Proactive Reliability Maintenance

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ABSTRACT

The four terms reactive, preventive, predictive, and proactive are possibly the most widely used buzzwords in maintenance today. What do these terms mean? How do they relate to each other? Is reactive maintenance always a bad thing? Is predictive maintenance proactive in nature? What does proactive mean? Does proactive maintenance replace these other methodologies? This article sets out to answer these questions.

INTRODUCTION

Four of the most commonly used buzzwords in maintenance are reactive, preventive, predictive, and proactive. This article sets out to explore the true meaning of these terms and their relationship to each other.

Many companies now aspire to adopt proactive maintenance. This implies a "forward looking" process. So how is this achieved, and how do the more traditional maintenance methodologies interface to this philosophy? This article sets out to explore these questions.

Reactive Maintenance

The term reactive maintenance is frequently used in place of the term breakdown maintenance. For many people this represents an absence of any organized maintenance strategy. By its very nature breakdown maintenance is therefore a reactive process. Perhaps because of the term's wide use in that context the notion of "reactive" maintenance is often regarded in a negative light, being seen as representing a lack of maintenance planning and control. Inevitably most plants, irrespective of their aspirations in terms of maintenance philosophy, will be subject to some degree of breakdown maintenance. Machines are, after all, built, operated and maintained by people, and people do make mistakes. Machines being operated outside their performance envelope, or maintenance activities being inadequately completed, etc will cause breakdowns. Some interesting facts are relevant here. Experience suggests that:

- The DIRECT COST of machinery repairs undertaken during breakdowns is at least 3x greater than the cost of planned repairs.

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- PRODUCTION OUTAGE TIME needed for the completion of an emergency repair is 3x to 5x than that needed for a planned repair.

So, breakdown maintenance is an inevitable aspect, and a necessary component of a reactive approach, but the terms are not synonymous.

Reactive maintenance can also indicate a conscious decision to adopt a Run-To-Failure (RTF) policy for selected plant items. These items would typically be machines with a low impact on failure risk, and where the maintenance cost would exceed replacement cost. Some refer to such machines as "throwaway" machines, and to this approach as “throwaway maintenance.” Most plants will include some simple, non-critical systems where such an approach to maintenance would be financially justified. There is, though, an important distinction to be drawn between RTF and the concept of throwaway maintenance. Although based on the same fiscal logic, the concept of "throwaway," machines can have a negative effect on attitudes towards them. If the machine is ultimately going to be discarded then are precision practices warranted for its installation? Improper or inadequate installation will lead to premature failure. The "throwaway" concept can also lead to components being bought "on price" at the expense of quality. This again can mean that shorter life is achieved, creating a vicious circle of repeated failures. Even in a run to failure maintenance program precision maintenance skills and quality components are important drivers [1].

Reactive maintenance is not just about reacting to machine failure. Some maintenance decisions can be influenced by a reaction to operational pressures or other organizational issues. For example, production pressures may cause a repair to be limited to replacing a bearing in order to return the machine to production as quickly as possible, when in fact the complete repair might also require shaft resurfacing, attention to lubrication issues and / or other considerations. This form of reactive maintenance sometimes results in machines being put back into service in an "as good as old" rather than "as good as new" state.

Reactive maintenance may also occur in response to predictive maintenance (PdM, or condition monitoring) activities. The ideal outcome from a PdM activity is the generation of a "planned" maintenance task, aimed at avoiding consequential risk and scheduled so as to minimize impact on production. Frequently, however, production pressures preclude implementation of the recommended activity, and so maintenance must be prepared to react to the breakdown that they know is coming.

In summary, adoption of a reactive approach "by default" does reflect a negative attitude towards maintenance. However, reactive maintenance undertaken knowingly and for the right reasons does represent a positive step in the maintenance management process. Reactive maintenance is an inevitable component in the blend of maintenance strategies required by most plants, and as will be seen later in this text, it can represent an integral part of a proactive approach.

