Asset Management 101

Part 1: Maintenance Strategy Overview

Larry Covino
Product Line Leader, Strategic Partnerships
Bently Nevada Asset Condition Monitoring,
GE Energy, lawrence.covino@ge.com

Michael Hanifan
Lead Technologist, New Applications Engineer
Bently Nevada Asset Condition Monitoring, GE Energy
mike.hanifan@ge.com

As industries contend with global competition, unprecedented economic conditions, regulatory demands, environmental concerns, and other pressures, the ability to manage their physical production assets has become increasingly important. The emphasis that industry now places on the asset management function can be readily noted simply by observing the number of individuals that currently carry the title "Asset Manager" on their business cards compared to just ten years ago.

The asset manager's first and most fundamental task in establishing an asset management program is to identify the appropriate maintenance strategy(ies) warranted by each asset. Accordingly, we are devoting a series of articles to this important topic.

IN PART 1, we provide an overview of the four basic maintenance strategies: Predictive Maintenance (PdM), Preventive Maintenance (PM), Reactive Maintenance (RM), and Proactive-Centered Maintenance (PCM). We also introduce the P-F curve and its relationship to these maintenance strategies. Finally, we introduce the concept of asset criticality.

IN PART 2, we explore the relationship between P-F curves and asset criticality in more depth, showing how an asset's criticality governs the level of analysis rigor necessary to choose an appropriate maintenance strategy. The various analysis methods are discussed, including Reliability-Centered Maintenance (RCM), Root Cause Failure Analysis (RCFA), and Failure Modes and Effects Analysis (FMEA), with guidance offered on when (and when not) to apply each method. We then review the four basic maintenance strategies introduced in part 1, and establish the condition monitoring methodologies and system requirements that correspond to each.

IN PART 3, the final installment of this series, we explore PCM in more detail with an overview of both offline and online condition monitoring systems and their role in PCM. Particular attention is devoted to explaining the role of scanning-type online systems (both wired and wireless) as they pertain to moderate- and low-criticality assets, and specific threshold criteria is offered to help users determine when to move an asset from an offline approach to an online approach. Part 3 concludes with a discussion of the impact that wireless technology has had on moving the online/offline threshold further down the criticality scale, and explores the categories of assets most suitable for wireless condition monitoring.

THE ASSET MANAGER'S FIRST AND MOST FUNDAMENTAL TASK IN ESTABLISHING AN ASSET MANAGEMENT PROGRAM IS TO IDENTIFY THE APPROPRIATE MAINTENANCE STRATEGY(IES) WARRANTED BY EACH ASSET.

Asset Management and the P-F Curve

Figure 1 shows an example of a Failure (P-F) curve, with P representing the point in time when the potential failure can be detected, and F representing the point in time the asset reaches functional failure. While not all failures manifest themselves in this manner, most failure modes do have technologies that can detect failures early in their failure cycle. The intent is to manage assets at the top of this curve.

While most companies strive toward managing their assets proactively, many plants often find themselves managing assets in a reactive mode. They are continually reacting to assets reaching functional failure without warning. This situation often results in spare parts shortages due to limited planning time, increased overtime and callouts, and poorer quality repairs and documentation. All of this can inhibit the plant from having the time and resources to complete the repertoire of maintenance routines and move into a more predictive mode.

Best-in-Class Practices

Best-in-class maintenance and reliability performers typically manage the majority of assets as far up the P-F curve as possible. This results in strong planning and scheduling programs, with condition monitoring technologies as one of the key work identification systems driving those programs. The maintenance and reliability teams spend the right amount of time identifying failures earlier for each asset, enabling improved coordination to better plan and schedule maintenance activities. Today's challenging economic environment, combined with the costs of HSE (Health, Safety, and Environmental) and regulatory compliance, makes it imperative to optimize the return on investment for maintenance activities.

