Managing a Successful Condition Monitoring Program

Managing a successful condition monitoring program may seem easy to begin with. The technologies may be presented (by the sales companies) as being easy to use, and with a number of the technologies, it is not immediately obvious if they are not being used correctly. In the early days of a program, fault conditions will be easier to detect (there are probably a lot of them) so it is likely that management will be pleased with the results.

But after a period of time, the task becomes more difficult. Machines fail unexpectedly. Incorrect diagnoses are made. Certain people within the plant are skeptical about the technology, and may not believe in the philosophy of predict maintenance, so they take pleasure in seeing the failures.

Sadly, worse is yet to come. As the program matures, management forgets why the investment in people and technology were made. If machines continue to fail unexpectedly, people blame the technology, and the program may be scrapped. On the other hand, if machine failures are reduced, management might not feel there is a need for such a program, and it is scrapped to save money.

Condition based maintenance should provide great financial benefits to all organizations, in the short and long term. Technologies such as vibration analysis do work. This paper discusses ways that you can make sure that the program is run successfully, providing a benefit to the company, and providing a stable and satisfying career path.

Getting Started

This paper will primarily focus on vibration analysis; however most of the ideas can be equally applied to all of the condition monitoring technologies.

Condition monitoring programs are started for a variety of reasons. A manager might attend a seminar and be convinced of the benefits. There may be a catastrophic machine failure and it is suggested that a technology such as vibration analysis might have prevented the failure. Whatever the reason, it is unfortunate that most programs start without sufficient planning or training.

Once the system has been purchased the analyst has quite a challenge ahead. In fact, the vibration analyst is surrounded by different types of challenges.

First they have to look at the machines in the plant. Each machine is a potential trouble maker. Thankfully, through changes in vibration/sound, electrical properties, temperature, and lubricant characteristics, the machines are trying to warn of impending problems. If you read the signs correctly and deal with them appropriately, you can be a hero. Miss them, or misinterpret them, and you can look like a chump…

Second there are typically people in the plant who don't understand what the vibration monitoring equipment can do - so they fear it. Often there is an us and them environment. The analyst makes a recommendation to make a repair, and "they" insist that the machine is fine. And then there is a stand-off; one hoping the machine is fine, the other hoping the bearing is shot… This is not a great work environment.

And third there is the manager. The manager means well, but maybe he or she does not quite understand what the vibration program can achieve. Perhaps he or she expects that downtime will immediately become a thing of the past. That puts unbelievable pressure on the vibration monitoring team/person. So, what is the answer? The author believes it is quite simple: you must understand the failure modes, you must have realistic expectations, you must create and follow a plan, and you must have on-going training.

Setting Expectations

Everyone needs to have identical (and realistic) expectations.

If every person who maintains, lubricates, repairs, and operates the rotating machinery understood what the vibration monitoring technology can achieve, and chooses to help/cooperate rather than do nothing (or actually work against the program), then the situation would be much improved. Imagine if these people actually told the vibration team what they knew about the machine, and gave them a heads up when they noticed a change in vibration (audible) or operating state.

And if the maintenance management, operators, production and planning folk understood what can be achieved with vibration monitoring (the capabilities and limitations), then realistic expectations would be set. When recommendations were made, they would have greater confidence in the information, and would be able to put it to greatest use.

Instead, what tends to happen is that everyone outside the immediate monitoring group has little understanding of the capabilities of vibration analysis, and not only do they question recommendations, but when a machine does fail, blame is quickly focused on the vibration group. (All of this is true for most of the condition monitoring technologies.)

The benefits of training

So how do we make it work? The first step is training - but not just for the vibration team - for everyone. You only have to look at a few vibration spectra to realize that vibration analysis is not easy to master. There is a lot to learn. You need to know how to operate the analyzer and software, but you also have to know how to interpret the spectrum and waveform patterns. Extracting the information out of the data is very tricky and interpreting the information is even more difficult.