Preventive Maintenance

A number of terms are used to describe the various activities that can be included under this general heading. These include:

- Planned maintenance
- Scheduled maintenance
- Calendar-based maintenance

- Time based maintenance

The term preventive maintenance can be used to describe any activities that are undertaken in the hope of avoiding machinery breakdowns. It seems intuitively obvious that assets that receive necessary and timely maintenance will run longer, better, more reliably and at lower cost. The range of individual activities covered by the term is diverse, and may include some tasks routinely undertaken whilst the plant is operating, e.g. watch-keeping activities, and other tasks that require the machine to be stopped in order to carry them out, e.g. periodic strip-down and overhaul. Preventive maintenance, then, can be disruptive.

Experience also shows that it can to some extent also be destructive. Conformance with planned maintenance schedules frequently requires that machines that are performing satisfactorily be shut down for maintenance. Unfortunately it is not uncommon for those machines to be returned to service in a "worse than before" state, due to some inadequacy in the maintenance process. Problems may include:

- Failure to correctly follow procedures / instructions

- Non-availability of recommended spares, resulting in re-use of old components, or use of inferior quality alternatives

The outcome of these issues is that these machines subsequently may have to be taken out of service in order to correct the faults induced by bad maintenance.

The potential pitfalls of PM programs are well documented, particularly by proponents of predictive maintenance systems. However, the pitfalls are greatly outweighed by the benefits offered in terms of risk reduction. Preventive Maintenance comprises a major component in the total maintenance strategy of most organizations.

Time Intervals For Preventive Maintenance

Preventive maintenance activities are by their nature time based, either according to the calendar or to hours-run. The time interval between such activities may be determined by a number of factors.

Regulatory Conformance

Various regulatory bodies have stringent requirements for preventive maintenance.

Machine Manufacturers' Recommendations

Suppliers of industrial plant usually have a vested interest in ensuring that their customers achieve expected levels of performance and reliability from their machines. The manufacturers' recommendations for preventive maintenance is usually based on practical experience gained in the field, and their suggested frequencies for inspections and overhauls usually carry a good weight of authority for these reasons. Machinery manufacturers also have a vested interest in protecting themselves from warranty claims, and so documented conformance to recommended preventive maintenance schedules is frequently a warranty condition.

Cases have also been known where manufacturers have bought business by offering low purchase price, expecting to recover eventual profit through sales of recommended spares and services.

Past Operating History

Time intervals for preventive maintenance activities are frequently based on knowledge of past plant performance. In some cases the assessment of this history is relatively superficial and subjective (gut feel based on experience). In other cases the assessment is more formal, perhaps utilizing Mean Time Between Failure (MTBF) calculations.

Predictive Maintenance

Simple plant inspection programs (perhaps undertaken by operators) are sometimes included in this category, but unless some form of objective technology is employed to quantify machine condition then such inspection programs are more correctly included under the "preventive" heading.

The term Predictive Maintenance is used to describe a range of technologies employed with the aim of detecting developing machinery faults at an early stage before they constitute a problem, thereby predicting the need for specific and targeted maintenance activities. This is forward looking, so is this "proactive" in nature? Some see adoption of a predictive approach as the embodiment of a "proactive" philosophy, but there is more to it than that.

Some would argue that predictive activities generate reactive tasks, since they incite a reaction to detected change in machine condition. However, the maintenance tasks generated as a result of PdM activities are usually undertaken on a scheduled basis. Furthermore these tasks are undertaken to prevent a fault from developing into a problem. These facts, combined with the realization that the monitoring activities themselves are usually carried out on time basis, suggest that predictive maintenance should be considered as a subset of preventive maintenance.

Proactive Maintenance

It is evident that none of the above methodologies provides the complete maintenance solution for an enterprise. The real solution lies in achieving the optimum blend of reactive, preventive and predictive maintenance.

The "Maintenance Wheel" (Figure 1) depicts such a composite program, and attempts to illustrate how the various methodologies interact with the corrective maintenance "core." The challenge here is to minimize the corrective core, and in particular it's "unplanned" segment, whilst at the same time optimizing maintenance cost / effort.

