5th Edition

From the Reliability Professionals at Allied Reliability

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New! Expanded Content Based on YOUR Feedback!

PdM SECRETS REVEALED

How to Improve Your PdM Program Or Start One from Scratch

Bonus Section Included

A Must-Read Guide for Maintenance and Reliability Leaders

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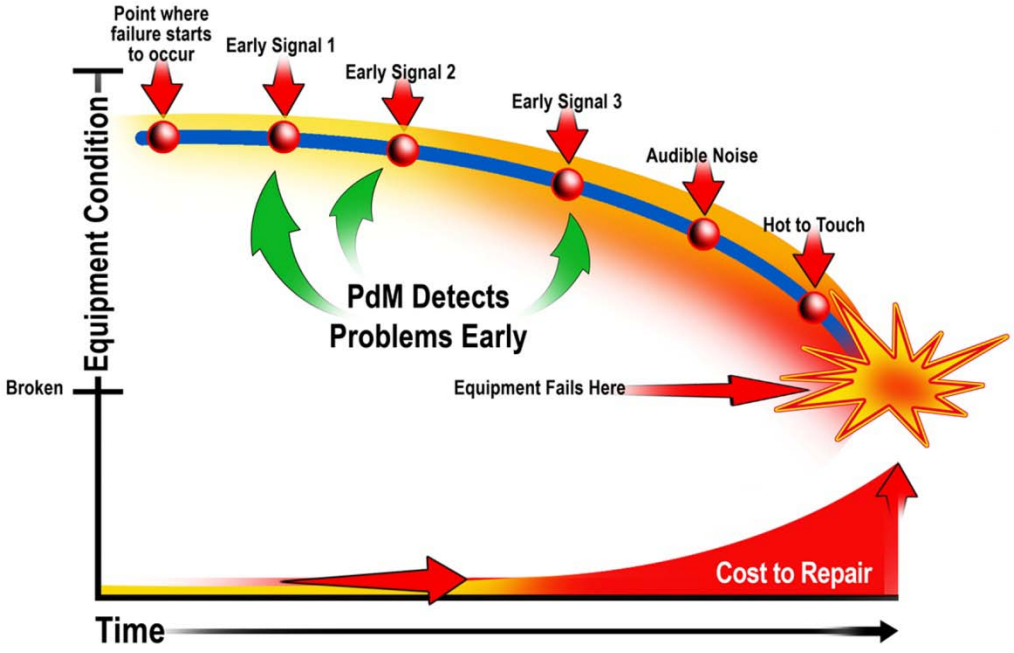
The Basic Concept of Predictive Maintenance

Although the Predictive Maintenance (PdM) technologies themselves can get quite complicated, the basic concept of PdM is simple enough:

Most industrial equipment does not suddenly breakdown and stop working. The truth is equipment breaks down gradually, over a period of weeks or months. Furthermore, it gives off numerous warning signals along the way.

These early warning signs, such as slight changes in temperature, vibration or sound, can be detected by PdM technologies. As a result, PdM gives you time to plan, schedule, and make repairs before the equipment fails.

The following graph illustrates this concept:



The bottom line, when it comes to maintenance, is that time is money.

The difference in repair costs between the time a PdM specialist can detect an equipment problem until the time an operator notices it can be huge.

In fact, one study showed that the cost of PdM-driven, proactive maintenance is half as much as emergency, breakdown maintenance.

No other maintenance strategy gives you more time for advanced planning and scheduling than PdM. That is why PdM should be your number one source of planned maintenance.

Also, studies have proven that a well-planned repair job typically takes only half as much time as an unplanned job. Planned work is always more efficient and less costly than unplanned work.

Reader Larry asked: "If we use PdM and it warns us of potential failure or detects a defect, how can we tell when it is going to fail?"

The exact time of failure cannot be know for certain. There are PdM technologies that can give you a longer warning time, but no technology can tell you exactly when it is going to fail. The real challenge is integrating this knowledge of an impending failure into the daily work stream and correcting it before it interrupts your schedule.

The Top 6 Benefits of Predictive Maintenance

In his book *Plant Engineer's Handbook*, Keith Mobley links the following benefits to PdM:

- Maintenance costs - down by 50%
- Unexpected failures - reduced by 55%
- Repair and overhaul time - down by 60%
- Spare parts inventory - reduced by 30%
- 30% increase in machinery Mean Time Between Failures (MTBF)
- 30% increase in uptime

These numbers may seem high. However, even if you take only a fraction of these benefits, the financial impact of an effective PdM program at most plants can easily reach into millions of dollars.

For the typical manufacturing plant, a 10% reduction in maintenance costs has the same bottom line benefit as a 40% increase in sales.

Another advantage of PdM is this:

Studies have shown that with a properly-engineered PdM program, you can replace up to 30% of your Preventive Maintenance (PM) tasks. Find out more about right-sizing your PM program with the guide: "Are You Doing Too Much PM? 16 Ways to Save Time and Money on Preventive Maintenance".

This guide is another must-read for maintenance and reliability leaders and is available at no cost from the professionals at GP*Allied*. Request your complimentary copy by emailing info@gpallied.com.

Reader Mike asked: "If PdM can really produce these kinds of savings then why don't more companies make PdM a priority?"

Exactly! It is mainly a lack of education about the benefits and the culture of "this is how we've always done it" that are actually to blame for PdM program successes not being sustained. That is why we recommend attending the Asset Health Assurance Training series. To view abstracts and more information, visit www.alliedreliability.com.

The Hidden Benefit of Predictive Maintenance

For at least the last 40 years, the financial benefits of PdM have been proven over and over again.

However, if you talk to Maintenance and Reliability professionals who have seen the change from the "reactive" to the "proactive" world, chances are you will hear something different.

Here are just a few examples of what they are saying:

“I like to fish and hunt and play with my kids. I’m definitely not a maintenance geek. Man, I don’t want to get called out in the middle of the night. I’m just telling you that if you don’t do this [Predictive Maintenance], God bless your soul. And you better like coming in and doing maintenance, because you’re going to do it a lot. I don’t like maintenance. I like my free time.”

“Now that we are down the road quite a ways in predictive technologies and implementing the overall proactive maintenance model, we are seeing the results of it. It’s made my job easier. There are less call outs than what we had in the past. That reduces my shop level and improves my employee’s morale and the overall relationship between operations and maintenance.”

“We’ve been able to demonstrate to the operations group the validity of PdM technologies and where we can plan scheduled outages around the PdM work that’s been identified. That’s less stressful to me. It’s safer because I can plan out that activity instead of working on it at midnight on Saturday night. It’s reduced my stress level.”

“I hardly ever get called in at night anymore. We don’t need as many people here every day. We are at a 70 or 80% proactive work level. The quality of life is a big improvement. A big improvement for the worker.”

