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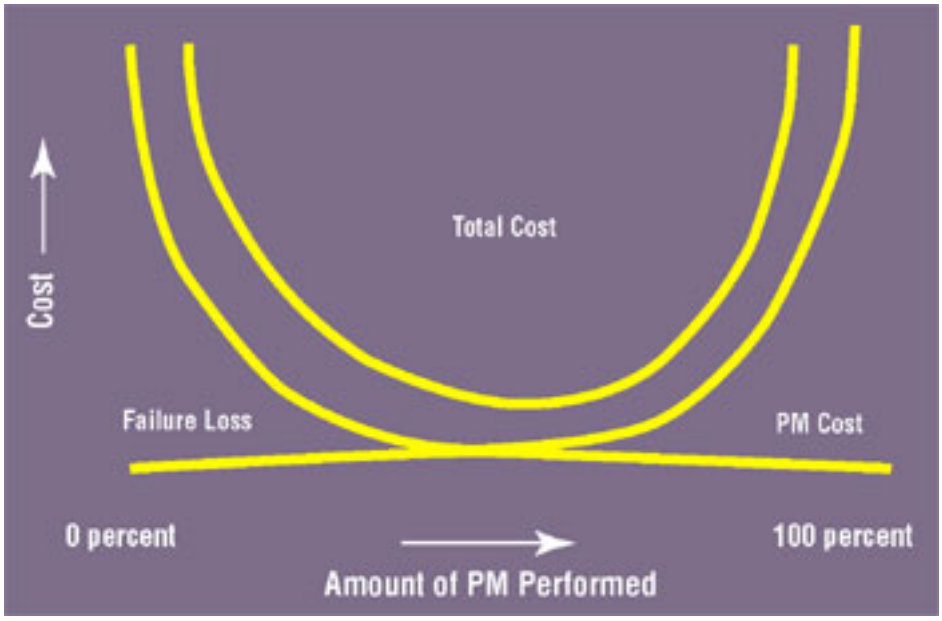
Friday, 01 March 2002 18:41

Here is a method for scoring the effectiveness of a preventive maintenance program.

Preventive maintenance (PM) is basic maintenance performed on equipment and facilities with an established frequency. The main goal of performing maintenance tasks on a periodic basis is to extend equipment life and assure its capacity in support of the facility's goals and targets.

PM can be a simple task such as an adjustment or a complex activity such as a complete overhaul. PM tasks can be performed when the equipment is shut down or while the equipment is running. The frequency selected for performing PM tasks takes into consideration the maximum time allowable before failure or extensive and costly corrective maintenance work is performed. Defining the right tasks and their associated intervals for execution is an important factor in limiting the cost of PM work without sacrificing the PM program value.



A PM classic curve illustrates the relationship between the costs associated with executing a PM program and the loss associated with equipment failure. The relationship shows that loss due to equipment failure is high when expenditure on PM is low, resulting in a high total cost. An increase in the investment made in implementing and executing a PM program results in a decrease in failure loss and total cost until the optimal minimum cost is achieved.

The assumption made in interpreting these curves is that the facility invests in and executes the most effective PM program. However, industry data reveals that above-average performers have PM programs that are running at half their potential. In addition, numerous facilities still deal with major and repetitive equipment failures although they report PM completion rates exceeding 90 percent.

Assessing a PM program

An overall PM rating assessment can be calculated;

Overall PM Rating = A x B x C x D

where:

A = Percentage of equipment with a well-defined PM program

B = Percentage of PMs that have the right tasks and frequencies

C = Percentage of PMs completed on time

D = Percentage of completed PMs considered to be executed properly

As an example, a 90 percent score on each element will give the PM program a score of about 66 percent and an 80 percent rating on each criterion would result in a score of about 41 percent.

Well-defined PM programs

Most companies have PM programs that cover 80 percent or more of their equipment. The remaining 20 percent of the equipment is considered noncritical and accepted to run to failure without any maintenance performed to prevent or mitigate the failure effect.

Determining how well defined the PM program is starts by analyzing existing PM tasks. If there is a computerized maintenance management system (CMMS) in place, generate a list of

equipment with PMs out of the total equipment database. To simplify the process, do the analysis on a sample of about 200 randomly selected pieces of equipment. The sample should include equipment from all categories (fixed, rotating, instrumentation, electrical, etc.) and all production areas.

Then determine whether there are PM tasks well defined for the selected equipment. If the equipment does not have PM tasks, the question should be whether there should be any PMs in place to support equipment reliability needs.

As a result of this assessment, if 80 percent of the equipment has well-defined PM tasks, then score factor A 100 percent. If only 60 percent of the equipment has PMs, then score A as 75 percent and so on.

Tasks and frequencies
Work on the same equipment sample as chosen for analysis of factor A.

