Precision Maintenance Concepts
How to save maintenance dollars on a tight budget

By John Lambert

These are basic maintenance strategies or programs. Which ones do you think will save you the most money?

Reactive Maintenance
Preventive Maintenance
Condition Monitoring
Predictive Maintenance
Proactive Maintenance
Precision Maintenance

I have added condition monitoring and precision maintenance to the mix because they have also become common place in the maintenance industry. They all work – even Reactive maintenance is a good practice for some machines (assets) – you run it to failure and toss it away. Its not worth maintaining or repairing.

Unfortunately many companies practice a form reactive maintenance but its not by choice. It’s where they react to a breakdown and have to do a repair in order to keep the plant running. It’s also known as “fire-fighting maintenance” but I used to call it “adventure maintenance” back in the days when I was doing it, each day was an adventure!

However, I still believe that a combination of these basic programs gives you the best return for your efforts. These basic maintenance strategies do work and you are probably using some of them already. For instance, a preventive maintenance program (PM’s) is a great structure to build a condition monitoring program using predictive instruments.
Yes, there are also many structured maintenance strategies such as Lean Maintenance but do they work? Ron Moore, author of *Selecting the Right Manufacturing Improvement Tools*, published a list of seventy five structured maintenance strategies or programs designed to improve your maintenance processes or as he called them, improvement tools. Some of them were:

- Total Productive Maintenance
- Reliability-Centered Maintenance
- Supply Chain Management
- Operator Maintenance
- Six Sigma
- Benchmarking

I know the answer to the question is yes they do work but only if they are implemented properly. I guess that stands to reason but if you think about what the implementation is, it’s just a way of organizing the end user (you) in the use of their structured system. It's also giving you a regimented procedure to follow – sort of like a personal coach at a gym.

Does that mean that if with some organization – a team with a plan – plus some discipline you can use the same tactic to improve your own maintenance effort? Following a maintenance strategy such as Reliability-Centered Maintenance will get you into the realms of *world class* or *best in class* maintenance. However, they are hard to implement and many companies have tried and failed. The reason they fail is that they take a lot of resource time, man hours, meetings, training, etc. And if you have a plant to run you can get short of man hours very quickly. These programs do work and you may not have the resources at this time but you can still do part of the program that is easier to implement such as a condition monitoring program.

If you don’t have one plan on doing it as soon as you can because it will save you down time and greatly reduce secondary damage. But best of all it can be as basic or as sophisticated as your budget will allow.

The premise behind condition based maintenance (and predictive maintenance) is, that most failures give some warning of the fact that they are about to occur.
Introduction to P-F Interval or the interval curve.

This warning is called a potential failure, and is defined as an identifiable physical condition which indicates that a functional failure is either about to occur or in the process of occurring.

Functional failure is defined as the inability of an item to meet a specified performance standard.

There are many different techniques to detect potential failures. You choose what is best for you. For instance, if you had a slow turning gearbox you may use oil analysis. The frequency of these inspections is determined by the P-F interval, which is the interval between the emergence of the potential failure and its decay into a functional failure.

The sooner a potential failure can be detected, the longer the P-F interval. Longer P-F intervals mean that inspections need to be done less often and more importantly more time is acquired, to take whatever action is needed to avoid the consequences of the failure. This is why so much effort is being spent on trying to define potential failure conditions and developing techniques for detecting them which give the longest possible P-F interval. This means that potential failure must be detected as early as possible. But the higher we move up this curve, the smaller the deviation from the "normal" condition. The smaller the deviation, the more sensitive must be the monitoring technique designed to detect the potential failure. But whatever techniques we use it’s still a measure of some kind and we all or should understand the importance of taking measurements.
To control a process you have to measure. If you can’t measure it you can’t do it. That which isn’t measured isn’t done.

Basic on-condition maintenance or Condition Monitoring techniques have existed as long as mankind, in the form of the human senses – sight, sound, touch and smell. The main technical advantage of using people in this capacity is that they can detect a very wide range of potential failure conditions using these four senses. However, the disadvantages are that inspection by humans is relatively imprecise, and the associated P-F intervals are usually very short (not quantifiable).

I draw your attention to sight, sound, touch and smell to point out the simplicity but we should all be aware that they are used every day for many inspections. What you need to do is add quantifiable measurement instruments as soon as you can. What instruments you use will depend on what you want to measure. For general rotating machines, vibration gives you the most information as to what's happening. However, don’t think that you have to start with vibration analysis, because you don’t. A simple meter with a vibration chart is a great place to start. You need to understand what you are measuring and all the ways you can use such a simple instrument before moving on. Note: if you don’t have a vibration reference chart e-mail us and we will send you one.

