Ron Moore - Definitions of reactive, preventive, predictive, and proactive maintenance

A question was posited at the open forum at the Society for Maintenance Professionals (SMRP), asking about the categories, definitions, use, benefit and measurement of various forms of maintenance, such as preventive, predictive, and corrective. This paper aims to offer some observations and suggestions in response to this query. For several years now, I have used the following categories and definitions, which includes the consideration of time, though the specific definitions and use for each may vary depending on a given organization's particular needs.

1. Reactive Maintenance: This can be described as run to fail, emergency, breakdown, or urgent, among others. My definition is that it is any work that you do this *week* that wasn't in your plan when you developed it last week—it's unplanned/unscheduled, and it breaks into your schedule. Add to that any available workforce you hold in reserve "just in case". For example, you only schedule 80% of the available workforce, "knowing" that it is common to have breaks in your schedule. You may "plan" it this way, but it's still unplanned/unscheduled, and therefore, reactive! Some may use work orders, others labour hours, others cost. I believe a good indication is labour hours, since it amounts to actual amount of work done. So, if 20% of your labor hours were spent breaking into your schedule, and another 20% was held in reserve, that is, unscheduled, your reactive maintenance level is 40%—pretty ordinary performance. Incidentally, I'm of the firm belief that you should schedule 100% of the available labor hours, BUT allow breaks to the schedule. You'll get more work done because you expect to do more work, and you'll make better decisions about what truly deserves to break your schedule.
2. Preventive Maintenance: This is periodic time-based, either calendar time or run-time, though most often it's the former. In this approach, you're doing tasks that help maintain the proper condition of the equipment to ensure that it is available when needed. The best examples here include inspections, filter and lube changes, calibrations, routine adjustments, etc., but generally should NOT include time-based replacement, unless you have data to substantiate that approach. Those of you who study reliability centered maintenance (RCM) will understand that you should minimize **intrusive** time-based maintenance, since most equipment fails randomly, and only apply that approach in specific justifiable circumstances, such as when you have a wear- or age-related failure mode for which you have data that validates the need for time-based replacement. Examples of this might include wear on a slurry pump impeller, brushes on a DC motor, and drill bits, IF consistently operated as to running hours and if you have consistent operating and maintenance practices. These and other variables can induce variation in the failure pattern and suggest using a condition-based approach.
3. Predictive Maintenance: This is condition-based. In fact, I much prefer the phrase "condition-based maintenance". "Predictive" implies that you can predict when something will fail, which is highly problematic: You can detect the defect, the severity of its condition, and the rate of failure, then make a judgment about its consequence of failure in order to give you a sense of priority, but it's more difficult to determine the timing of the failure. This approach is often done through the use of predictive maintenance tools such as vibration, oil, and ultrasound and infrared inspection and analysis, allowing you to detect a problem early on, then plan and schedule the corrective action so as to minimize the consequence of the pending failure. Importantly, however, it also includes operators conducting "look, listen, feel, smell" as well as observing the process condition and performance to identify when defects are developing. Several experts say that operators can detect as much as 40% of the defects in equipment using this method.
4. Proactive Maintenance: This is root cause-based. It involves work that you do to eliminate the source of the defect that caused the failure or to extend equipment life. More importantly, in my world, it is not restricted to maintenance, though proper maintenance is an essential part of it, e.g., precision alignment and balancing, quality build plans, lube filtration, etc. That said, my view is that proactive maintenance is anything you do to avoid failures or extend equipment life, i.e., designing for reliability and ease of operation and maintenance, procuring for total cost of ownership (vs. just

cost), storing to retain reliability and quality parts, operating with care and discipline in startup, shutdown, general operation, shift consistency, etc. And, of course, precision maintenance is essential. If we expect to have reliability, we must eliminate or effectively manage all the defects in our system, irrespective of the source.

5. Corrective Maintenance: This is pretty self-explanatory. It's the work you do to restore the equipment to a condition that is like-new. It can be reactive—do it now; or preventive/time based—do during the next shutdown; or predictive—do it next week, after you've had time to plan and schedule the work to make it more efficient and effective; or proactive—not only are you going to restore it, you're going to improve it through changes you make to the design, operation, or maintenance. An essential point here is that the more we work to eliminate the defects creating the problems in design, procurement, operations, and maintenance (and giving people the proper tools and training), the less corrective work we will need to do. We will also get better production, better maintenance, lower costs, better quality, and, last but not least, fewer injuries.

