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Top Six Tactics to Prevent Machine Failure

by Paul Berberian

In the Maintenance & Reliability community we discuss at length strategies and methods for preventing and predicting machine failure. There are many presentations, books and consultants available to teach the strategies for Predictive and Reliability-Centered maintenance programs.

This short tutorial offers 6 basic tactics for use in any maintenance program to further aid in the prevention of machine failure.

According to the US Department of Commerce, there approximately 12.4 million electric motors, 1hp and above, currently operating in industrial facilities in the United States. Close to 25% of these motors will fail this year. These tactics will help any company save money in maintenance by ensuring less machine failures. Operations will make money because there will be less production loss, downtime and scrap. Motors will run more efficiently, saving money on energy consumption and the reduction of the green house gas footprint. As legislation is introduced that taxes pollutants, toxic materials, and harmful emissions, organizations that reduce such issues will also reduce potential punitive costs.

Training, Documentation, Commitment

"Unless commitment is made, there are only promises and hopes... but no plans."
-Peter Drucker

"Excellence is an art won by training and habituation"
-Aristotle

A common thread through all of these tactics will be training, documentation and commitment. Everyone involved needs to be trained, not only how to perform these essential tasks, but also why it is important. Documentation will ensure that they do it correctly, every time. Commitment to follow through will keep the program going and produce long term results.

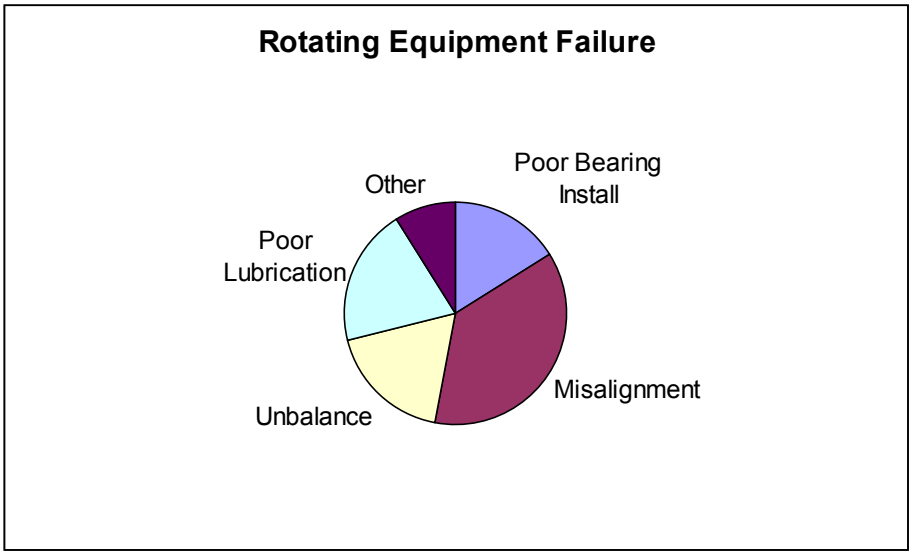
Training is readily available in our industry. Manufacturers and consultants offer on-site and classroom training for all of the disciplines we will be discussing. Do your homework and investigate your training options. Make sure you know what you want and what you are getting. Do you want training on how to use a certain product or to you want training to teach the entire process? Ask the potential trainer for a course synopsis and make sure it covers the topics you need. Ask the trainer if they are a practitioner!

Documentation is essential. It has been often said that people only respect what others inspect. Training ensures that things are done correctly and on time. Documentation can serve to highlight areas where more training is needed. It also provides a maintenance history for each piece of

equipment that can be valuable when trouble-shooting a particularly bad actor. And, sorry to say, documentation provides proof that the task was actually performed.

Commitment means buy in from every level – from the maintenance reliability professional to management. Commitment to make sure tasks are performed to schedule, commitment to provide proper training, commitment to not end the program prematurely if results do not come fast enough. There are short term benefits to be had from using these tactics, but in the end, this is a long term strategy.

The Top Five

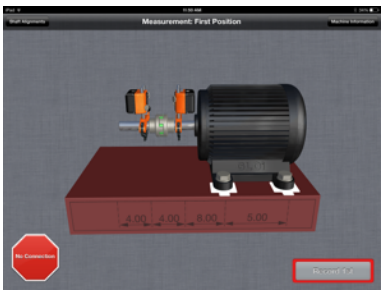


This chart identifies the main causes of failure in rotating equipment. Predictive programs can identify these problems, but training and commitment to do things right the first time, every time, will reduce them significantly. Commitment to eliminate these problems will improve the life cycle of any machine. If you are looking for a way to start improving your machine reliability, get committed to eliminating these problems.