"When you start implementing a [PdM] program like this there is always some push back. 'What's in it for me?' 'Why are we doing this?' Basically for a guy that likes a lot of overtime at the end of the day - his paycheck is less. But on the flip side of that is they're not working as hard and you're not fighting as many fires and you get more time off. About 5 years ago we'd have an estimated 120 calls in a year's time. Now we are running the plant 24-7 and are down to about 12-20 calls."

"My life has gotten much simpler. I'm not involved in the emergencies because typically we don't have that many and they are usually not catastrophic. Not as many phone calls in the middle of the night – a lot fewer."

There you have it – the "hidden" benefits of successful PdM:

Less stress. More peace of mind.

An easier job. More free time.

Now, let's go behind the scenes and look at some of the secrets of highly successful PdM programs.

The First Job of Your PdM Program

Despite what you may have heard, the foundation of a successful PdM program is a simple list – a detailed and accurate equipment list.

Why? Your equipment list is the foundation for all of the key steps that follow. For example, a good list is essential for:

- Identifying how your equipment can fail
- Choosing the right PdM technologies to apply to the asset
- Determining the ideal amount of PdM coverage for your plant
- Ranking the criticality of each piece of equipment
- Building databases for each PdM technology
- Determining PdM staffing levels

Readers John, Joseph, Richard, and Roland all asked for the specifics of how to design and develop comprehensive PdM Programs.

These specifics are far too detailed to be covered in this guide. There are a series of courses designed to answer these and many other questions related to Asset Health Assurance, PM/PdM Best Practices, and program development.

The Asset Health Assurance Overview, Mechanical, Electrical and Stationary courses, are designed to provide the framework you need to reach Best Practices in PM and PdM in the shortest possible time and at the lowest overall cost.

To learn more about the Asset Health Assurance Training Series, visit www.alliedreliability.com.

If your list is incomplete or incorrect, everything that is built from it will be flawed. Any shortcuts or inaccuracies will be exposed as big problems later.

What makes a good list? For starters, it should include:

- Equipment number
- Equipment description
- Equipment type
- Area/location of the equipment

Surprisingly enough, most plants do not have a good equipment list, unless the data was captured when the plant was built. If you do not have this information, or if it is less than 75% accurate, here are two options:

1. Use the manual, paper-based approach

In the past, the conventional method was to walk up to each piece of equipment with a clipboard, write down the key information, and have the data transcribed and entered into a database.

Depending on the size of the plant and the number of pieces of equipment, this process can be extremely time-consuming and prone to error.

2. Use a software tool

Equipment lists can be created much faster and easier with a tablet PC or other handheld electronic device and software.

First, import the existing equipment data from an Enterprise Resource Planning (ERP) system or Computerized Maintenance Management System (CMMS) into the software application. Data is then gathered in the field and entered directly into the tool. Finally, it is a matter of exporting the compiled data to the appropriate databases and CMMS.

This speeds up the process tremendously and greatly reduces effort compared to the manual, paper-based approach.

However you decide to do it, do not be tempted into taking shortcuts on this step. A good equipment list is one of the most overlooked and underappreciated elements of a successful reliability initiative.

Allied Reliability's walkdown software application is just one several tools that enable fundamental processes such as:

- Asset Cataloging
- BOM Development
- Asset Criticality Analysis
- Equipment Maintenance Plan Development
- Developing Effective Work Procedures
- Planning
- Scheduling

- Work Execution
- RCM
- Scorecarding/KPI Management
- Integrated Condition Monitoring Reporting
- Operator or Maintenance Rounds Logging
- Work Order Prioritization
- Process Reliability Statistics

All Allied Reliability tools and applications can be purchased as a Software as a Service (SaaS), stand-alone single user, or network version. Stand-alone software applications and other modules are also available through our training curriculum. For further details, please contact us at 888-414-5760 or info@alliedreliability.com.

How to Choose the Right PdM Technologies

Many companies begin a PdM program by choosing one of the most common technologies, like Vibration, Infrared, or Ultrasound. After they get some basic training and experiment for awhile, they start applying the technology to their most critical equipment.

Makes sense, right?

Wrong. Let's go back to the basic concept of PdM.

Almost all equipment gives off early warning signals – such as changes in temperature, vibration, or sound – before it fails. These warning signals, or failure modes, can be detected with certain Condition Monitoring (CM) technologies.

The problem is that one or two technologies alone cannot detect the majority of the warning signals in your plant. As a result, a single-technology PdM program will miss far more faults than it catches.

The key to a successful PdM program is to make sure it is highly sensitive to the failure modes of your equipment. That is why you need to apply multiple technologies, so you can detect the majority of failure modes in your plant.

Ultimately, it is your equipment's failure modes and criticality that determine which technologies you apply, not the other way around.

The concept is simple, but you would be surprised how many companies get this backwards.

A multi-technology approach also lets you double-check and confirm "fault findings" between technologies. Additionally, it allows you to catch problems with one technology that might be missed by another.

Ultimately, the biggest reason to apply multiple technologies is this: there is little, if any, payback from using just one or two PdM technologies. You will miss most of the early warning signals that occur, so the equipment will fail anyway.

The payback comes from integrating a full range of technologies across a high percentage of your asset base. That is why the fundamental starting point for a PdM program is:

- Understanding all of the failure modes in your plant; and
- Applying the technologies that will detect them.

Recommended Resource for Determining Asset Health

If you do not have the time or expertise to determine the failure modes for all your equipment and map them to the appropriate PdM technologies, there is a software-driven process that can help.

An Asset Health tool will use a database with several hundred equipment types already mapped to the appropriate technologies. With this, you can take the equipment on your equipment list and identify the possible failure modes for each, then confirm which PdM technologies and inspections to apply

Below is a sample of recommended technologies by equipment type for a specified environment:

Equipment Type Versus Technology Application(s)	MECHANICAL				ELECTRICAL				STATIONARY			
	Vibration	Ultrasound	Infrared	Oil Analysis	MCA Online	MCA Offline	Infrared	Ultrasound	Visual Inspection	Ultrasonic Thickness	Dye Penetrant Testing	Eddy Current
Chiller	X	X	X		X	X		X	X			X
Centrifugal Pump	X	X	X	X	X	X	X		X	X	X	
Air Compressor	X	X	X	X	X	X	X	X	X			
Tank			X						X	X		
Evaporator			X				X		X			

This tells you which PdM technologies are required to cover your equipment. Best of all, the whole process takes hours to complete, rather than weeks or months.

Find out more about the Allied Reliability Asset Health Matrix tool by emailing us at info@alliedreliability.com or visiting our website.

Readers Larry G., Tony, and Ahmad all asked a variation of the same question: - what PdM technology should you choose if you are only able to choose one?