There is another issue to consider. One way to handle vibration analysis is to try to remember the vibration patterns, perhaps with the aid of a wall chart. When you view the spectrum you can look for the classic patterns. And if you are not sure, just glance up at the wall chart and see if you can find a matching pattern. Sadly, in the author's opinion, this method is flawed.

Vibration analysis, in reality, is not that simple. The patterns for a given fault condition are not always the same. And when you consider that a machine may have multiple fault conditions (with varying degrees of severity), and that machines come in all shapes and sizes, the vibration patterns we actually see can be quite different to the simplistic patterns shown on wall charts.

This author believes that it is far more important to understand the machine, the analyzer, and the way vibration changes according to the forces present inside the machine. There is a reason why we see peaks, harmonics, sidebands, raised areas of the noise floor, and so on. If you understand, you can look at a spectrum and determine why the vibration has changed the way it has, and therefore what is wrong with the machine. This is extremely important in vibration analysis, and in other condition monitoring technologies.

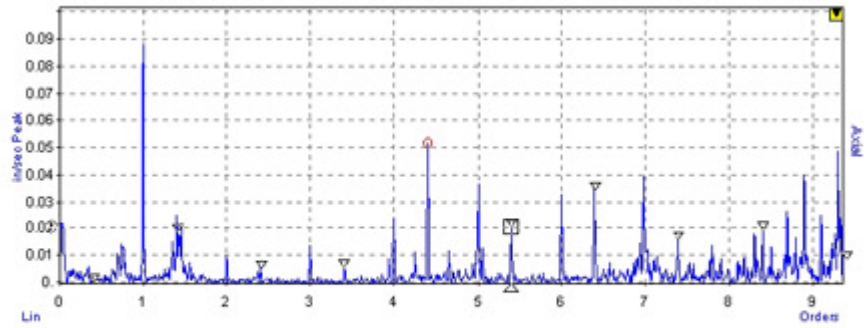

Figure 1: A typical vibration spectrum – not easy to understand, is it?

These days there are two ways to learn. The traditional classroom training suits a lot of people, and allows people to focus their time on learning the technology. However, without the correct teaching aids; classroom training can be very ineffective. By the end of the course, most people have forgotten what they were taught on the first day. And most people are forced to try to remember concepts and theory because the instructor does not have the time or the tools to ensure people understand. The use of interactive training aids, simulators, 3D animations, and hands-on tools offer the best solution.

A slight variation on public classroom training is on-site classroom training. Travel costs are greatly reduced, and the curriculum can be tailored to the customer's specific industry. But, as always, the tools used in the course determine whether the concepts, procedures and theory will be understood.

Web-based and computer-based (CBT CDs) offer a great alternative. While some people do not learn as well in a self-paced environment, the ability to revisit the lessons again and again ensures that the education can be most effectively applied.

A combination of traditional classroom training and Webbased/CBTs offers (in the authors biased opinion) the best alternative: learn before the course so that you can get the most out of the course; learn during the course with the most modern techniques; and continue learning after the course so you never forget what you were taught.

But wait, so far we have only discussed training for the condition monitoring technical staff. What about the rest of the maintenance staff?

I firmly believe that practically everyone needs training. No, the person who lubricates the machine does not have to know how to analyze spectra, and the maintenance manager does not have to know how to diagnose bearing wear, however:

1. Everyone should know why we perform condition monitoring. They need to know that if the condition of the machine changes, the vibration level and/or pattern will also change.

2. Everyone should also have an idea of the limitations of the technology. Everyone should know that vibration analysis and other technologies can be applied to certain types of machines, and can detect certain types of faults. They need to know that some machines can present real challenges (for example machines under varying speeds and loads), and that some fault conditions can develop too quickly to be caught by vibration analysis.

3. And they also need to understand the concept of predictive maintenance versus breakdown and scheduled maintenance. A good idea of reliability centered maintenance would help too.

The goal is:

1. When they see the condition monitoring technicians collecting data, they know it benefits them (and their company).

2. When they witness a change in operating and maintenance state, they may like to tell the condition monitoring team. They should volunteer relevant information.