As with most things, however, the devil's in the detail, and in this instance, I'm frequently asked about how to set standards for these definitions on the shop floor. The short answer is that you get to define them as you wish according to your specific operating circumstance, then work to improve them. The most important thing is to **minimize the amount of reactive maintenance** (the best plants I've seen are less than 10% reactive) and to apply a model that is heavily focused on doing preventive maintenance (PM), predictive maintenance (PdM), and proactive maintenance (PaM), as described above, in a cost-effective way. It's also generally better to do more condition-based repairs, replacements, overhauls, and so on, than it is to do time-based repairs, replacements, and overhauls. In any event, the right amount of these "better" three categories requires judgment in light of your business objectives, systems, etc.

Now, let's consider some common questions. Before providing answers, I should note that there are no correct answers in the absolute sense. Again, the key is to establish reasonable definitions that work for you, then work to improve from there. For example, some companies lump together routine PM (lubes, inspections, calibrations, filter changes, etc.) and PdM (a form of inspection using more advanced technology). I tend to agree. As for the common questions, here are my answers:

1. **What is reactive maintenance?**

See the above comments. That is, if the work is not to be considered reactive, you had to have known about it and planned and/or scheduled it *at least* a week ago. Some people use a shorter interval, while others use a longer interval. It's your choice, but in general, any time you break into your weekly schedule, you're doing reactive maintenance. Add to that the labor hours you don't schedule in a given week.

2. **Is vibration analysis a PM or PdM activity?**

I would call periodic PdM (such as vibration, oil, thermography, etc.), data collection, and a PM (it's a time-based inspection, though using more advance technology). BUT, I would call any work done as a result of the inspection wherein we found a problem or fault to be a condition-based or PdM effort, so long as you have at least a week to plan and schedule the work. If you have to do it in less than a week, it's reactive. Note that RCM principles generally lead to doing mostly condition-based maintenance. You inspect to find a potential problem, then do the maintenance before the potential problem becomes a functional failure. The inspection is a PM and the work resulting from finding a problem is a condition-based activity that minimizes the consequence of failure.

3. **What about "look, listen, feel" efforts? Are they a PM, PdM, or nothing at all?**

If it's being periodically done by the maintenance technicians, I'd call this a PM (time-based inspection). If it's being done by the operators, I'd put it into the shift log or other appropriate document. I would put the findings from these inspections that indicate a problem or maintenance requirement into the condition-based maintenance or PdM category—we found a condition that needed correcting, hopefully after appropriate

planning and scheduling a week in advance, as well as minimum consequence—lower costs and less downtime. Otherwise, it's reactive.

4. **What about, for example, replacing a bearing during a "maintenance window" after a PdM survey (inspection**)?

I'd put this into the PdM category—we found a condition that needed correcting and had enough for planning and scheduling a week or more in advance, again with minimum consequence to costs and downtime.

5. **What about replacing a bearing immediately, finding it to be hot or having spun it around during a routine inspection PM? What about other components that are found defective during an invasive inspection?**

I think I'd stop invasive inspections unless it was the only way or a statutory requirement, and I'd stop spinning bearings by hand, since we're generally more likely to introduce defects into bearings and other equipment by doing such invasive inspections. BUT, if this isn't possible, I'd call the inspection a PM, but the work that resulted in a repair from finding the defect a reactive maintenance effort, given that the work needs to be done immediately. It's reactive if we found the bearing in such a condition that it needed immediate attention, and it has little or no planning or scheduling attached to the work. If we can wait a week or more, I'd call it a condition-based, or PdM, effort.

6. **What about changing the way we operate or changing the design of our equipment to eliminate the defects or problems?**

I'd call this work proactive. It may not be maintenance per se, but it is proactive—you're eliminating the source of the defect that resulted in the failure and maintenance work, using better design, procurement, shutdown, installation, startup and commissioning, and operating practices. Recall that RCM studies indicate that some 67% of equipment has the infant mortality failure pattern, i.e., the highest risk of failure and/or inducing defects is during startup and notionally during the first 30 days thereafter (it might be five minutes for an electronic component or one year for a transformer), after which the risk of failure is very low but also random. It is also noted that one chemical company found that they were 7–17 times more likely to incur defects and failures during startup than during normal operation. Hence, it is critical that we have excellent practices for shutdown, installation, startup, and commissioning to minimize that risk.

What about precision alignment and balancing for maximizing equipment life and performance, particularly when it's done during a condition-based maintenance repair?

I'd call this work proactive work (if you can distinguish the costs in your system). If not, categorize it as condition-based.

In conclusion, I'd like to repeat that the key is to adapt these suggestions to your organization and establish reasonable definitions that work for you, then work from there to improve your processes. All this requires a focus on defect elimination—stop doing the things that result in failure or premature wear, such as changing your operating practices, changing your installation and startup practices, changing your design, and improving the precision and craftsmanship in your maintenance efforts. Beyond that, it is essential to do lots of condition monitoring to detect problems early enough to be able to manage them and minimize their consequence. From time to time, it's okay to let things run to fail if the consequences are inconsequential.

These are my thoughts, and I hope you find them useful.