Maintenance Strategies

Below, we summarize the four fundamental maintenance strategies in use today. It is important to note that multiple strategies may be (and often are) applied to a single asset. The strategy(ies) chosen for a particular asset are a function of its criticality—a concept explored later in this article—and its failure modes and consequences. Certain failure modes, for example, may have serious consequences, but are not be detectable by any currently available condition monitoring technology. Routine quantitative inspections must be carried out instead. Other failure modes on the same

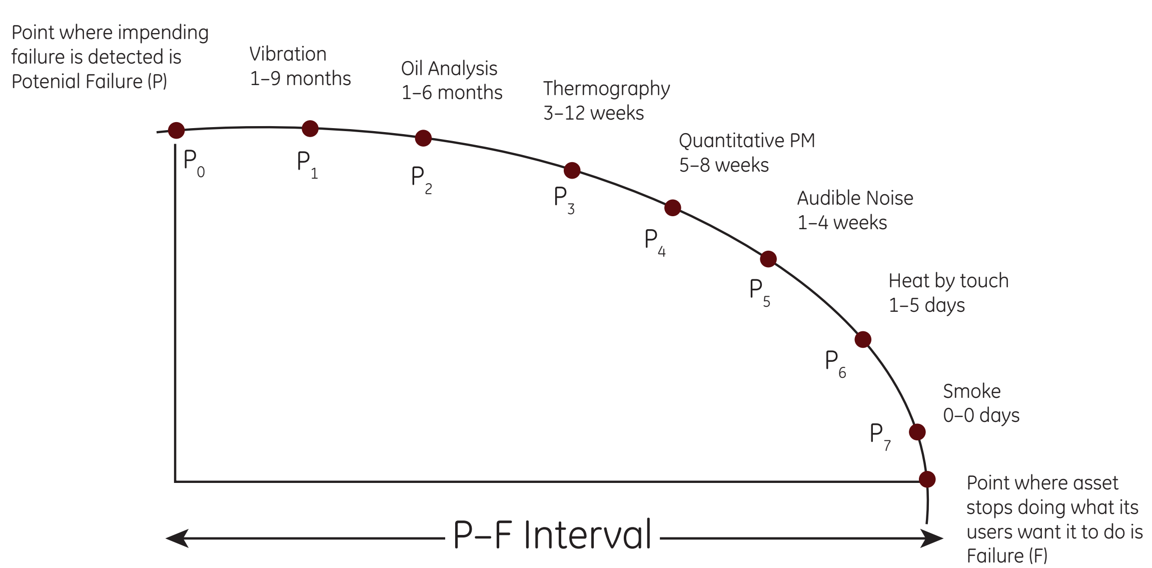

Figure 1. Potential Failure to Actual Failure (P-F) Curve.

asset may have equally serious consequences, yet can be readily detectable by a particular technology, such as thermography. Such an asset would employ a mix of preventive maintenance (e.g., time-based inspections) and predictive maintenance (e.g., thermography).

1. Preventive Maintenance (PM)

A PM strategy is often based on OEM recommendations for specific production assets, with preventive maintenance performed at specified time-based intervals. The intervals are generally based on the MTBF (Mean Time Between Failure) data compiled by the OEM. PM includes intrusive time-based inspections and requires taking the asset out of service and opening it to look for worn parts or incipient failures. Often, since an asset is opened for inspection, wearable parts may be replaced even though they do not show wear. Also, any intrusive maintenance has the potential of imparting maintenance-induced failures, often called infant mortality. Since asset failures can happen between scheduled maintenance intervals, a strictly time-based strategy may not be right for many assets and certain failure patterns.

Quantitative preventive maintenance incorporates non-intrusive predictive maintenance inspections into a preventive maintenance program. Using gauges to measure belt tension on a motor-driven blower is an example of a non-intrusive inspection to detect pending failure. In this case, tension can be measured without opening the machine and is one indicator of excessive roller, bearing, or belt wear.

While such inspections are non-intrusive, they are still time-based. Further, they cannot be performed on an asset unless the asset is shut down for testing. Therefore, while it does not result in the typical problems inherent in intrusive inspections, it still results in a loss of production while the asset is shut down. This, in turn, may reduce the life cycle of those assets for which starting and stopping incurs greater wear than steady-state operation.