3. When the condition monitoring guys make a recommendation, whether it turns out to be right or wrong, everyone should know that they did so with the best intentions; using technology that gives a good, but not perfect, insight into the machine's condition.

4. When the budget becomes tight, management should still allow staff to receive training, and continue the program, even though there may not have been a spectacular save (or failure) recently. While the condition monitoring people need in-depth technical (and practical) training, the remainder of the maintenance staff, both the field workers and managers, need to have a training program suited to their needs. It may only require an hour a week for a few weeks, or a one day 'awareness seminar'. The benefits are significant.

Starting a program

The following sections describe a number of factors that should be considered when starting (or revitalizing) a condition monitoring program. The ideas are based on observations made by the author over a 20 year involvement with condition monitoring, but also from a survey conducted on users of our vibration analysis training product.

Use the right people

The selection of the people involved in the condition monitoring program is critically important. It takes a special kind of person to be successful in condition monitoring; regardless of the amount of training they receive. The condition monitoring technician (and program manager) must want to do the job; they must enjoy a challenge; they must be determined and have an inquisitive nature. Intelligence is also important; but that should not be confused with being well educated. Even with limited education, an intelligent person can master technology and perform investigative work in order to determine the condition of a machine.

The selection of condition monitoring technicians is handled in vastly different ways from one site to the next. In a small percentage of cases, people are tested in an attempt to assess their suitability. In many cases people are selected because they have shown an interest or have demonstrated the desired qualities in a different field of work. Unfortunately, in other cases people are chosen simply because they are available, or because, due to union rules, they are the next most senior person so they are taken off the tools and into condition monitoring. Often this results in a very poor condition monitoring program.

You need a champion

Most of the successful condition monitoring groups have a champion. He or she is the person who drives the program forward, inspires the people collecting the data and performing analysis, but also involves people from other sections of the plant - providing training and involving them in meetings.

And most importantly (for the success of the group), the champion inspires management to maintain and grow the program.

Find a mentor

If you can find someone with experience to oversee your program, either from a sister plant or an outside consultant, you may avoid making costly mistakes. Don't be too proud to ask

for help. The profitability of your plant (and the continuation of your employment) may depend on it.

Start small

Although this point is contentious, the author believes it is important that the program starts small. If you try to test too many machines you will spread yourself thin. It will take time to get the system set up correctly (the database, etc.), and it will take time to streamline the measurement routines and analysis procedures. Choose a small group of machines and try to do a good job with those. Have some success before you take the next step.

I cannot stress this enough. Take small steps. Start with simple machines, just so that you can get some experience using the equipment and the software. Analyze data that is relatively easy to understand. It is important for your own confidence that you do not immediately begin testing a large number of machines, or the most complex machines - even if they are critical.

Once you have some experience, work up to the larger machines. That is when you can establish the program and start a regular program. But do not rush into it. Take your time, and do the serious work only when you are ready.

Select the machines wisely

If the plant stops when a machine stops, monitor that machine. (Also look for expensive machines, machines that are difficult to replace, and machines that pose safety risks.) However, if that machine poses significant technical challenges, then it may be wise to avoid the machine - to begin with. For example, if it operates under varying speed and load, or it is very difficult to access the monitoring points, or it has a very complex gearbox, then it may be beyond you to successfully collect or analyze the data.

Figure 2: Technician collecting a vibration measurement

To begin with, it is better not to monitor the machine than to try and fail. You need to build your own confidence, and the confidence of the rest of the maintenance and production staff.

However, it is essential that your manager knows which machines are being monitored.

Select an appropriate test schedule

It is normally recommended that you test a machine every thirty days. If a machine appears to be “healthy”, and the condition is not changing, and it is not critical, then you could push it out to a sixty-day or even ninety-day cycle. However, if the machine does appear to have a fault condition, then, depending on the severity of the condition, and the criticality of the machine, you may even monitor it weekly or daily.

