Reliability Centered Maintenance – Part I

An Online Continuing Education Course for Engineers

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Introduction

Reliability-centered maintenance (RCM) is employed by thousands of organizations worldwide to address a host of reliability issues to improve overall equipment effectiveness while controlling the life-cycle cost. This course provides tools to assist organizations in implementing and institutionalizing an RCM approach to achieve and maintain world-class facilities.

In the past, organizations commonly used a *Preventive Maintenance* (PM) program, which is based on the following:

> "One of the underlying assumptions of maintenance theory has always been that there is a fundamental cause-and-effect relationship between scheduled maintenance and operating reliability. This assumption was based on the intuitive belief that because mechanical parts wear out, the reliability of any equipment is directly related to operating age. It, therefore, followed that the more frequently equipment was overhauled, the better protected it was against the likelihood of failure. The only problem was in determining what age limit was necessary to assure reliable operation."

Preventative maintenance assumes that failure probabilities can be determined statistically for individual machines and components and that replacing parts or performing adjustments in time can often preclude failure. For example, a common practice has been to replace or renew bearings after a specified number of operating hours, assuming that bearing failure rate increases with time in service. The introduction of computerized maintenance management systems and the availability of computers solved the problem of when to overhaul many types of equipment to assure required reliability.

Maintenance and operations, failure and reliability data being reported by airlines highlighted problems with this approach. Specifically:

> "In the case of aircraft, it was also commonly assumed that all reliability problems were directly related to operating safety. Over the years, however, it was found that many types of failures could not be prevented no matter how intensive the maintenance activities. Moreover, in a field subject to rapidly expanding technology it was becoming increasingly difficult to eliminate uncertainty. Equipment designers were able to cope with this problem, not by preventing failures, but by preventing such failures from affecting safety. In most aircraft, essential functions are protected by redundancy features which ensure that, in the event of a failure, the necessary function will still be available from some other source. Although fail-safe and "failure-tolerant" design practices have not eliminated the relationship between safety and reliability, they have disassociated the two issues sufficiently that their implications for maintenance have become quite different. "

A significant question remained, however, concerning the relationship between scheduled maintenance and reliability. Despite the time-honored belief that reliability was directly related to the intervals between scheduled overhauls, searching studies based on actuarial analysis of failure data suggested that the traditional hard-time policies were, apart from their expense, ineffective in controlling failure rates. This was not because the intervals were not short enough, and surely not because the tear down inspections were not sufficiently thorough. Instead, it was because, contrary to expectations, for many items, the likelihood of failure did not in fact increase with increasing operational age. Consequently, a maintenance policy based exclusively on some maximum operating age would, no matter what the age limit, have little or no effect on the failure rate.

Figure 1 shows the failure distribution of a group of thirty identical ball bearings installed on bearing life test machines and run to failure, using standard test procedures. The X-axis identifies the individual bearing being tested while the Y-axis is the number of revolutions achieved before fatigue failure of the individual bearing. The wide variation in bearing life precludes the use of any effective time-based maintenance strategy.