Think of what you do now without Infrared, Ultrasound, Vibration etc… You probably use Visual Inspection or your other senses right? The PdM technologies should enhance your senses and, in many cases, compensate for what you cannot humanly see, hear, or feel.

The first sense you want to enhance should be your vision. Infrared is a very useful tool for that. It is applicable for mechanical and electrical fault finding and is used to quickly scan a large amount of equipment. It is an excellent tool for prevention of fires/explosions. Because it is very visual, it is quickly understood, making it easy to point out changes in heat signatures and trend changes in your equipment health. Additionally, when it comes to quick “wins”, one thermographer can spend three days scanning equipment and find more work than your planning and scheduling can address in a month’s time.

Remember: Training is important. Just because a person can switch on a camera and see what is hot and what is not, does not make it a silver bullet. It is important to know the normal temperature ranges of your equipment and understand the common traps and limitations of the technology. If your equipment should run hot but is cold, you do not want to assume it is operating normally or without defect.

More detail on Infrared and other PdM technologies’ applications to equipment types can be found in the Asset Health Assurance Overview class. Please visit www.alliedreliability.com to view abstracts and registration details for this course.

Which Equipment to Monitor with PdM

If you have a detailed criticality ranking of your asset list, you can determine your maintenance strategy, prioritize work, and make better risk management decisions. Criticality rankings should be a single score based on collective agreement from:

- Production
- Maintenance
- Purchasing and Logistics
- Health, Safety, and Environmental (HSE)
- Accounting
- Sales and Marketing
- Customer Service

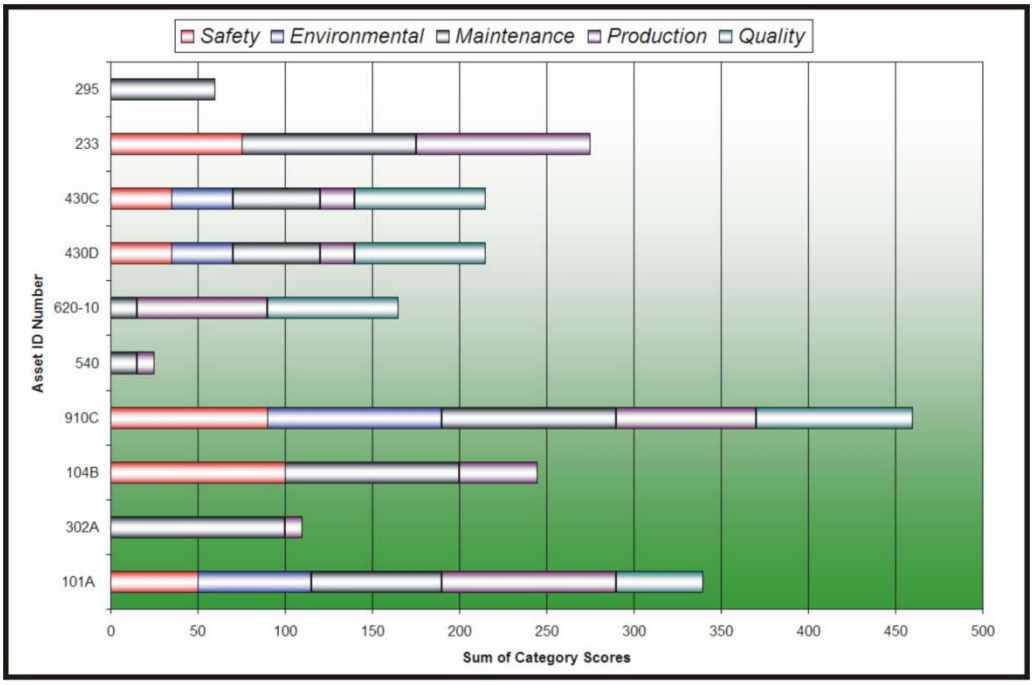
The problem is that a lot of companies use the ABC approach, with all equipment being given an A, B, or C priority. With this method, most equipment falls somewhere in the middle and gets a “B” rating. When it comes to priorities, which one are you going to work on first? You cannot address all of them at once, so what is your priority?

This is why you need a single score and overall ranking for each asset. With this information, you can focus your PdM resources on equipment that has the biggest impact on plant performance.

A sample criticality ranking for a single piece of equipment is shown on the following page. Notice how each asset has a single, composite score based on 5 key criticality factors

- Safety
- Environmental
- Maintenance
- Production
- Quality

Sample Criticality Ranking



Reader Andre asked us when he should use RCM analysis.

The key to implementing any PdM analysis tasks that are 1) applicable for detecting potential failures, and 2) effective at mitigating the consequences of your failures is to have a thorough understanding of your failure modes. The best way to build a failure modes driven maintenance strategy is to perform RCM analysis on your critical assets. PdM complements RCM; it does not replace it.

You should use RCM for any failure mode associated with the operating context of the equipment. Allied Reliability recommends utilizing the RCM Blitz™ methodology when performing your RCM analysis. This method allows you to complete the analysis faster and begin implementing the tasks that will produce results quicker than more traditional methodologies. To find out more about RCM Blitz™, contact us at info@alliedreliability.com.

Reader Mark asked about the cost effectiveness of PdM inspections.

The value of PdM inspections should be judged against the criticality of the component being inspected, .ie. the cost of catastrophic failure or the cost of unplanned downtime. The actual cost of the component is usually of little concern.

Choosing the Right Level of PdM Coverage

For most industries, benchmark data is available describing how much PdM coverage is considered Best Practice for that industry. For example:

Coverage by Technology	Vibration	Mech UE	Elect IR	MCA Offline	MCA Online	Oil Analysis	Mech IR	Elect UE
100% Theoretical	3,400	3,078	5,016	2,939	2,939	2,869	4,179	5,016
1st Quartile	2,720	2,155	4,815	1,470	1,470	1,492	2,925	4,815
2nd Quartile	2,312	1,693	4,364	1,176	1,176	1,090	2,298	4,364
3rd Quartile	1,530	1,077	3,862	882	882	717	1,463	3,862
4th Quartile	600	369	3,260	588	588	344	501	3,260
Existing Coverage	220	0	0	0	0	135	0	0

Mech – Mechanical UE – Ultrasound IR – Infrared Thermography
Elect – Electrical MCA – Motor Circuit Analysis

As you can see, the data compares existing coverage for each technology to 1st, 2nd, 3rd and 4th quartile performers. This is extremely useful information to determine how your current coverage ranks versus best practices in your industry.

Reader Bon asked for more explanation about the PdM Coverage Model.

Theoretically, if there is a failure mode that a particular PdM technology could detect, it should be applied to that asset. 100% Theoretical Coverage is not necessarily 100% coverage of a specific asset type, because the technology may not be appropriate for all failure modes. There will be some failure modes that NO PdM technology can detect, and those should be assigned a PM task.