Don’t work in isolation

Vibration monitoring is great, but it is not perfect. It cannot help you to understand the condition of all plantequipment. Vibration monitoring will not necessary give you the earliest warning of a fault condition.

Infrared analysis, oil analysis, wear particle analysis, acoustic emission, motor signature/circuit analysis, and other technologies all play a vital role. If someone is performing these tests within your plant (either in-house or a consulting service) make sure that you learn about the technology, and befriend the people involved. Share the data to get the best results.

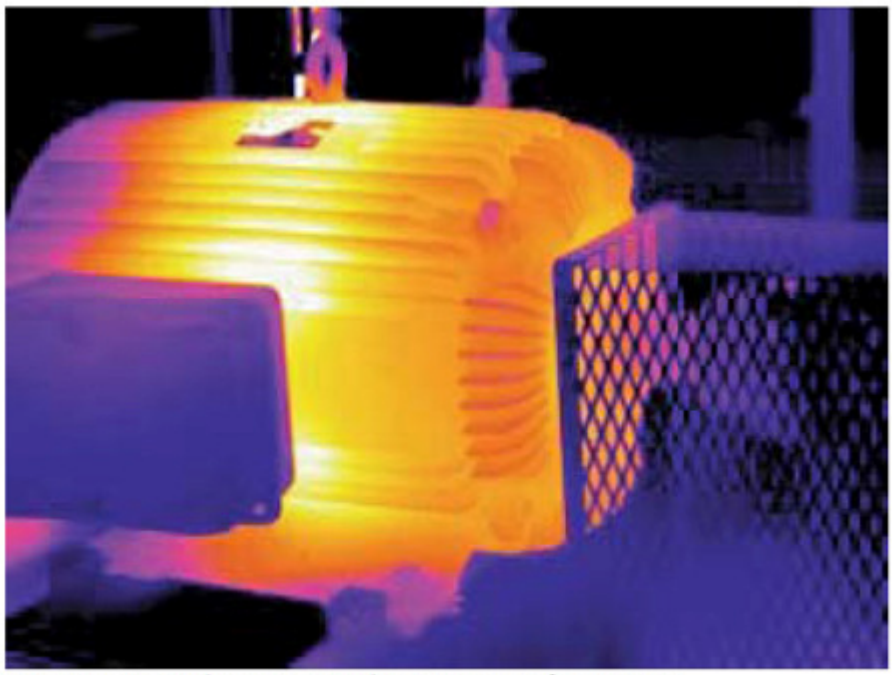

Figure 3: A thermographic image of a motor

Understand the failure mechanism

Before you begin to monitor a machine with any condition monitoring technology, you should do your best to learn as much as you can about the machine. If you have access to mechanical information (bearing number, gear ratios, vane counts, lubricants, motor details, etc.), that will assist your condition monitoring work. But it is more important to understand the maintenance history and failure mechanisms. For example, knowing that a machine has a history of bearing failures will help to focus your attention, and you can choose the measurement types (shock pulse, enveloping, PeakVue, etc.) accordingly.

Understand the reporting process

When you detect a fault condition, be sure to report it to the right people. Make sure that your report is clear and understandable. It does not make sense to present a series of spectra and vibration levels (for example) to people who do not understand them. Find out what they need to know, and report it to them in the desired format.

There is a growing trend in the vibration analysis world (especially with some consultants who have taken legal advice) to be as vague and non-committal as possible. If a report states that a machine has a "stage three bearing fault and it will only run for eight weeks", then a consultant could be liable if it fails in just a few weeks, or the bearings are found to be in good condition when the machine is opened. If the analyst has economic pressures to complete the test/analysis phase quickly, and he/she is concerned about liability, then the report is more likely to read vibration levels indicate a possible increase in bearing wear.

Don't be too gung-ho

If you think you will change the world in a day, and try to force people to accept your recommendations, and try to take on too much, you are likely to fail. You need to be cooperative. You need to be seen as an ally. You need to help people achieve their goals. Once people perceive you as someone who can help, rather than as a threat, then you will have success.

