identify the level of operator and analyst that will be required. This will help both identifying existing manpower that is capable of performing the task and/or additional manpower that will be needed. In particular, the ability to provide Human Resources with a list of the skill sets necessary for the reliability or maintenance position.

Once the appropriate manpower and CBM equipment has been selected, procedures for the application of the CBM maintenance tasks can be completed. Within the procedures,

<sup>3</sup> Risk = Probability of Failure x Severity of Failure

<sup>4</sup> Example from A Novel Approach to Industrial Assessments for Improved Energy, Waste Stream, Process and Reliability, Penrose, SUCCESS by DESIGN Publishing, 1999.

<sup>5</sup> Penrose, "The Multi-Technology Approach to Motor Diagnostics," ReliabilityWeb.com, 2003.

<sup>6</sup> Penrose, "Basic Overview of an RCM-Based Approach for Motor Management Programs," ReliabilityWeb.com, 2004.

or for the individual equipment, the condemning criteria should be noted.

## **Conclusion**

In the past, the selection of CBM technology was based on perceived needs versus actual requirements. Through the use of a RCM-Based process, the appropriate technologies can be specified and selected. In addition, personnel with the appropriate skill set can be selected and procedures developed. The objective is to ensure the success of the actual motor management program and the resulting impact on the bottom line.

## **About the Author**

Howard W Penrose, Ph.D., CMRP is the President of SUCCESS by DESIGN Reliability Services. He has over a quarter Century in the rotating machinery industry and has been a pioneer in the development of successful industrial assessment and motor management programs since the early 1990's.

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