PROACTIVE MAINTENANCE OPTIMIZATION
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“As Proactive Maintenance (PM) Programs get larger and more complex and their tasks more heavily influenced by the Quality and Safety Groups, are they actually still preserving asset functionality?” Dan Miller, a Principal Reliability Engineer with ABS Group asks as he evaluates the strength of a PM Program. “The organization’s performance measures often include PM Completion (or Compliance) data to ascertain how well the Maintenance and Reliability Group is achieving its goals."

“The metrics may give leadership confidence in how the program is running”, Miller adds; “but if the PMs are not effective, they will do little to improve overall performance and reduce quality and safety issues. Often, the Proactive Maintenance Program, the most visible part of the Asset Management Program, can be its most neglected.”
Organizations that have reached the Enterprise Asset Management (EAM) level of performance already have a methodology to assess the effectiveness of their PMs on a regular basis. PMs are performed and the results are analyzed; worn parts replaced, labor hours recorded, and follow-up work orders are written. These organizations also routinely include an analysis of the correlation between asset (commonly called equipment) performance and the effort expended to maintain that performance. The concept described above is called Proactive Maintenance Optimization (PMO) and it is not a secret, it is the dynamic process used to keep the Asset Management Program relevant and at the Enterprise level.

True PMO efforts are comprised of analyzing current PMs and increasing asset reliability by identifying potential gaps in both PM performance and PM frequencies. “It is a very detailed and time consuming endeavor,” Miller adds, “Especially if the PM Program was put together with minimal effort or expertise or has been running autonomously month after month for several years.”

Attempting to improve PM performance can appear to be overwhelming and may prohibit or delay making needed changes based on the perceived magnitude of the effort or understanding of where to start. A generally accepted practice, according to Quinton GoForth, Director—Reliability Services for ABS Group, is to “First perform an Asset Critically Ranking (ACR) on all operational assets to determine those most critical to the operation. Then follow this up by executing FMEA (Failure Modes and Effects Analysis) on the top 5-25% (based on the assets deemed to be in the highest tier of criticality) to determine which failures will have the greatest impact on asset functionality and address these with effective PM strategy development.” These two processes will narrow down a PMO endeavor focusing on the most important assets first and provide the greatest impact in a relatively short time.
“If the tasks are not placed in an effective sequence, there may be excessive time consumed moving from one area of the asset to another.”

“Why perform PM Optimization?” There are numerous PMs getting performed without clearly understanding their value. For example, many PMs are written word for word solely from OEM recommendations. This approach on its own may not take into account the environment or conditions the asset is exposed to during operation or any associated policies impacting the asset. Also, there may be too many labor hours spent on the PM. If the tasks are not placed in an effective sequence, there may be excessive time consumed moving from one area of the asset to another (i.e., performing all electrical steps, then all mechanical steps even though some of the steps may be physically adjacent to each other; assuming all tasks can be accomplished by the same technician). Without a thorough examination of the PM tasks, too many good components may be replaced. Not only does this add to the time an asset may be down for PM execution, but it also has an impact on Maintenance Cost. It is common to see programs where PMs do not take into account tasks that can be performed while an asset is running versus those required when it is in an idle state, such as disassembling a pump just to check the seal. These build unnecessary and excessive asset down time into the operational schedule. In these ill-fated programs there is simply no consideration for utilizing runtime observations to help determine if the assets functionality is being preserved.
PMs should be designed to maintain an asset in optimum operating condition. Often times too many failures are allowed to occur because: 1) PMs aren’t effective at detecting failures, 2) PMs don’t detect failures early enough, 3) PMs are not focused on protecting required functions, 4) PMs do not clearly specify intended target failure modes or indicators, and 5) There is always an increased likelihood of failure due to unnecessary replacement of components. Performing a PM too frequently or when its tasks are poorly written means that the asset undergoes an intrusive activity where the likelihood of the asset failing increases entirely because the PM was performed in the first place.

A good PM will answer four basic questions: 1) What are we trying to protect? 2) What are we trying to protect it against? 3) What are we going to do about it? 4) How are we going to do it?