Keep management informed

No matter which machines you choose to monitor, no matter which technologies are used, no matter how often they are monitored - make sure your manager has a clear understanding of what can be achieved. It is the wrong time to explain your plan after there is an unexpected failure.

Mature program

The following is a list of tips for an established condition monitoring program - how to keep the program alive and continue to be successful and effective.

Record your successes

It is essential that you document the benefits of your program in a way that will continue to prove to management that the program should continue for the long term. The 'obvious' way to do that is via cost savings, reduction in downtime, and other financial benefits. But there are two important warnings:

1. It can be easy to generate savings that are not believable. For example, if you detect a bearing fault and that bearing is replaced, you could argue that if the bearing failed catastrophically there would have been "thousands" of Euro or dollars lost in downtime, additional parts (due to secondary damage), and additional labor. While that may be true, most managers will not credit the program with such savings every time a bearing fault is detected.

2. When a program is started there are bound to be a large number of machines with fault conditions, and there have probably been recent failures that are still fresh in everyone's memory. However, as time progresses the number of failures should be reduced, and the number of faults detected should also be reduced. Therefore, if you base your success on the reduction in failures or faults detected, you may find that after a year or two you may not have very much to report - therefore it may be concluded that the program is no longer required. Sadly, this has occurred a number of times. (And of course, it won't take too long before the failures begin to occur again and someone will decide to start a condition monitoring program.)

You must be vocal and clear. Take pictures, keep notes, build case histories, and make sure everyone knows about the effectiveness of the program. Don't show off or annoy people, but if management does not understand the group's value, budgets will be squeezed (there goes the training budget) and squeezed (there goes the software upgrade) until the group no longer exists (there goes your job).

But you have to be sensible. If you continually report that you are avoiding thousands of dollars every time you detect bearing wear, nobody will take you seriously.

Investigate other technologies

As I have already stated, vibration is not the only condition monitoring technology, so explore other methods (infrared, oil analysis, etc.).

Expand the program

Try to expand the program in small steps. Slowly increase the number of machines monitored. That may require additional staff to collect data, and as the collection periods are increased on certain machines you will naturally have more time available.

Consider installing permanent sensors on machines that are difficult to access, and on-line monitoring systems on machinery that is either difficult to monitor, difficult to predict faults (bearings seem to fail quickly), very critical to production, or that pose a safety risk.

You should learn the language of upper management. You cannot simply report the benefits of a new technology. You should determine the ROI, NPV, IRR and other financial measures when you propose additions to your program.

But please, don't build an empire. Don't add people and technologies just so that you have a larger group. A technology might be "cool", but it may not be appropriate. Remember, the goal is to save the organization money in reduced downtime and reduced repair/maintenance costs. Bigger is not always better!

Perform root-cause analysis

When you determine that a fault condition exists you must find out what caused the problem in the first place. Why did the bearing begin to wear prematurely? Was the lubricant contaminated? Was the machine misaligned? With that knowledge you can review your monitoring practices AND you can review the operation/maintenance of the machine so that the machine is more reliable in the future.

Verify the repair

When a machine is returned to service, collect more data to make sure that the fault was actually repaired (and that it is balanced and aligned). Your diagnosis may have been incorrect, so the machine may not be fit for service - and you still need to determine what is really ailing the machine.

Survey results

The survey was sent to a number of the author's iLearnVibration users from small and large companies, from a variety of industries, and from different countries. Given that they are iLearnVibration users, they are probably value training, but their comments and results were interesting nonetheless. Here are a few comments:

Management support

Almost all respondents said that their biggest concern was that their management did not understand what they did. They felt that with greater understanding they would get better support, and greater cooperation when either funds were needed for training, upgrades, etc., or more importantly, when a recommendation was made to correct a fault condition.

Training

The majority of people said that their management appeared to value training. A number reported that when times got tough the training budget was slashed.

All respondents believed that training was essential to their success. All respondents believed that on-going training, and quick access to a good reference was essential. All respondents believed that computer based training was the most effective form of training, because they could learn at their own pace, at their own timetable, and could get refresher training at any time.