In the sample coverage table, you can see that the row with 100% Theoretical shows the total number of assets at this facility that could 'theoretically" be covered by a given technology in the green header, because the technology is known to be effective at detecting failure modes on those assets. Each yellow cell is broken down to show you just how many pieces of equipment could be covered by the technologies above in the green. In the 100% Theoretical example, those numbers show that we could cover 3,400 pieces of equipment where Vibration has application to help detect/ identify a failure mode on that equipment.

Remember the statement from above and assume that there are other assets not included in this 3,400 because there may be NO PdM technology known to detect failure modes in that asset. The same holds true in the other columns for the other PdM Technologies; 3,078 assets could potentially be covered by Mechanical UE, 5,016 by Electrical IR, and so on. The likelihood that you could cover 100% of equipment with applicable technologies is not high; however, a 1st Quartile performer could cover 2,720 pieces out of 3,400 with Vibration and still have a tremendously successful PdM program.

In our example, the plant covered only 220 pieces of the available 3,400 that would have benefitted from Vibration Analysis. This company is not even at the lowest performing Quartile or 4th Quartile coverage of 680. The remainder of the red row shows many zeros, revealing that several of the PdM Technologies are not being used at all. In fact, this facility is using only Vibration and Oil Analysis and on far fewer pieces of equipment than they could actually be. This facility has some opportunity to drive more returns from its current "level" of activity but must be done with a systematic approach.

When designing or enhancing a PdM program, the 100% Theoretical Model gives the facility a glimpse at what the maturation stages look like. Factors such as workflow maturity, criticality, craft skills, and knowledge/acceptance need to be taken into consideration when deciding to implement the appropriate PdM program for your business. Ideally, a site should select the technologies that will generate the quickest Return on Investment (ROI) while demonstrating vital momentum to build upon. Technologies should complement your business processes, not overwhelm them.

Reader Andre asked us to define failure modes.

Simply put, failure modes define the part, what is wrong with it, and why. One such example may show a failure mode for a bearing defined as: bearings, fatigued, due to misalignment. Remember, the list of failure modes to be analyzed should represent those that have failed or are likely to fail.

Reader Tad asked us about time-based maintenance frequency.

Referencing the original RCM report by Nolan and Heap and subsequent studies by the U.S. Navy Submarine fleet, we learned that time based maintenance is only appropriate for 11% of the failure modes. These failures have a strong wear-out mechanism. The other 89% of the time, the failures require an inspection to detect incipient failure. Therefore, time-based maintenance strategies are less than effective for 89% of failures in a plant.

Reader Jerry asked about the power of different PdM technologies.

There is not one "all-powerful" PdM Technology. Each one of them detects different failure modes, so think of it as: "which ones can I use to detect failure modes that are likely in my machinery?"

Engineering Your Program At-a-Glance

Now that you know what technologies to apply, which equipment to apply them to, and what level of coverage is considered Best Practice, you are able to:

- See different program scenarios based on the criticality of your equipment
- Compare your coverage versus Best Practice performers
- See which equipment would be included if your technology coverage is increased to the next quartile

Essentially, this is the information you need to engineer a PdM program, evaluate your "best investment", and compare it to Best Practices based on 1st, 2nd, 3rd, and 4th Quartiles of industry coverage.

This information is displayed in the following Asset Health Matrix.

					MECHANICAL				ELECTRICAL				STATIONARY			
CRITICALITY	ASSET COUNT	ASSET DESCRIPTION	CMMS #	ASSET TYPE	Vibration	Ultrasound	Infrared	Oil Analysis	MCA Online	MCA Offline	Infrared	Ultrasound	Visual Inspection	Ultrasonic Thickness	Liquid Penetrant Testing	Eddy Current
	561				273	276	300	283	269	269	406	137	203	199	50	0
1650		#1 GERM DRYER REC. CYCLONE B	SP03009B	CYCLONE									X	X		
1650		1200 AMP LOAD SWITCH FOR MCC 354	FL03009D	SWITCHGEAR			X					X				
1500		1200 AMP LOAD SWITCH FOR MCC 355	FL03009E	SWITCHGEAR			X					X				
1500		2ND STAGE RC B SET	SP03014B2	TANK									X	X		
1400		3RD STAGE RC B SET	SP03014B3	TANK									X	X		
1300		4TH STAGE RC B SET	SP03014B4	TANK									X	X		
1200		GAS TURBINE/GENERATOR	SP03009C	GENERATOR	X	X	X	X	X	X	X		X			
1000		#1 PREDRYER CYCLONE FAN	SP03009D	CENTRIFUGAL	X	X	X	X	X	X	X		X	X	X	

Reader Edi asked for clarification on how PdM differs at varying types of facilities, such as a power plant.

The mechanical and electrical failure modes identified with PdM are a function of machine design, not industry vertical. The rolling element bearing works the same whether you are pumping water or crushing rocks, and everything in between. The concepts of alignment, balance, and tolerances are universal.

What to Measure – 11 Key PdM Metrics

There are many ways to measure the results and impact of a PdM program. It is important to consider carefully which metrics to use. The following are some guidelines and suggestions.

If you do not measure it, you cannot prove that it happened.

You may have heard the saying, “In God we trust; everybody else, bring data.” If you want to prove the success of your program to upper management, you need to have the data to back it up.

The less you know, the more you have to measure.

For any process, if you know little or nothing about it, everything appears to be random. As a result, you need to measure it until you understand it.

What gets measured gets improved.

Measurements are a great way to drive positive behavior changes.

With that said, the number one PdM metric to consider is this:

What percent of total maintenance man-hours is driven by PdM?

This is the single most important metric to track. On average, Best Practice reliability programs generate approximately 50% of their work from PdM inspections and corrective work. If PdM and the results of PdM are not generating at least half of your work total, you have room for improvement.

PdM is proven to be more cost-effective than PM or emergency maintenance; shouldn’t it account for at least half of your work?

Surprisingly enough, most companies do not know how much PdM work they do. That is because they mix PM and PdM together, so they cannot break out a true PdM value. We have found that the majority of plants in North America generate less than 10% of their maintenance work flow from PdM.

What Else To Track

Depending on the maturity of your program, here is a list of the other 10 metrics that should be used to track the success of your efforts:

1. PdM effectiveness – hours of corrective work identified by PdM divided by hours spent on PdM inspections
2. Percent of PdM recommendations completed within 30 and 90 days
3. Percent of work flow that is planned maintenance (target is 80%+)
4. Total planned work in planner's backlog
5. Adherence to PdM schedule
6. Wrench time
7. MTBF
8. Maintenance costs as a percent of asset base
9. Maintenance costs as a percent of sales
10. Overall Equipment Effectiveness (OEE) and asset utilization

Reader Jason asked: "What is the number one thing you should track?"

