The Dilemma – To Call or Not to Call

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If you observe a change in machine condition and report this change to maintenance,

AND if maintenance disassembles, inspects and reassembles the machine without finding an observable defect,

THEN *there is no value in Predictive Maintenance*.

OR, if you monitor the changing condition of a machine until there is no doubt of imminent catastrophic failure,

THEN the fault is easily detected by the human senses

AND *there is no value in Predictive Maintenance*.

OR the machine does fail catastrophically and the question is, "Why didn't you report this?"

AND *there is no value in Predictive Maintenance*.

We have all experienced this dilemma and have to live with it. Its resolution directly determines the long term success of a Predictive Maintenance Program, which operates on every level of the organization. With strong management support, Predictive Maintenance can be forced upon the organization. But, the dilemma remains and the value of Predictive Maintenance is still in question. However, if the mechanic sees the value of Predictive Maintenance, then Predictive Maintenance is universally understood throughout the organization as being a core value.

There are three scenarios in this dilemma – no observable fault discovered, fault is observable to the casual passerby, and failure without warning. We will look at each scenario individually and discuss the merits of the supposed conclusion (*no value in Predictive Maintenance*). We will then propose a method to marginalize the dilemma.

A dilemma, by definition, compels a choice between two or more unsatisfactory results. Ours is to say nothing and allow machines to fail, or speak too often and work on machines needlessly. Neither provides value to a company.

It is frustrating to the analyst because the technology allows us to determine a change in machine condition well in advance of the ability of the human eye or sense of touch to detect. In bearings, for example, the defect begins sub-surface and progresses to the microscopic before becoming visible. Once visible, time-to-failure is very short. It frustrates the mechanic to replace seemingly perfect bearings on a seemingly perfect machine. Often, the mechanic believes that the disassembly, cleaning, inspection, replacement and re-assembly was a complete waste of time. However, the vibration analysis reveals a completely different story. The trend plot shows lower overall vibration levels, the defect frequency is absent in the spectral plot, or both. This information should be shared with the mechanic whenever possible. It will not make them vibration analysts, and it probably will not convince them that the work was worthwhile, since it was not a change that was discernable to the touch, feel or eye of the mechanic. However, it will let the mechanic know that there was a reason for the work and a result from the work. There is some truth to the saying, "Seeing is believing." Show them something they can see.

The analyst could continue to monitor the condition of the machine and allow the fault to progress, which has some merit. It allows more run time on the machine, increasing availability numbers. It extends the time between failure, which is another benchmark to measure the effectiveness of the Predictive Maintenance Program. It also has a positive impact on production and capacity numbers. In a perfect world, we would want to get all the remaining life out of the defective component. While we should strive to achieve these results, we must do so cautiously and within reason.

We all know that failures do not follow a linear progression. The closer to failure we get, the more rapidly failure is upon us. We can, under some conditions, detect minute defects in our machines. As these defects become more defined, the time-to-failure becomes shorter. It would always be better to wait until a defect is obvious during cursory inspection. This will maximize runtime, but not without cost:

- Running slightly longer causes collateral damage, increasing the cost of repair.
- Running a little longer causes the machine to exhibit symptoms of noise and heat that are detectable by the human senses.
- Running too long causes catastrophic failure.

None add value to the Predictive Maintenance Program. More importantly, they create doubt about the capability of the Predictive Technology and the ability of the analyst.

The goal is lofty and rarely attainable: shut the machine down at exactly the right time and replace only the single component that started the failure scenario. We, in the Predictive Field, have been done a grave disservice by the ones who first coined the term "Predictive Maintenance." For one thing, there will always be the occasional random failure. For another, it is all but impossible to predict the time-to-failure from onset of the fault. Machines do not fail in a linear fashion.

The analyst does not want to replace a bearing with remaing life any more than the mechanic. There are tools available to the analyst that will allow them to reasonably approach the expectation of the mechanic. There are several methods to alert or 'alarm' the analyst to a change in machine condition. Properly applied, there will be a minimum of random machine failures.

The most easily understood of these alarming methods is the overall amplitude alarm. If the amplitude increases to a certain level, then the machine is said to be running rough and in need of repair. Many people have devised many charts to divine what are acceptable and unacceptable amplitudes. A few have developed charts specific to certain classes of machines. None of the charts is designed for my particular machines, mounted on my particular pedestals, under my particular load conditions. This is true for everyone and every machine. Although the same, they are different. There is a better way, but it takes time, effort and patience.

Using historical data, a statistical method can tailor amplitude level alarms to specific machines. The longer the method is in place and complied with, the more accurate the method becomes. I will not bore you with a detailed discussion of statistics because software is readily available to perform the calculations.

Briefly, the method can be summarized as follows. Take the average or mean amplitude for a measurement point and add two standard deviations to set the 'Alert' level alarm. Add three standard deviations to set the 'Danger' level alarm. The more data you have, the more accurate the result will be. The more accurate the data, the more accurate the alarms. In other words, take the data at the same place, in the same way, under the same load conditions every time. At least six months of data are required to have confidence in this method. If the data are collected every 30 days, you will have six data points for every location.

The first alarm setting is to prompt the analyst to greater vigilance. Data will be collected more often and different kinds of data will be taken. This may take the form of high resolution data, or high frequency data, or performance data, or in-

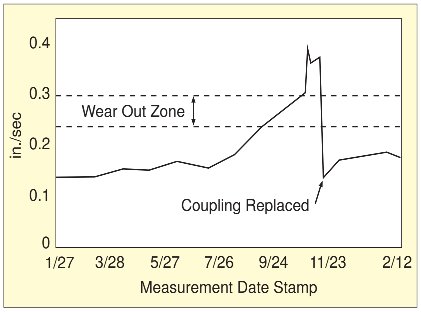

Figure 1. Plot of wear-out zone.

frared data, etc. This is an attempt to gather enough information to correctly diagnose the machine fault. When the second alarm level is reached, a work order is created.

This philosophy allows some run time between the detection of the fault and the actual maintenance. It allows time to improve the accuracy of the diagnosis and provides a comfort zone to the analyst. There is some assurance that an observable fault will be found by the mechanic. Increasing monitoring until the second alarm level is reached increases the confidence that the machine condition has deteriorated to the point that maintenance is required. In other words, a wear out zone is established between the first and second alarm levels (see Figure 1). This philosophy reflects the analyst's desire to detect a fault as early as possible and the expectation of the mechanic to work only on those machines that have obvious defects.

Experience shows that this method works well – most of the time. There are a couple of situations where caution is needed. For instance, the statistical method assumes a machine to be in good condition at the beginning. An unhealthy machine could very likely fail before six months of data are collected. Published severity charts can minimize this risk. Another alternative is to collect data on a population of similar machines and apply the statistical method. The opposite may also be true. An extremely smooth running machine with a very small standard deviation may not allow enough wear-out zone. In this case, maintenance might be performed before the defect becomes visually observable.

In either case, time and history will cure both problems – time to gain experience, time to collect data, and time to gather feedback. It takes time to build confidence in a Predictive Maintenance Program and it takes time for the Program to mature. Consistently applying this statistical method will enable that. We may never be able to completely solve our dilemma to the satisfaction of all, but by correctly setting expectations and alarms, we will be able to demonstrate the value of a good Predictive Maintenance Program. S/V

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