Most respondents also believed that it was essential to also attend seminars, conferences or classroom training so that they could get face-to-face with trainers and their peers.

Return on investment

Almost all respondents said that they were sure that the investment in condition monitoring technology was an excellent investment, with an ROI achieved in less than one year. In many cases, however, they did not have the financial data to justify that statement.

Sometimes it was difficult to gather this information. One person queried “how can you tell what the cost saving is by not delaying a space shuttle launch by a few days”. While we don’t all work for NASA, it is not always easy to determine the exact financial benefit of avoiding unexpected failures and improving reliability.

Financial information

Almost all respondents believed that recording financial data was important, so that they could justify their program, however less than half of the respondents appeared to actually record the figures. One person said I don’t do money!

Certification

Certification options have changed a great deal in the past couple of years. The ISO has released the standard 18436, and part 2 deals specifically with vibration analysis. There are other parts of the standard that related to other condition monitoring technologies.

The ASNT has also defined a recommended practice for vibration analysis which includes a specification of the topics that must be covered and the format of the exam.

Certification is predominantly used to measure a person’s understanding of the concepts and skills that must be used as a vibration analyst. It is not yet possible to provide a practical examination of a vibration analyst’s competency.

However it is believed that certification to an internationally recognized standard will become a requirement for vibration analysts in the future. The advice
provided by the analyst, and the potential for significant financial ramifications if an analyst misses a fault condition (or misdiagnoses a fault condition), will result in employees and clients demanding a proven level of proficiency.

The costs required to run a program

Often when a company is looking to purchase a system, a great amount of time is spent analyzing the purchase costs. Bargaining and horse-trading continues until the lowest price is achieved. But little thought is given to the ongoing costs - the life-cycle costs.

All respondents stated that salaries were by far the largest cost. In the first year (when equipment is purchased), the purchase costs represents a large percentage (if you do not take depreciation into account), but still not as much as the staff salaries. In subsequent years, the maintenance costs (vendor support contracts, upgrades, etc.) can still be quite expensive, but still the dominant cost is staff (depending upon the size of the program, the number of employees, etc.).

So, what is the point? It is essential, in the author's opinion, to ensure that the equipment you purchase will do the job for you. If you understand your plant, and the failure modes of your equipment, you will have a better chance to buy appropriate equipment. Make sure you buy equipment that enables you to achieve the desired goals. That does not mean that you have to order the optional bells and whistles, but you should spend money wisely. (And remember, it is easier to buy wisely in the first place, than to go back later and ask for more money.)

The second point is that you should analyze the on-going costs of the program - training, upgrades, and maintenance contracts. Consider the future.

Failed programs

Three main reasons were given for failed programs:

1. Lack of management support. Management either assigned staff to too many tasks, not realizing what it took to run a vibration program, or they did not understand the financial benefits (whose fault is that?) and simply cancelled it because it was considered too expensive.

2. Lack of understanding of the real benefits. In a mature program there should be fewer failures. Based on root cause failure analysis, maintenance procedures (and purchase procedures and design processes) are changed so that machines are more reliable. Greater reliability will result in fewer failures, which can result in upper management asking what have you done for me lately - just before they cut the program. You can suffer as a result of your own success.

3. Lack of training. Staff felt so frustrated at not knowing how to use equipment, or more-so not understanding the technology, that they could not be successful. They grew frustrated and gave up.

Conclusions

There is little doubt that condition monitoring can be used to determine machine health, and that maintenance can be planned based on that data. However, it has been shown that without the right people, training and management support, most programs will fail. The condition monitoring program will be halted, either as a way to save money, or simply because it is believed that the technology does not work.

The solution is to select the right people who are well suited to condition monitoring; continuously conduct training courses to ensure a high level of skill; carefully plan and execute the use of the technology; expand the program as time, budget, and necessity exists; and collect and distribute information to relevant management that sells the benefits of the program.

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