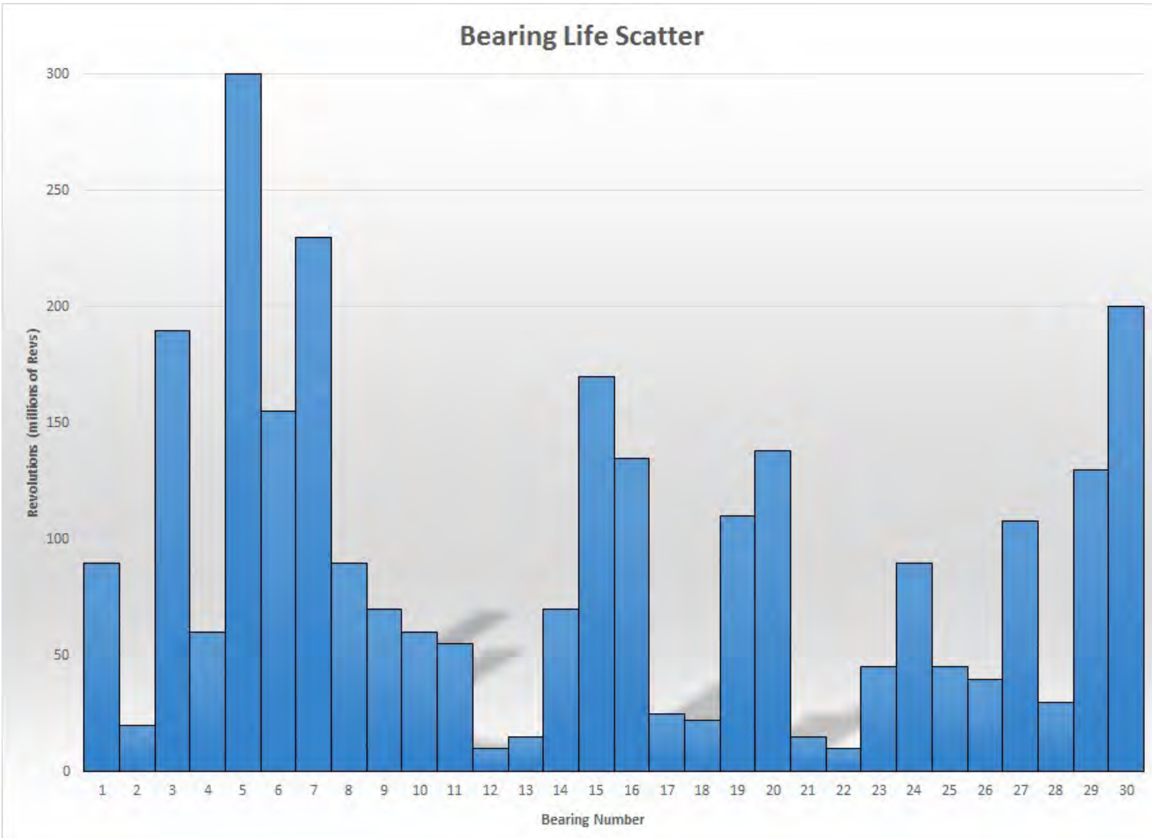

Figure 1

By the 1980s alternatives to traditional Preventive Maintenance (PM) programs began to migrate to the maintenance arena. While computer power first supported interval-based maintenance by specifying failure probabilities, continued advances in the 1990s began to change maintenance practices yet again. The development of affordable microprocessors and increased computer literacy in the workforce made it possible to improve upon interval-based maintenance techniques by distinguishing other equipment failure characteristics. These included the precursors of failure, quantified equipment condition, and improved repair scheduling.

The emergence of new maintenance techniques called *Condition Monitoring* (CdM) or Condition-based Maintenance supported the findings of F. Stanley Nowlan, Howard F. Heap, and others while revealing the fallacy of the two fundamental principles in traditional PM programs:

- A strong correlation exists between equipment age and failure rate.
- Individual component and equipment probability of failure can be determined statistically, and therefore components can be replaced or refurbished before failure.

Subsequently, industry emphasis on Condition-based Maintenance increased, and the reliance upon PM decreased. However, Condition-based Maintenance should not replace all interval-based maintenance. *Interval-based maintenance* is still appropriate for those instances where an abrasive, erosive, or corrosive wear takes place; material properties change due to fatigue, embrittlement, or similar processes; or a clear correlation between age and functional reliability exists.

While many organizations were expanding PM efforts to nearly all other assets, the airline industry took a different approach and developed a maintenance process based on system functions, a consequence of failure, and failure modes. Their work led to the development of *Reliability-Centered Maintenance*, first published in 1978.

In 1982 the United States Navy expanded the scope of RCM beyond aircraft and addressed more down-to-earth equipment. These studies noted a difference existed between the perceived and natural design life for the majority of equipment and components. In many cases, equipment greatly exceeded its perceived or stated design life.

Development of relatively affordable test equipment and *computerized maintenance management software* (CMMS) during the last decade has made it possible to:

- Determine the actual condition of equipment without relying on dated techniques which base the probability of failure on age and appearance instead of a condition.
- Track and analyze equipment history as a means of determining failure patterns and life-cycle cost.

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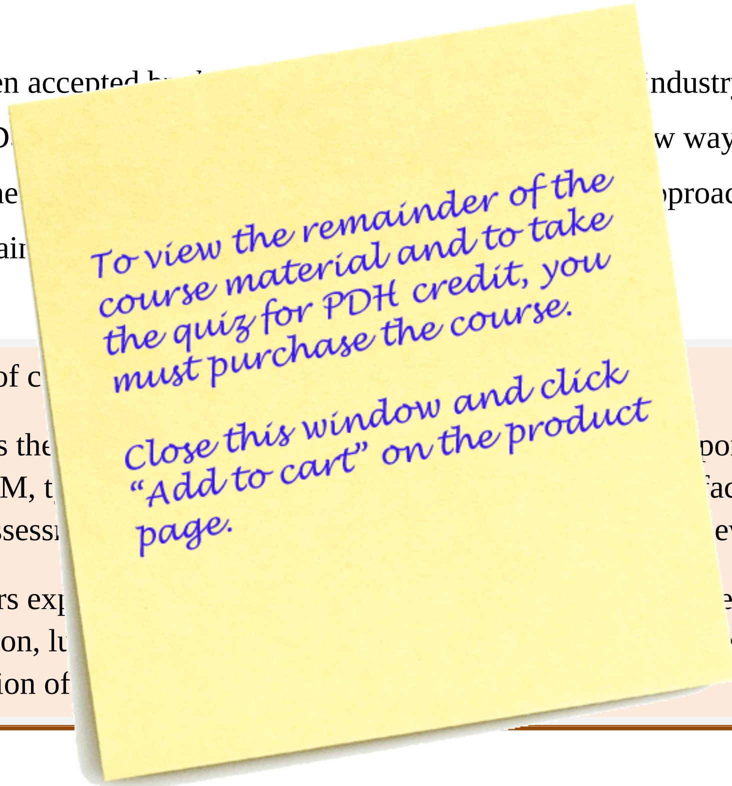

This series of c…

Part I covers the … ponents of RCM, types of RCM, t… facilities condition assess… ewed.

Part II covers ex… edictive testing and inspection, lu… nitoring, and the application of…