In determining if the right tasks are being performed, typical questions to ask are:

- Will this task reduce the risk involved with equipment failure if performed properly?
- Is there enough information available to prevent system contamination (no oil type indicated), equipment misalignment (appropriate settings not indicated), or personal injury (lack of safety requirements)?
- Is the task lacking relevant information such as requirements for recording functional data such as temperature, pressure, and thickness?

The task frequency is usually set based on manufacturer recommendations or historical data at a test value. This interval can be too short and, as a consequence, the task will be performed too often. In this case the cost involved in performing the PM tasks is high; the equipment will exceed its return on investment until the right frequency is selected. In contrast, a task frequency too long will make the PM tasks ineffective at preventing equipment failure.

For example, a V-belt failure on a critical conveyor system caused a significant number of hours of downtime. The solution implemented after the system was returned to service was to check

the belts every week. Checking the belts required the removal of a large guard in a difficult area that was not accessible by crane. The proper belt tension and condition verification was performed for some time; however, after a while the failure faded from memory, and maintenance stopped performing the task under the assumption that somebody else was doing it.

Two years later the belts failed again. This time, the plant performed a failure analysis using principles of root cause failure analysis. Based on experience and failure history, it was determined that the most feasible and effective PM task was an annual belt adjustment and condition verification. In addition, technical information related to belts, pulleys, and tension and alignment specifications was included in the PM task documentation.

On time completion
Experience shows a multitude of unintentional ways the reported PM completion rate might not be accurate.

Past due PMs. For every 100 new PMs issued weekly, assume a reported completion rate around 90 percent. How should the remaining 10 percent be classified? In addition, the 90 percent completion rate reported might mean 80 new and 10 old PMs (which is actually an 80 percent completion rate of new PMs).

A proposed method for calculating a more realistic completion rate is:

- Close all uncompleted PM work orders as not completed
- Add the PM backlog to the new PM work orders
- Divide the completed number of work orders by the sum of the PM backlog and new PMs

For example, if there are 100 new PMs, 20 old PMs in the backlog, and a total of 90 PMs completed, then:

90/(100 + 20) = 90/120= 75 percent completion rate

Reliability professionals define a 100 percent completion rate as desired, 90–99 percent as good, and less than 90 percent as requiring attention for improvement.

"As needed" PMs. When the PM tasks cannot be performed at the defined frequency because the equipment is not available for maintenance, the PM tasks will be performed when possible. These PMs inflate the completion rate because the only time they are opened (counted) is when there is some certainty for their completion. Oftentimes these PMs are on critical equipment such as generators, transformers, and switchgear. This situation can be avoided by involving operations personnel in the process of defining the right PM task frequencies.

Blanket work orders. Some blanket work orders are often PMs that no one wants to track. For example, even a daily inspection performed in a motor control room should be categorized as a PM task, which is part of the PM program defined for the area or system.

Predictive maintenance (PdM). In many facilities, vibration routes are established and recorded using a computer system dedicated to the effort. This system may not be tied into the CMMS and, therefore, the PM completion rate reported might not include the predictive activities completion rate.

Incomplete tasking. What happens if the PM tasks are not entirely completed? If 90 percent of the task is completed, is the PM closed as 100 percent completed? What about an 80 percent task completion or 70 percent? If the PM program has a weekly PM route with daily tasks, should the PM be closed as completed when only 4 out of 7 days (57 percent) are completed?

To avoid this situation:

- Divide large PMs into smaller PMs with a smaller number of tasks
- 100 percent completion rate means 100 percent
- Redefine weekly PMs performed daily as daily PMs

Proper execution

This factor is one of the most difficult to determine, mostly because it is the result of direct human intervention on the equipment.

A PM quality audit can be performed as follows:

- Observe the employees completing the PM tasks (20 points)
- Ask questions related to the PM execution and job knowledge (20 points)
- Observe the condition of equipment (20 points)
- Evaluate the quality of PM documentation (20 points)
- Count the number of work orders written from PM work (20 points)

In each category score 20 as excellent, 18 as very good, 15 as good, 10 as fair, and 0 as poor.

Observations, employee job knowledge, and equipment condition. The PM employees should be informed on the scope of the audit. Let maintenance staff take you on a route and show you what they do. Ask for any ideas for process improvement. Let the maintenance person explain maintenance procedures and actions. While touring, take notes on the good and not so good things observed. Make sure the notes include observations on cleanliness, tools availability and condition, and procedure availability.

PM documentation and work orders generated. Completed PMs should be filled out completely with all pertinent data recorded including completion dates and maintenance personnel signatures. There should be one completed PM sheet for each PM recorded as completed in the CMMS. In addition, all the findings identified during PM execution and requiring correction should be reflected in the generation of corrective work orders. Experience shows that an effective PM program will generate three corrective work orders for every 10 PMs performed.

Final score

The purpose of this assessment exercise is to learn about the effectiveness of the PM program and also the opportunities available for its improvement. The goal for any facility should be an effective program, which ultimately will translate into improved equipment reliability and plant profitability. **MT**

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