The percent of work flow that is planned maintenance (target is 80%+), so you will know if your current maintenance is effective.

What Not to Measure

Some organizations spend a lot of time tracking cost avoidance. In other words: "If we hadn't caught this problem early, it would have cost us X dollars in emergency repairs later." Here is the problem: you will never find cost avoidance on your company's financial statements. It has little real value to your management.

What is important to measure is any item that leads to:

- Lower labor costs
- Reduced energy consumption
- Lower spare parts inventory
- Improved product quality
- Better safety performance
- More throughput capacity

These are the key factors that directly impact financial performance.

Reader Hasmukh asked whether instrumentation alarms can be used as a good PdM indicator.

Process instrumentation alarms are excellent indicators of when things have changed. Whether or not they are considered PdM is determined by the status of the problem they are indicating. If it is an impending loss of function, then it can be considered PdM. If the loss of function has already occurred, then it is not considered PdM. You can refer to the PF Curve for the graphic illustration of this point.

Four Reasons Why PdM Does Not Work

After applying PdM technologies, many people expect that a more reliable plant will magically appear. This idea is attractive, appealing – and wrong.

You see, it is one thing to identify equipment problems with the technologies. It is another thing to plan and schedule the corrective work, get the craftsperson out there, and have the repairs done in a timely, disciplined, and orderly manner.

That is why the heart of a successful PdM program is a sound work order system. Ultimately, it is your work order process that lets you leverage the power of PdM.

Remember, the true return on your investment in PdM comes from *eliminating* defects, not just identifying them. You must be able to plan, schedule, and execute the corrective work that results from PdM inspections. Otherwise, there is very little value associated with Condition Monitoring (CM) technologies.

A good work order system does not have to be highly sophisticated; however, you must have a process in place that will turn PdM work requests into work orders.

Sounds easy, right? You might be surprised at the number of issues we see with PdM work requests. Here are the four most common problems with a PdM work request:

1. PdM corrective work is identified, but the work request never gets to planning.
2. The corrective work is planned but never scheduled.
3. The work is put on the schedule, but when it is time to perform the job, the parts are not available.
4. The work is planned and scheduled. The parts are available. Then emergency work takes precedence, and the PdM corrective work is never executed.

That is why the specific PdM work processes must be outlined and mapped for your facility. For example:

- How the PdM schedule will be managed
- How the reports will flow
- How special analysis requests will be managed
- How PdM corrective work will be performed

Another key consideration is the routing and approval process for PdM work.

Some companies want all PdM work requests reviewed and approved before converting them to work orders. The problem with this is that very few Maintenance Managers, Reliability Engineers, and Planners are well-grounded in PdM technologies. As a result, they cannot always make the best decisions about the requested work.

We believe that if you have qualified PdM technicians, they should be able to put in their own work requests. Then, as soon as the job is planned, it is turned into a work order.

This process is not always acceptable to organizations. If you want to have someone reviewing and approving PdM work requests, make sure they are well-educated in the PdM technologies.

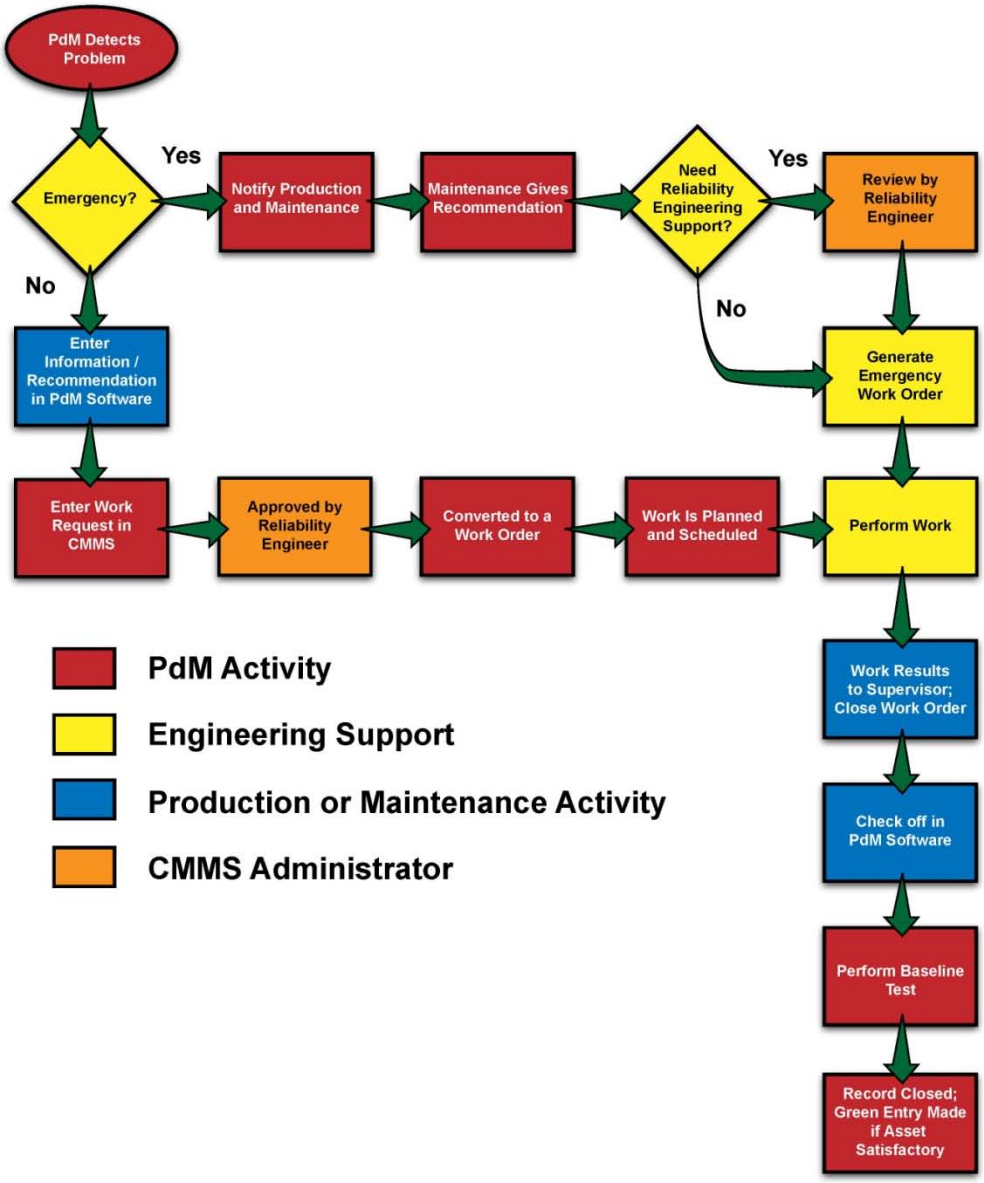
One final point to consider is that increasing your PdM inspections will increase the amount of work in your system. The question is: how much additional PdM work can your plant absorb?