Precision Alignment

"Industry worldwide is losing billions of dollars a year due to misalignment of machinery"

-John Piotrowski

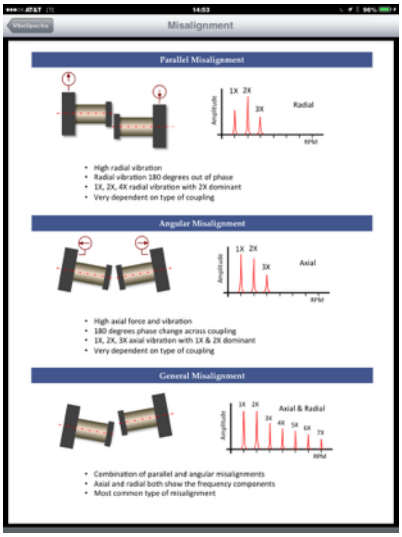


Misalignment is the #1 cause for machine failure. Misalignment occurs when the center lines of two shafts are not co-linear. Misalignment destroys bearings, seals, couplings, rotors, stators, shafts, etc. Misalignment of the driving and driven shaft(s) in a machine train adds stress forces to the shafts, which are transferred to the bearings, seals, etc. These forces work against all of these components to reduce the productive life of the machine. Misalignment will also create high levels of

vibration and friction. This can result in excess heat that can reduce the effectiveness of the lubricant. Excess vibration will result in shorter machine life and, in some cases, poor product quality resulting in scrap and waste.

Misalignment can be diagnosed using vibration analysis tools. There are distinct patterns that reveal the presence of misalignment.

- Angular misalignment is characterized by high axial vibration caused by the push/pull movement of the misaligned shafts.
- Offset misalignment is characterized by high radial vibration.
- Misalignment typically appears in the spectrum at 1 times and 2 times running speed.



There are many programs that still insist that a straight edge is sufficient for aligning two machines at the coupling. This may be acceptable for a rough alignment, but it is no replacement for a precision alignment tool.

Dial indicators can be a precise way to align shafts, but you must be well trained in the methods and the math. Laser alignment tools are a faster alternative to dial indicators. They are easy to learn with the proper training. Laser tools take the guesswork out of the alignment process by displaying the offset and angle of the shafts and calculating the necessary moves to correct the problem. While dial indicators are less expensive, laser tool kit prices have been coming down and are now a very affordable alternative.

Whatever tool you choose to use to correct misalignment, you still need to get alignment training. The tools are only measuring units. They show the misalignment and the necessary corrections, but they don't align the machine. Good alignment training includes more than just the how and when and why of using the measuring tool. Good training teaches the fundamentals, math and theory of misalignment, as well as, good strategies to use to align machines of all sizes and includes hands-on training. Make sure your trainer has real world alignment experience.

Good documentation is important in alignment. It is a record of who performed the alignment, when it was done and how well it was done. Documentation will also point out where additional training is required. Proper documentation should be electronic to prevent anyone from altering the document.

The commitment for alignment is to do it every time a machine is installed and make it a regular preventative maintenance step when machines are inspected. A quick alignment measurement can save a lot of headaches down the road.

Imbalance

"Mass imbalance is at the top of the list because it is the most common cause of vibration and the easiest to diagnose"
-Victor Wowk

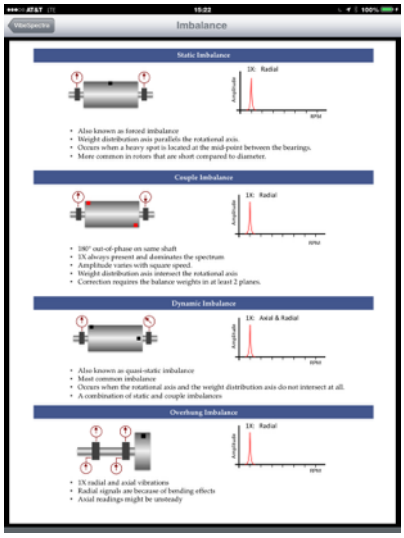
Think of imbalance as an imaginary heavy spot on a rotating shaft. This heavy spot is pulling the shaft and the center of rotation of the center line off the shaft on every rotation. The force of the imbalance is transferred to the bearing and case of the machine causing heat, friction, lubrication failure, and bearing faults. Extreme imbalance can cause looseness in the machine train.