2. Predictive Maintenance (PdM)/ Condition-Based Maintenance (CBM)

PdM and CBM are synonymous. A CBM program evaluates machinery via instrumentation, either periodically or continuously, to determine its condition, usually through a condition monitoring (CM) program. It allows planners and schedulers to schedule maintenance when it is most cost-effective and precedes functional failure. A condition monitoring program monitors the health of the asset early in the P-F cycle and helps identify the required maintenance work. Ideally, this allows reliability and maintenance professionals to conduct all required maintenance on a given piece of equipment simultaneously, saving costly downtime.

CM programs have often been characterized as “vibration monitoring” programs. However, while vibration monitoring is a critical aspect of most CM programs, there are more than 75 different types of non-intrusive CM technologies, such as oil particulate analysis, temperature, thermography, and ultrasonics. The selection of CM technology(ies) and corresponding data collection/analysis frequency is done on an asset-by-asset basis by considering both the asset’s criticality and it’s failure modes.

The goal of predictive maintenance is to use condition monitoring technology to detect future failures through the evaluation of early warning indicators. A robust PdM program has many benefits over other maintenance strategies (see Table 1).

Table 1. Attributes of PdM/CBM.

Benefits	Methods
• After initial hardware costs, less expensive recurring maintenance costs than preventive maintenance or reactive maintenance (see Figure 2) • Early detection of failures generates maintenance work plans, resulting in more planned work rather than unplanned • Failure identification results in less downtime during maintenance	• Compares physical measurements against engineering limits and specifications • Tracks trends to detect changes from normal • Uses state-of-the-art technology to discover failures • Allows alarm limits to be established • Employs continuous online monitoring, intermittent online monitoring, or manual data collection, depending on the asset failure cycle

Once a robust PdM program is in place for an asset, PM routines can be reviewed and in many cases optimized or eliminated. As an example, assume that a particular OEM recommendation is to change a bearing after 30,000 hours of operation. With proper application of predictive technologies, the health of the bearing can be monitored and managed to a high degree of reliability. By managing the health and condition of the asset, time-based maintenance intervals can be extended or eliminated altogether.

Finally, PdM is not only more effective in driving early warning and the ability to plan and schedule properly, but it is also less costly than reactive and time-based strategies (Figure 2).

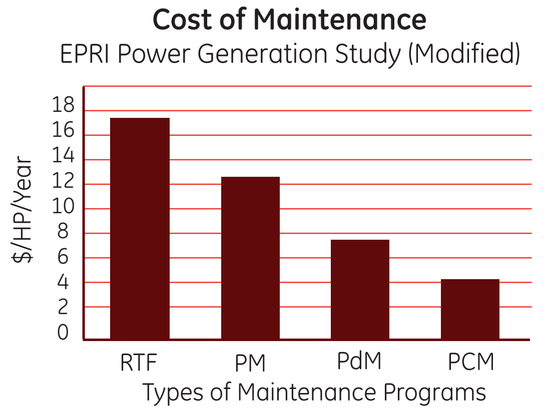

Figure 2. Potential Failure to Actual Failure (P-F) Curve.

3. Reactive Maintenance (RM)

RM, sometimes referred to as "living life at the bottom of the P-F curve," is maintenance performed after a failure, or after an obvious, unforeseen threat of immediate failure. Running machines in run-to-failure (RTF) mode is an appropriate strategy for assets where the consequence of failure (including cost to replace) is so low that the expenditure of valuable maintenance time doing PM or PdM tasks cannot be justified.

Unfortunately, for many companies without good PM and PdM programs, RM is not a deliberate strategy applied to only selected assets; it is instead a vicious cycle where daily maintenance activities are dominated by unforeseen failures, hindering the transition to a more proactive approach for managing assets.

Indeed, RM may consume up to 80 percent of the total time and budget of companies stuck in this mode.

Referring again to Figure 2, RM (i.e., RTF) also has the dubious distinction of being the most expensive type of maintenance when applied indiscriminately to all assets in the plant.