You must factor this realization into the equation when you are designing or expanding a PdM program. The goal is to take full advantage of the technologies without overwhelming the capacity and limitations of your work management system.

Reader Stan asked about the use PdM as a prognostics tool.

The name “Predictive Maintenance” was never intended to mean that one could use it to predict the life of a component. “Predictive” came from the fact that one could know which machine was going to fail next, but not necessarily when it was going to fail. The proper name for these inspection methods is Condition Monitoring. In all cases, this is all that can be done. One can monitor the condition of components, but fault progression is still speculative work based on a given set of conditions.

The following diagram is an example of a successful PdM work management model:



Are You Collecting the Right Data?

In essence, PdM is a data-driven process. It is all about collecting and analyzing data to determine what corrective work needs to be done. The key is to make sure your PdM team is looking at the right data.

Unfortunately, many companies spend a lot of time looking at the wrong data because the data collection specifications were set up incorrectly from the beginning. The data cannot do what it is supposed to do: identify equipment problems.

This is why setting up the PdM technology databases is such an important step. Done properly, these databases allow you to trust your alarms to catch impending problems. Then, when you look at exception reports, you see what equipment is in alarm and are able to analyze that equipment only.

If you cannot trust your data and the alarms, your analysts must look at all data from all equipment and all collection points.

The difference is huge. For example, with the right database, a vibration analyst can collect and analyze data on 400-450 pieces of equipment per month. Without it, productivity drops by 50% to 200-225 pieces of equipment per month per technician.

As you can see, having the right database has a direct impact on the productivity of your team and the success of your program.

Depending on the size of the plant, setting up these databases can take a lot of time and effort. However, it is well worth it because the payback is enormous.

Reader Muhammad asked about the usefulness of fault frequency in your PdM program.

The collection of fault frequency information, such as bearing type, full load amps, insulation class, and lubricant type, can make analysis more rapid, more certain, and, in some cases, more accurate.

The Number One Question to Ask

When setting up PdM databases, the main question to ask is this:

What data do we need to collect so that if there is a problem with this equipment, it shows up and we see it?

The answer requires that you understand:

- The failure modes of the equipment;
- The capability of each PdM technology to detect the failure modes;
- Which points on the equipment to look for the failure modes;
- The theory behind the PdM technology;
- How to present the data for analysis;
- How the individual hardware and software package works; and
- What the alarm limits should be.

Granted, that is a lot to know – and it does not come from a one-week training session. This is why setting up PdM databases is a task best handled by analysts who hold a Level III Certification, with several years of experience in that specific technology.

What Kind of PdM Program Should Be Used?

At this point, you know:

- What equipment you have in your plant;
- Which PdM technologies should be applied;
- To which equipment you should apply the technologies;
- How to manage the PdM work flow;
- What metrics to use to measure the success of your program; and
- How to set up the PdM databases.

Now it is time to make a sound, strategic business decision on the right PdM sourcing model. Here are the four options you have when deciding what type of PdM program to implement:

1. Internal

The PdM program is managed entirely in-house, including all data collection, interpretation, analysis, and recommendations.

2. Contract

All key functions are outsourced to a professional, third-party PdM service organization.

3. Hybrid

Part of the work is done in-house and part of it is outsourced. For example, data collection is handled internally and analysis and recommendations are outsourced.

4. Remote Diagnostics

The collected data is sent directly to a world-class analyst for analysis and recommendations.

How do you decide which option to use? It is simply a matter of running the numbers to see which type of program makes the most sense for your organization. Here are some of the key factors to consider:

- Labor costs
- Training and development
- Coaching and mentoring
- Recruiting and staffing
- Hardware and software
- Timeline for implementation
- Remote diagnostics and supplemental support
- Union versus non-union environment
- Career development opportunities

Additionally, there are five unique situations that tend to favor outsourcing.

1. You need the PdM expertise right away

Some companies cannot wait years to develop the PdM capabilities in-house; they need the improvements now. You can accelerate the process by bringing in qualified analysts who are already trained and certified, have the right tools, and understand the capability of the predictive technologies.

2. PdM is not a core competency

For many companies, PdM is not a core competency within their maintenance organization. They do not have properly-trained analysts; they do not have the right tools and equipment; and they do not have the time to get up to speed.

If your team lacks an in-depth understanding of the full range PdM technologies, their capabilities, and how to apply them, outsourcing makes a lot of sense.

3. The company has multiple sites

Having multiple sites means each facility has to learn PdM on its own and at its own pace. Partnering with a third-party provider allows you to quickly implement standardized methods across many facilities. Each site gets immediate support in the areas where it needs it most. This means they can focus on the results of the PdM program, rather than on developing the program itself.

4. There is an opportunity to improve other areas of Reliability

There are plenty of other aspects to Reliability that offer a big payback, such as improvements in leadership, planning and scheduling, precision craft skills, root cause analysis, or RCM analysis.

These are essential elements that, for the most part, you have to do yourself. If these represent major opportunities for improvement, consider focusing on them instead of PdM.

5. You want a true picture of the health of your equipment

Typically, internal PdM programs are overly optimistic about the health of their equipment. Why? There is internal pressure to make assets look better than they really are.

Having a third-party provider of predictive services means you will get a better, clearer picture of the condition of your assets.

How to Choose a PdM Service Provider

When you look at the range of PdM service providers, you will find a mind-boggling number of companies covering a large span of specialties - from local motor shops and machine shops to large oil companies, bearing manufacturers, and compressor manufacturers.

There are three keys to look for in a service provider:

1. They have the ability to integrate multiple technologies: Most service providers only focus on one or two PdM technologies. As you know, an effective PdM program requires a multi-technology approach to detect all the possible failure modes for your equipment. Therefore, the provider should have the ability to bring in 8-12 of the key PdM technologies that comprise 15-20 specific PdM applications under one integrated approach.

2. PdM is a core competency: Different companies have different core competencies. Whether motor rewind shops, data collector manufacturers, bearing manufacturers, or oil refiners, those are their core competencies. To think that they reach outside of their core competencies and effectively deploy MCA, Ultrasound, Vibration – and all of the other PdM technologies – simply is not realistic.

3. They have qualified analysts in each technology: It is critical to have qualified analysts who can identify the root causes of equipment problems. Otherwise, you will constantly be fixing symptoms rather than the root cause. For example, if you have an alignment problem on equipment that is causing bearing failures, you can spend a lot of time and money replacing bearings. Or, you can address the root cause and fix the misalignment problem.