Additionally, there are two recognized and generally accepted approaches to optimizing a PM Program; FMEA and MTA (Maintenance Task Analysis). Performing an FMEA which has already been mentioned as the preferred method for critical assets. Evaluation of the PM Tasks is: Based on results from a FMEA performed on the asset/asset class, is proactive in nature, and takes human, environmental, system, process, and procedural factors into account.

PERFORMING FAILURE MODES AND EFFECTS ANALYSIS

Failure Modes and Effects Analysis (FMEA) is a step-by-step approach for identifying all possible failures in a design, a manufacturing or assembly process, or a product or service; according to ASQ (American Society for Quality). ‘Failure modes’ means the ways, or modes, in which something might fail. Failures are any errors or defects, especially ones that affect the customer, and can be potential or actual. ‘Effects analysis’ refers to studying the consequences of those failures. Failures are prioritized according to how serious their consequences are, how frequently they
“The purpose of the FMEA is to take actions to eliminate or reduce failures, starting with the failures with the greatest consequences.”

The second approach is Maintenance Task Analysis (MTA). Where an FMEA is comprehensive and focused on new equipment, an MTA is focused on the actual PM Tasks already being accomplished for each asset in an existing program. Evaluation of the PM Tasks through this approach is based on: Safety Risk or Exposure, OEM Recommendations, Engineering and System Design, Reliability Factors (Maintainability), Cost of PM, PM Cycle Impact to Wear, Breakage and Asset Performance, and Subject Matter Expert (SME) Recommendations. Jim Parish, a Principal Reliability Engineer with ABS Group who has extensive knowledge of PM Optimization, states that “Some of the criteria used to evaluate PM Tasks (individually) should include 1) Assessing Applicability of the task to the Asset, 2) Determining if the Tasks help in foreseeing failure, 3) Eliminating Redundant/Repeated Tasks, 4) Determining if the cost of completing the task is worth the value added in accomplishing it, 5) Eliminating Tasks for lesser priority assets, or 6) Designing-out the necessity to complete the PM or task.” Parish goes on to say that “An MTA can produce beneficial results to the PM Program in the early stages of the organization’s journey to EAM and can provide the basis for a more thorough Optimization through FMEA later via process improvement.”
PM OPTIMIZATION GOALS

The goals of PM Optimization should be to: 1) Identify gaps or improvement opportunities quickly, 2) Identify ideal range (periodicity) for PM frequencies focused on run time (i.e., hours, miles, cycles) versus fixed time (calendar based), 3) Identify PM additions, deletions, or revisions which positively influence cost effectiveness and asset reliability, and 4) Effectively improve MRO Inventory Management by identifying spare parts requirements to increase material availability and minimize PM deferments due to awaiting parts.

Figure 1: A recent analysis of an existing PM Program’s Job Plans revealed that more than half of the original tasks (62%) could be either deleted (red, 8%), reassigned (yellow, 22%), or replaced (blue, 32%). The tasks that were identified for reassignment were primarily redundant tasks that were already being performed during normal operator care activities (i.e., observing asset operating temperatures and pressures). The tasks that were identified for replacement were inspection tasks that could be replaced by the implementation of Predictive Maintenance technologies (i.e., vibration analysis, thermographic imaging).
EXECUTING OPTIMIZED PMs

“An optimized PM may look very different from the PM it will replace. That’s okay,” says Miller. “If the PM is unrecognizable to the technicians performing it, though, it may be challenging for the technician to effectively execute it. Even if the steps are recommended by a technical Subject Matter Expert (SME) who has performed the original PM, the tasks may still meet resistance on the manufacturing floor.” Seasoned technicians become very comfortable in performing PMs that are scheduled each month or quarter to replace identified parts and may not see the benefit of a new approach right away, especially if the task in the revised PM calls for an evaluation to be performed to determine if the replacement is necessary in the first place.