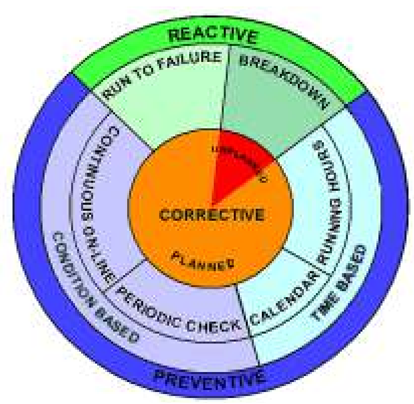

Figure 1 The Maintenance Wheel: Representative of a Composite Maintenance Program.

Employing the optimum blend of methodologies will have a significant impact on maintenance costs. Experience suggests that maintenance costs typically account for between 15% -40% of manufacturing costs. Studies have shown that in some cases as much as 50% of the maintenance being carried out was unnecessary. This implies then a potential saving of up to 20% of manufacturing costs! Studies also suggest that corrective maintenance accounts for between 20% -70% of total maintenance costs, and that corrective maintenance typically costs around ten times as much as predictive maintenance.

The optimum blend of methodologies is arrived at by means of a Maintenance Strategy Review (MSR), the function of which is to determine the optimum sizes for the various reactive and preventive segments (and sub segments) of the wheel. A variety of MSR techniques are commonly used for this purpose. Typically, selection of the MSR technique is driven by plant criticality. Such reviews may be qualitative (by means, for example, of a Reliability Centered Maintenance study [2]). As machine criticality (and financial risk) increases the more quantitative methodologies such as Risk Based Maintenance may be used [3].

This poses the next question. Having carefully arrived at this optimum blend of reactive, preventive and predictive approaches, have we thus created a "proactive" maintenance program?

The concept of proactive maintenance has gained a firm foothold in the engineering community in recent years.

In discussing this topic it is appropriate to begin with some clear definitions of what precisely is meant by this term.

Proactive maintenance is:

- The combination of operator-performed maintenance, preventive maintenance, and predictive maintenance activities whereby maintenance is conducted to prevent, eliminate, delay or reduce maintenance before failure [4].

- The application of analytical methods, tools, and techniques to eliminate failures, extend component life, mitigate consequences, minimize downtimes, and optimize all resources. It consists of systematic identification and elimination of potential problems in all aspects of reliability, availability and maintainability [5].

Proactive maintenance, then, is a process that utilizes the optimum mix of reactive, preventive and predictive methodologies, appropriate to the specific needs of the enterprise. However, the resulting composite maintenance program must then itself be subject to a stringent process of continual improvement and optimization.

In proactive maintenance the status quo is not an option. Proactive maintenance is forward looking, continually striving to bring reliability improvements and cost optimization. A proactive approach to maintenance will be a dynamic process, requiring continual, ongoing review of:

- The justification for individual maintenance tasks.

- The efficiency with which they were carried out.

- The effectiveness of those tasks on completion.

Improvements in maintenance practice that may be suggested by this process must be analyzed to ensure that any costs incurred in their implementation are justified in terms of the degree of plant reliability / productivity that they confer [6].

Tools to Support Pro-Active Maintenance

There are a number of tools that can help in this improvement process.

Root Cause Failure Analysis (RCFA)

Root Cause Failure Analysis (RCA) is a structured investigation that aims to identify the true cause of a problem, the cause-effect relationships, and the actions necessary to prevent its repetition.

These studies should be performed on all critical problems. To prevent the problem from recurring, the root cause(s) should be eliminated. It is essential to know cause-effect relationships to prevent problems from recurring. The output of an RCFA study is in the form of recommended actions [7].

Improvement activities resulting from RCFA studies may include not only machine design improvements, but also targeted training for operations or maintenance staff, and /or provision of specialist equipment for monitoring / maintenance of relevant machinery.