What to measure, according to John Moubray author of Reliability-Centered Maintenance II:

**Dynamic effects** - this would be energy emitted from machines in the form of vibration, shock pulses, or even acoustics.

**Particle effects** - could be in the form of contamination in oil as an obvious one.

**Chemical effects** - can be the leak detection of gases or fluids.

**Physical effects** - is the change in the structure of an item in the form of distortion, cracks, fractures, etc.

**Temperature effects** - obviously the monitoring of temperature changes.

**Electrical effects** - monitoring changes in resistance, conductivity, etc.
It’s you and your team who chooses what to measure so start simple and grow a maintenance team made up of well trained, conscientious, proactive employees. You will prevent more machinery break downs than any maintenance program – so invest in them and put the right tool in their hands and you have got something.

So a condition monitoring program is an inspection where the machine stays in service unlike a PM where we shut it down. We take quantifiable measurements that we record and trend. We monitor the trend and if there is a change in the condition of the machine, we will see it in the trend.

We still need a good PM program because it is hard, sometimes impossible, to inspect some machines as they are running. However, we can get a lot more information by unobtrusively monitoring our machinery without shutting them down. We do this using predictive maintenance instruments and techniques.

Condition monitoring does work. BUT…

If you inverse this curve and put a dollar figure against it you will see that the later the failure occurs the greater the cost, usually because of secondary damage. By that I mean: it’s one thing to replace a bearing, but if the bearing seizes onto a shaft, you now have to replace the shaft. And if that shaft is in a motor, you had better hope you have a replacement! Therefore, the cost of secondary damage can be huge so yes, Condition Monitoring does work and if done right it saves you lots of time and money. It saves you time to plan, time to schedule parts, and saves you downtime. It saves you the cost of man power, equipment as you control the outage. It’s cost avoidance = cost savings.
But it still does not prevent a failure.

If this line below is the machines life expectancy, the problem is that we don’t know when the potential failure (P-F curve) will occur.

If it happens here we call it premature failure.

If it happens here we call it random failure.

We would like it to happen here, at the end – but only at the end of its full life cycle.

The point is that failure is random and we don’t know when it will happen.

So Condition Monitoring can be successful by itself but will not improve your maintenance processes.
The “Bathtub” curve

This bath tub curve is a better example of the life of a machine. We have early failures sometimes just after start up or within a year or two (aka “infant mortality failures”). We have random failure which happens anytime and of course we have wear-out failures.

If you look at this curve long enough as I have, you will see that there is gold here. This is where the greatest saving of maintenance dollars can be made – the big bucks.

Lets say you buy a new car and you run it for 60,000k and the break pads need replacing. So you take your car to the local guy who replaces the pads and you run your car another 40,000k and guess what, the pads need to be replaced again. You still have wear out failure but not with the life expectancy that we expect. This means that just because your machine wore out, it doesn't mean you got the optimized life of that machine.

Early failures or “run-in” failures, what are they? We used to run machines in many years ago, but not now. They’re expected to start with a bang and to keep on ticking. Early failure is usually the result of poor maintenance practices, poor installation or poor workmanship.

Random failure does not happen if the machine is sized right, installed and maintained correctly.

Can you do something about this? Yes, you use Proactive maintenance and Precision maintenance.
Proactive Maintenance
It’s simple. It basically means that when you detect a failure in your condition monitoring program, you do something about it! More than just repairing, you have to find out what’s causing the failure and make the necessary changes to make sure it won’t happen again (understandably not always easy).

Ask the question WHY (Did it break down)?

Precision Maintenance
Also a simple concept. It means to work to a set tolerance that you, and your team agree on. The tighter the tolerance the better the result, but you cannot have a tolerance that you can not measure. Precision maintenance means “up-skilling” your people – getting the right tools but also the right training. It’s machinery acceptance standards, precision balancing, alignment of shafts, chains or belts, base flatness standards, the removal of machine stresses, etc. Most importantly it’s commissioning to a standard and documenting the process.

The answer to the question WHY is usually found in Precision Maintenance.

In a nut shell, to save maintenance dollars the machine has to be installed or re-installed using precision maintenance techniques if you want your machine to be before the curve.