There are many reasons for imbalance to be present in a rotor.

Deposit and build-up causes imbalance as deposits of dirt and grime build up on a rotor and its parts over time. The build-up of these deposits may be gradual, but not necessarily equal and can cause an imbalance condition. While the build-up may be gradual, the deposits will break away at an uneven rate causing a more serious imbalance. This can be especially true of fan blades. Fan blades will tend to collect deposits in a linear fashion, but the deposits will not come off at the same rate. They will come off in unequal pieces causing serious imbalance. Make cleaning of rotor, rotating parts and fan blades a regular part of your scheduled inspection and preventative maintenance.

Rotors can also be damaged when exposed to abrasive or corrosive materials. This will cause uneven wear and an imbalance condition. When you choose products, make sure their rotors are made from materials that can withstand corrosion and abrasion over long periods of time.

Eccentricity exists when the true or geometric centerline of a part does not coincide with its rotating center. This can be a manufacturing defect. Eccentricity can also be caused by out of roundness of the shaft, variations in electrical properties or uneven heating. With proper training, eccentricity can be measured with dial indicators.



Imbalance is characterized in the vibration spectrum by a dominant one times peak. Imbalance can be corrected in the field with balancing tools and proper training.

Special measuring tools and training are required to detect and correct imbalance. A best practice for helping prevent imbalance is to require all motors coming into your facility, whether new or rebuilt, to have a certificate of balance included. Set a standard and make your suppliers live up to it with documentation.

Make sure all of your millwrights, mechanics and technicians are trained to recognize and correct imbalance in the equipment they are responsible for.

Lubrication

"When it comes to oil analysis and lubrication, it goes without saying that execution beats brilliance."

-Jim Fitch

Lubrication is huge. Lubrication is used in rotating equipment to reduce friction between surfaces, prevent corrosion and wear and prevent contamination from outside sources. The proper lubricant at the proper schedule will allow the bearing to achieve its expected life and protect the inside of the machine from contaminants. This can be especially important in pumps where we don't want contaminants in whatever we are pumping.

Too often we hear that if a little lubrication is good, then a lot is great. In truth, over lubrication is just as bad as under lubrication. Ask any motor shop and they will tell you that many of the failed motors they get in for repair are packed end to end with grease. In the end, as most electric motors are air-cooled, they just overheat and die.

Training is paramount for proper lubrication. The wrong type of lubricant is just as bad as too much or too little. Machines should be tagged (color codes work well) with the type of lubricant required, the lubrication schedule and/or frequency and the amount of lubricant to be added each time.

The commitment with lubrication is to document the lubrication requirements of your machines and commit to a lubrication schedule. Lubrication technicians need to know the requirements and schedule of the machines for which they are responsible.

Most machines come with this information. It is also included with bearings, so if you change the bearing type, you may have to change your lubrication process for that machine. Keep good records and know what the requirements are for each machine and bearing. Document the type, amount and frequency of lubrication for every machine.

More advanced lubrication programs will add ultrasound to their lubrication process. The consistent use of ultrasound in a lubrication program – from baseline to route based activities - will allow the bearing to tell you when it wants to be lubricated, a condition-based response instead of a time based response. An ultrasound tool used during lubrication will tell you when there is enough lubrication and prevent over-lubrication – the #1 cause of bearing failure. This is another tool that requires training, documentation and commitment.

Bearing Installation

As we saw in our earlier chart, improper installation of bearings cause upward of 16% of all bearing failures. These problems can arise from poor fitting, the use of brute force and not having the correct mounting tools and methods.

Let's look at the basic things you need to keep in mind for proper bearing installation.

How the bearings are stored and handled is a huge consideration. Rolling bearings should be stored in a cool, low humidity environment that is free from shock, vibration and dust. Poor storage conditions can cause defects to the bearing races before the bearing is ever used. Stored bearings should also be rotated periodically to prevent wear in one spot. Simply, the most effective bearing maintenance is to keep it clean.

Prior to mounting a new bearing, check the bearing housing and shaft to make sure they are clean and not damaged. Also, check the shaft and housing for out of round and taper. Use the tables supplied by the bearing manufacturer to ensure that the correct amount of clearance will be present when the bearing is installed. Make sure you are replacing the old bearing with one that is identical. The lubricant must be clean and of the correct specification. Have the correct tools and equipment on hand and keep the work area clean.