4. Proactive-Centered Maintenance (PCM)

A one-size-fits-all approach utilizing RM has already been shown to be the most expensive and least effective maintenance strategy when indiscriminately applied to all assets. However, the same can be said for both PM and PdM. Simply applying any particular strategy to all assets—independent of the asset's criticality—is non-optimal. PCM recognizes this and emphasizes doing the right maintenance on the right assets at the right time.

In most cases, a PCM approach increases the use of PdM, while continuing to utilize PM. It also utilizes RM, but correctly limits this approach to assets with little or no consequences of failure. However, PCM's purview encompasses more than just where to apply RM, PM, and PdM. It also concerns itself with procedures, operating parameters, processes, and designs in order to limit or prevent recurring failures, thus reducing the total number of asset failures and extending the mean time between asset failures. A PCM program is continually being optimized with feedback from Root Cause Failure Analysis (RCFA) repairs, Quantitative PM's, PdM routines, CM systems, and operations. This feedback is used proactively to keep assets in their optimal operating condition.

Referring again to Figure 2, PCM can result in up to a 42% reduction in maintenance costs when compared to PM and up to a 59% reduction when compared to RM.

Asset Criticality

As previously mentioned, determining the appropriate maintenance strategy(ies) for a particular asset is a function of the asset's criticality, which is in turn a function of the consequences of failure for the asset.

Table 2 summarizes the five broad criticality classifications for assets based on their consequences of failure. Also included is the approximate percentage of assets populating each category in a typical industrial plant. The middle column in the table indicates the analysis method used to establish the maintenance strategy. This linkage between methodology and maintenance strategy will be discussed in more detail in part 2 of this series of articles. For now, it is sufficient to note that the methodology employed depends on asset criticality, and asset criticality depends on the consequences of failure.

For example, it can be seen from Table 2 that "Highly Critical" assets should always employ an RCM methodology to arrive at the appropriate maintenance strategy(ies), while "Critical" assets may or may not employ an RCM methodology. Those with more serious consequences of failure would employ RCM; those with less serious consequences of failure would employ FMEA.

Summary

Four fundamental maintenance strategies exist today: RM, PM, PdM, and PCM. Ideally, the maintenance strategy(ies) selected for a particular asset will correspond to the asset's criticality and failure modes/ consequences. Indeed, as the criticality of an asset increases, the more likely that it will require a mix of maintenance strategies. RM, although a valid approach for some assets, is very costly when applied indiscriminately. The widespread use of RM in a plant typically characterizes those with asset management programs in the bottom quartile amongst their peers. In contrast, best-in-class performers typically use more predictive maintenance than their peers, and have often moved beyond simple RM, PM, and PdM to Proactive-Centered Maintenance which combines the elements of RM, PM, and PdM while proactively addressing factors such as operating parameters, processes, and designs to limit or prevent recurring asset failures.

STAY TUNED...Part 2 of this 3-part series continues our discussion of asset criticality, showing its relationship to the P-F curve. It also examines the analysis methods of Table 2 in considerably more detail. It then explores the particular condition monitoring system attributes warranted by each asset criticality classification.

<table>
<tr><th colspan="3">Table 2. Asset Criticality Classifications and Analysis Methods</th></tr>
<tr><th>Classification
(based on consequences of failure)</th><th>Analysis Method
(method used to determine maintenance strategy or strategies)</th><th>Distribution
(percentage of total assets)</th></tr>
<tr><td>Highly Critical</td><td rowspan="2">Reliability Centered Maintenance (RCM)</td><td rowspan="3">10–20%</td></tr>
<tr><td rowspan="2">Critical</td></tr>
<tr><td rowspan="3">Failure Modes and Effects Analysis (FMEA)</td></tr>
<tr><td>Mid-Level Critical</td><td>30–40%</td></tr>
<tr><td rowspan="2">Low-Level Critical</td><td rowspan="2">45–55%</td></tr>
<tr><td>Asset-Specific, Pre-Defined Maintenance Templates</td></tr>
<tr><td>Non-Critical</td><td>RTF</td><td>5–10%</td></tr>
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