It is best to have objective criteria which drive this determination. For example, if a task in the original PM required that the technician replace a drive belt each month, but the new (optimized) PM includes steps to verify that the drive belt needs to be replaced (utilizing criteria such as fraying greater than 20%, excessive cracking, or when the take-up has reached its maximum limit), the technician may not feel comfortable determining a qualifying condition or may not believe delaying replacement will result in optimal asset performance until the next PM. An effective approach is to solicit input from the technicians that maintain the assets from the very beginning.”
beginning. In our example, Miller stresses, “The optimization exercise would include asking the technician a list of questions focused on conditions they believe would require a drive belt replacement. The conditions would be included in the optimized PM. It would be an expectation of the optimization exercise that any necessary training or education would take place to ensure the technician has the necessary skills and knowledge to perform the PM.”

KEEPING THE PM PROGRAM CURRENT WITH TECHNOLOGY

A more advanced approach to optimized PMs is to leverage technology. This would mean that the outcome of a PMO effort would include pictures, diagrams, schematics, scientific formulas, and graphs (i.e., Mollier diagram to help determine steam saturation). Advanced PMO efforts could even include videos, virtual reality depictions, or an interactive chat line from an OEM. Future PMs may be dynamic. Imagine a PM where the steps are written real-time based on process monitoring systems (i.e., SCADA or Supervisory Control and Data Acquisition System), Predictive Maintenance analyses, or operational cycles.

ADDING OR ENHANCING PREDICTIVE MAINTENANCE

Predictive Maintenance (PdM) is defined as techniques to determine the condition of operating assets or equipment to provide objective data for analysis that will ‘predict’ when maintenance intervention should take place to remediate potential functional failure. Based on the invasive nature of fixed time preventive maintenance inspections, PdM is the preferred method in most cases and is often times less costly and provides more data to make calculated decisions. PdM technologies include analysis of vibration, infrared, ultrasonic, and tribology or lube oil analysis. PdM also includes statistical analysis of operating conditions such as asset speed, motor amperage, accumulation, cycle stops, and yield trends to assist the Maintenance and Reliability Group in anticipating pending failures.
SUSTAINING THE PM PROGRAM

An optimized PM Program allows the Maintenance and Reliability Group to preserve each asset’s functionality and ensure its intended purpose is attained throughout its entire lifecycle. A PM must be written so that the expected outcome is achieved, it minimizes (preferably eliminates) unanticipated failure, it can be consistently scheduled (known durations), and allows the technician to become familiar with the asset and its designed operating conditions. Optimizing PMs is an ongoing process whereby the PM Program is periodically reviewed and updated based on operating conditions, asset health, regulatory requirements, and the knowledge and experience of the technicians performing the work. Miller concludes that; “Tasks to preserve the functionality of critical and support assets need to be evaluated for their effectiveness, their most efficient method of execution, and each effort to maintain the equipment is elevated to its most optimum level.”
PM OPTIMIZATION DO’S & DON’TS

Do

• Ensure Step Sequence is Safe and flows safely and efficiently
• Assure Clear, Concise, and Specific PM Instructions to Assure Consistent, Reliable Execution of The Proactive Maintenance
• Remove Non-Value Added PM Instructions In PMs
• Standardize Format (Safety Steps First, Use of Action Verbs, etc.)
• Clearly Identify Spare Parts Requirements and Lubrication Needs
• Evaluate PMs for Criticality
• Review PMs for consistency in content and frequency across the enterprise where appropriate
• Evaluate current state asset condition and performance and develop plan for improvements
• Adhere to change control process for PM Review
• Develop Audit PMs for Supervisors / Managers
• Eliminate Redundant and/or non-value added PMs
• Review completed PMs for Optimized Planning (Actual Labor Hours vs. Estimated Hours)
• Ensure PMs are crafted to allow consistent planning and scheduling
• Ensure PMs are crafted to evaluate adequate PM Frequencies

Don’t

• Don’t include steps that are unsafe, such as:
  - Hold the rim of the turntable to stop rotation and press the jog button until the turntable jammed indicator illuminates.
• Don’t use generic phrases, such as:
  - Replace or repair as necessary.
• Don’t combine run time intervals or frequencies with fixed time, such as:
  - Oil changes are required at intervals of 10,000 operating hours or every two years.
• Don’t include steps that reference unrecorded trends or conditions, such as:
  - Replace chains when they have stretched a maximum of 2%.