Don't remove the bearing from its wrapping until its time to install and do not wash the bearing. Make sure you know what method will be required to mount the bearing.

Mechanical mounting methods are acceptable for small bearings. Always use the correct mounting tools (as opposed to a sledge hammer) and apply "minimum force with maximum control". Never strike the bearing directly! Improper mechanical installation can damage the bearing and start it on the path to premature failure. For larger bearings, heating and induction methods can be used. This method will allow the bearing to fit over the shaft and into the housing more easily.

Once again, the key is training and commitment. Your bearing supplier should have a quality training program. While you can purchase bearings from a number of sources for a variety of prices, availability of training should be a paramount in your bearing supplier selection process.

Visual Inspection

"Inspect: verb, to view closely in critical appraisal"
-Webster's Dictionary

Stop, look and listen! Sometimes low tech is your best defense against early failure. This is a good way to get machine operators involved with maintenance. Train them to look for the signs that their machines are having a bad day. In fact, train everyone that walks the plant floor to look and listen for the warning signs. Schedule regular visual inspections and use a clear checklist that everyone can understand to document any problems. Make sure everyone understands any gauges associated with the machine (oil level, temperature, pressure, etc.) and that they know the acceptable operating levels.

Learn what a good running machine sounds like. Then listen for grinding, squeaking and other irregular sounds – all indications of worn or damaged bearings. These noises will be loud compared to a good machine.

Look for problems like oil or grease leaks around seals. Check for cracked bearing housings and machine feet. Look for missing bolts and check for loose bolts.

Check the lubricant levels for under or over lubrication. Discolored or dark lubricant is a sign that the lubricant is contaminated or worn out. Worn out or contaminated oil may be caused by overheating. If it is cloudy, there may be water contamination. Always make sure the air vent is not obstructed.

A good visual inspection program, where every one knows what to look for, should involve all the senses. Feel for excess vibration and hot bearing housings. Listen for sounds that are out of the ordinary. Smell for electrical, friction or burning.

iPad Applications and What They Mean to Reliability Maintenance

"With a relatively small investment, companies can re-create the whole information-on-the-fly scenario that was nearly impossible before unless they made enormous investments in PCs, cable networks and ruggedized PCs."

-Pierfrancesco Manenti

So, what do iPad based solutions offer? First, is cost. iPads cost around $500.00 and they are coming down. Their processing power is typically greater than that of the average single purpose data collector. Another huge cost reduction factor are the apps that are developed for each technology. Once a company owns an app, they own it forever. That means that apps are free to the user after the purchase of the first unit. Upgrades are free through the App Store – and they come automatically, with alerts on your iPad when they are available.

Second, all of the different technologies can be developed as apps – vibration, infrared, balancing, ultrasound, motor testing, laser alignment – all can be apps on a single platform. Need a new technology? Contact the vendor for any hardware and download the app. The iPad is a one-time purchase.

Thirdly, iPads are not purpose built. It can function as whatever tool you want it to be that day. Because all of the functionality is developed in software it is simple to upgrade (most upgrades are free through the App Store) and it is simple to add new functions and capabilities as customers ask for them. There is no need for a list of upgrades that will be included in the next version of hardware. The iPad will adapt to your needs with hardware accessories and apps.

You dropped your iPad? No problem, you run to the local computer store and get a new one and re-sync all your apps and re-load your data from the cloud. It is less expensive and takes less time than sending your unit back for repair and waiting 2-3 weeks to get it back.

What else can we do with an iPad?

- Preventative maintenance checklists
- Photo documentation
- Video documentation
- Inspection checklists
- Integrated reports with multiple technologies on the same report
- Training videos
- Complete user manuals
- Maintenance procedures
- Work orders with part lists and specifications
- Whatever you can think of - the iPad is a blank slate empowered by the App Store

One iPad, multiple technologies, add new technologies when you want/need to.

Summary

"Learning is not compulsory…neither is survival."
-W. Edwards Deming

By now you are probably thinking this is all just common sense, but sensible or not, it is not that common. All programs start out with great goals, but without commitment at all levels, great training and good documentation these goals can get lost.

Never be afraid to question the status quo ("Because it has always been that way") or to ask why. Always look for training opportunities – on-site, classroom or online. If you make a strong commitment to the maintenance process – and own it – then others will follow.

About the Author

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