Failure Modes and Effects Analysis (FMEA)

The assessment of these actions is generally not addressed within the RCFA context. These would typically be the subject of an FMEA process, whereby possible actions are assessed after their effect, in terms of risk mitigation.

Failure Mode and Effect Analysis (FMEA) is a systematic method of identifying and preventing product and process problems. An FMEA focuses on preventing defects, enhancing safety, and increasing customer satisfaction [8]. By way of example, the outcome of an RCFA exercise might recommend a design improvement to eliminate recurrence of a problem. Application of FMEA to the new situation might then indicate that a modification to the established maintenance regime is warranted, perhaps, for example, replacing a timed PM task with some PdM activity.

Precision Maintenance Skills

During installation commissioning and maintenance best practices should be applied wherever possible. Application of precision alignment and balancing techniques will pay significant dividends in terms of reliability improvements. Ensuring that the maintenance workforce is equipped with the proper tools for the job and adequate training in their use, will not only pay dividends in terms of reliability improvements, but also offer timesavings in maintenance time and in many cases improvements in safety too.

Operator Driven Reliability (ODR)

Effective operator involvement in watch-keeping and monitoring will provide timely warning of a variety of impending problems. Implementation of a full ODR program, whereby operators accept responsibility for undertaking simple maintenance tasks themselves offers potential for further significant cost savings and reliability improvements [9].

Plant Access

Access ladders / platforms, lifting points etc should be provided where appropriate to ensure that maintenance tasks can be carried out safely and without undue delays.

Purchasing and Spares Holding

Relationships between maintenance and purchasing teams should be scrutinized to ensure that departmental goals do not conflict. For example, if the purchasing department is attempting to reduce expenditure, and therefore buy components on price at the expense of quality, then this can have a rapid and serious impact upon plant reliability and hence perceived maintenance effectiveness. Similarly, in a reactive maintenance environment, ill-considered reduction in spares inventory can result in extended downtimes due to non-availability of required parts.

Key Performance Indicators (KPIs)

KPIs are an indispensable tool in any continual improvement process. A structured family of KPIs should be established, starting with the business goals of the enterprise (typically financial in nature) and working through the organizational hierarchy down to functional KPIs that shop floor staff can more directly relate to [5,10].

Decision Support Systems (DSS)

Experience is indeed a wonderful thing. Someone once defined it as being "that ability we have to recognize a mistake the next time we make it." Practitioners of proactive maintenance value experience and endeavor always to capture and learn from it. The record keeping facilitated by modern Computerized Maintenance Management Systems (CMMS) is therefore a valuable, indeed essential component in a proactive approach to maintenance. However, most such systems capture data rather than experience. Increasingly such systems are being supported by decision support software, which not only speed the decision making process, reducing reaction time to plant problems, but which also help avoid the repetition of past mistakes and the associated consequences in terms of cost, downtime, and lost profit. One recent study showed that Fortune 500 companies stand to lose some $31.5 billion by 2003 due to re-work and the inability to find information [11]. The potential ROI on such systems is considerable, and they will undoubtedly become an invaluable aide to proactive maintenance practitioners.

CONCLUSION

Reverting to the analogy used earlier in this article, proactive maintenance provides an effective "tire" for the "Maintenance Wheel."

A wheel provides a means of transport, but by enclosing it within a tire we get a faster, safer and smoother ride. It adapts to changes in road conditions, and allows faster cornering to avoid collisions with reduced risk of skidding completely off track.

Figure 2: The "Proactive Tire."

Proactive maintenance, then, is not some new methodology that replaces established preventive, predictive or reactive process. Indeed these established processes, including reactive maintenance, are important, fundamental components of a proactive approach to maintenance.

Proactive maintenance is a structured and dynamic process to ensure that the correct blend of maintenance methodologies is applied, and that the resulting mix is continually optimized in light of experience gained, to meet the changing needs of the business. It is a dynamic process, constantly evolving to provide the enterprise with ever-higher levels of plant reliability to support the business in increasingly competitive markets.

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