It is imperative to have PdM analysts who can make the right recommendations for your organizations. At a minimum, the service provider should employ analysts with:

- Training and certification in the technology
- Desire, motivation, and passion for the job
- A technical background in the field
- 1-2 years of experience under a mentor

Putting It All Together – The PdM Design and Scope

Your PdM program will be most effective when the scope of the program is clear and well-defined. A Design and Scope Document provides your team with the information necessary to clarify and fully understand the program.

Basically, a Design and Scope Document is a blueprint that helps plan, schedule, and control the implementation of the project. Listed below is some of the information that should be included:

- Targeted equipment for applying PdM technologies
- Resource requirements for deploying the PdM program
- The resource model to be used – internal, external, or hybrid
- Costs involved for ongoing support
- Workforce training and individual development plans
- Written standards for personnel certifications and qualifications
- Written standards for inspection procedures and technology standards
- PdM work flows and work management processes
- Performance metrics and targets for each category
- A two-year Gantt chart with implementation timelines

In addition, it should include the business case – an objective financial analysis of current and expected benefits of the PdM process. The business case can be broken down into maintenance cost components, such as:

- Parts/materials
- External labor
- Internal labor
- Tools and rental equipment
- Production improvements
- Other reliability related results
- Capital expenditures

Having all of this information compiled and published in one final document is a powerful way to lay out your plans.

Why go through the trouble of preparing a Design and Scope Document?

First of all, it serves as a reference guide that justifies the investment in the program.

Secondly, in a lot of companies, managers turn over every 2-3 years. So when a new manager comes in and starts asking questions, you can pull out this document and show exactly what you are doing and why.

An anonymous reader asked about how to position a PdM and asset reliability initiative with maintenance crews.

The easiest way is to allow them to participate in the process. However, this will be difficult if management has never listened to them on the other things the crafts people have told them in the past. The more you involve them, the more likely you are to have success. If you do not involve them, your inititative is destined to fail.

Conclusion

To sum it all up, there are two ways to do maintenance on equipment. You can choose to wait until it breaks down and then fix it. Or, you can use predictive technologies to monitor equipment, diagnose conditions, and anticipate failures before they occur.

The choice is yours.

“We've known for a long time, both intuitively and through RCM studies, that a condition based approach, when combined with effective work management, planning and scheduling, and a proactive, defect elimination mindset, is the most cost effective means of maintaining a plant."

Ron Moore, author of *Making Common Sense Common Practice*

Bonus Section: Key Facts, Figures, and Trends You Should Know About the PdM Industry

How big is the PdM industry? What are the key trends?

These are simple questions. Surprisingly, few facts and figures have ever been published about the PdM industry, though.

That is why we sat down recently with industry consultant Michael Vann. We turned to Michael because his company, The Vann Group (http://www.vann-group.com), has published one of the few known studies on the PdM industry.

Please read on as Michael reveals key facts, figures, and trends about the business side of PdM in this special Bonus Section to *PdM Secrets Revealed*.

Q: Michael, can you give us a quick history of predictive maintenance?

A: PdM is really a creation of the last fifty years. Before World War II, maintenance wasn't even considered an important part of equipment design. The machines were very basic compared to today.

After World War II, equipment became more complex, and more breakdowns started to occur. That's when preventive and planned maintenance techniques emerged.

Then in the 1950s, the basic concepts of reliability mathematics were developed by statisticians at the U.S. Defense Department. And that paved the way for the early use of PdM technologies.

In the 1960s, the aerospace and defense industries recognized the tremendous value of PdM for reducing the risk of failures. Later, PdM technologies were adopted by the civil aviation and nuclear industries.

Finally, as the Cold War came to a close, a lot of defense and aerospace workers migrated into commercial industry, and they took their PdM knowledge with them. Many struck out on their own and formed new companies to provide PdM services.

So it wasn't until the late 1980s and early 1990s that predictive maintenance services became mainstream.

Q: Overall, how much do companies actually spend on industrial maintenance?

A: In our studies, we focused specifically on the U.S. industrial market for maintaining rotating equipment. That's estimated to be at least $200 billion a year.

Q: How much of that is spent with maintenance contractors?

A: There was a survey done in 2001 which indicated companies spend about one-third of their maintenance budgets with contractors.

Q: How big is the predictive maintenance market?

A: It's almost impossible to say exactly, because the market is so fragmented. But it's safe to assume there's a multi-billion dollar market for PdM equipment and services. So it's pretty sizeable - and it's been growing at double-digit rates for years.

Q: What's causing the growth?

A: It's simply because PdM has become more cost-effective. The equipment is smaller, portable, and more user-friendly. The technologies are easier to use, and it's easier to interpret the information.

Plus, equipment costs have dropped, and that's reduced the barrier to getting into PdM.

So now it's easier and more cost-effective to let PdM technologies make the first assessment if an equipment problem exists or not.

Q: Who are the biggest users of PdM services and equipment?

A: Certainly those industries that are asset-intensive, like food & beverage, pharmaceutical, refining, petrochemicals, power generation... the ones that own and operate a lot of valuable, expensive equipment.

Q: What is the profile of the typical PdM service provider?

A: As I said, it's a very fragmented industry... there are thousands of companies involved. But we know that most PdM service companies are small, and they are focused on a local market. There are only a handful of companies that have a national footprint.

For example, when we interviewed thermography companies, if they had 4-5 guys, that's considered a big shop. That was a big service company. There's only so much work that 4 guys can do.

Q: What about revenues?

A: It varies by technology, but we generally found that the average PdM service provider had revenues in the $1-2.5 million range.

Also, out of hundreds of companies we researched, very few offer more than one or two technologies. Most are limited to one - maybe two - technologies such as vibration and infrared.

Q: What about the PdM equipment manufacturers?

A: Some of them offer services too - as a value-add for their customers. But services are a very small percentage of their overall revenues.

Q: What trends do you see in the future?

A: I think the market is definitely going toward fully integrated solutions. Companies are realizing that one or two technologies can't solve the majority of reliability problems that exist in their production processes.

Until recently, an integrated solution may have been a little premature. It wasn't quite at that tipping point yet. Now I see it becoming more mainstream.

Q: What's going to happen to the small, local service providers?

A: I think they'll always be around. But for large-scale corporations who want to build strategic, competitive advantages - that's tough to accomplish through dozens of local PdM service providers. Big companies want consistent services and standards delivered across all their plants.

So that's good news for service companies who can bring a total, integrated PdM solution to the customer's sites.

Q: What about information systems?

A: Managers now want to see data from all the PdM technologies integrated into a single database. Before, it wasn't easy to view information from the different technologies in a useful format.

Now decision-makers can see accurate, real-time information - the kind of information they've always dreamed about. By drilling down into key performance trends and historical data, they can make better-informed decisions about maintenance and production.

Q: What about finding skilled PdM technicians?

A: There's definitely a shortage of skilled manpower - especially in remote areas where it's hard to attract workers. That - plus the retirement of PdM professionals - is reducing the available labor pool. Just trying to find employees is a challenge, so that's another reason why outsourcing has become popular.

The good news is the jobs being created are good jobs, like planners and schedulers, PdM technicians and analysts, reliability engineers, trainers ... people who work both with their hands and their theoretical knowledge. These are not the typical blue-collar jobs traditionally associated with industrial maintenance.

Case Study Results

Readers Victor, Mike, Paul, William, and Tom all asked for case histories. Included here are two case studies.

Case Study #1

INDUSTRY: Pharmaceuticals

ISSUE: Patented product going off patent

	PRIOR TO RELIABILITY INITIATIVE	AFTER RELIABILITY INITIATIVE
Healthy Assets	35%	85%
Reactive Maintenance	71%	7%
Overtime	22%	5%
Maintenance Employees (FTEs)	350	250
Staff/Personnel		Added 9 Planners, 7 PdM Technicians, and 8 Reliability Engineers
Inventory		Reduced to 33% of previous level
Availability		12% Increase
Production Deviations		1/10th of previous levels
Maintenance Budget		Reduced 40%
Insurance Premiums		Reduced 30%

Case Study #2

INDUSTRY: Steel

ISSUE: Company was on verge of bankruptcy

	PRIOR TO RELIABILITY INITIATIVE	AFTER RELIABILITY INITIATIVE
Reactive Maintenance	70%	20%
Availability (based on 8,760 hours)	78%	91%
Product Quality (yield)	76%	91%
Inventory Reduction		$40,000,000
Maintenance Costs		Reduced 50%

Following implementation of the Reliability Initiative, the Company was named Most Profitable Steel Producer in 1999 and ranked as #1 Steel Maker in the World by Dow Jones.

Recommended Resources

Asset Health Assurance Training Series

Here is your chance to transform your PM and PdM programs into Best Practices with our targeted series of workshops.

Now, no matter where you are on the road to reliability, you can learn and apply the secrets from some of the most successful programs – and program managers – in the world.

Plus, in each of these classes, **Overview, Mechanical, Electrical and Stationary**, you will have access to powerful proprietary software tools to help you put your new knowledge into practice.

These tools include a roadmap tool, an equipment walkdown tool, a criticality analysis tool, an asset health matrix tool, a PM evaluation tool, and a self-assessment tool. Each one contains a storehouse of knowledge.

There is no excuse not to have a successful PM and PdM program. With these workshops, you get comprehensive training in all of the technologies, designed around your own equipment and packaged together with the software tools you need to make the job faster and easier.

Asset Health Assurance Training Series is designed for people with little or no formal training in PdM and CM technologies. This includes maintenance technicians, supervisors, planners and schedulers, reliability engineers, and plant managers.

For information about public offerings of this series or private classes held at your location, send an email to info@alliedreliability.com or visit our website.

Maintenance Planning and Scheduling

To go from reactive to proactive maintenance, you must have an effective planning system in place. Why? Proactive maintenance is planned maintenance.

Without good planning and scheduling, maintenance is haphazard at best, chaotic at worst. Left alone, maintenance tends toward emergency work and fire-fighting – with no time left for the preventive and predictive work.

The result? Higher material costs, more overtime, and higher repair costs.

Oddly enough, one-third of all companies have a maintenance planner, yet less than 10% of these planners are used effectively. That is why training is critical if you want planning to run efficiently and effectively and avoid bad work practices.

Discover the keys to successful planning and how to unlock its tremendous power in this course. Training includes instruction on Best Practices from experts in the field.

Reserve your spot today at one of our public training sessions by visiting the training schedule at www.alliedreliability.com. For more information, email us at info@alliedreliability.com.

Phase I PM/PdM Evaluation

What is the fastest, easiest way to improve your maintenance program?

Get a third-party evaluation of your PM and PdM program and an assessment of your use of the five major technologies.

You will find out exactly what you need to do to improve PM and PdM, lower your maintenance costs, and improve the reliability of your plant.

After designing, operating and managing over 200 PdM programs, Allied Reliability has taken everything we know and packed it into a powerful analysis tool. You will get more work done in days than you could do in months on your own.

"I believe that Allied's Phase I PdM analysis is an excellent addition to the Reliability process we have implemented and will add significant value to the bottom line of our company. I'm excited about the results of the analysis... and I am a guy that is not very easily excited!"

– Gary Johnson, Reliability & Maintenance Manager
Alcoa Primary Metals Business Unit

It is a tremendous time saver. Ready to start? Call 888-414-5760 or send an email to info@alliedreliability.com.

About Allied Reliability, Inc.

Founded in 1997, Allied Reliability, Inc. (Allied) has become one of the largest maintenance and reliability engineering firms specializing in Predictive Maintenance and Condition Monitoring services.

Today, Allied serves clients in over 200 plants and facilities in 40 states in the U.S., 3 provinces in Canada, and countries in Europe and Latin America.

Our technicians routinely monitor over 150,000 pieces of equipment with a full range of PdM technologies.

Contact us for more information about our offerings in:

PM/PdM Program Design

- Criticality Analysis
- PM Evaluation
- Asset Health Matrix
- PdM Technologies Evaluation
- Work Management Evaluation
- Contract PdM
- Remote Diagnostics
- Coaching and Mentoring

For details, email us at info@alliedreliability.com or call 888-414-5760.

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What Are Industry Professionals Saying About *PdM Secrets Revealed*?

"This is a quick read, worthy of the time spent on it by those responsible for equipment reliability and maintenance cost effectiveness. PdM represents one of the best tools for increasing profits and improving competitiveness in the global marketplace. Decision makers should pay attention to this subject as it represents one of the last frontiers for improvement in quality and capacity for delivery of products and services at the lowest cost."

– Jack R. Nicholas, Jr., MBA, P.E., CMRP, CEO Maintenance Quality Systems LLC

"I read through this report several times and my conclusion is - The "Content" is in perfect harmony with the "Title". Indeed, this report is a must-read practical guide for all maintenance and reliability practitioners regardless of the maturity or success of their PdM Programs.

I highly appreciate the logical flow as well as simplicity and yet comprehensive nature of the material… This is a job worthy of commendation. I say a big thank you to Allied Reliability for reaching out to and educating maintenance and reliability practitioners globally in an ever evolving field where we are faced with the challenge of achieving excellence in the light of harsh economic situations."

– Victor Itulua E., DML Lab, Mechanical Engineering Dept, Tennessee State University

"Thanks for the report. Great information! Your information makes me look like a genius to the rest of the management group! I liked the straight forward, no nonsense approach. I don't have a lot of spare time to try to sort through questionable advertising fluff. This report has the information I was looking for and tells me where to find the answers. I just want to thank you for the concise information in a great format. This report articulates the things I all ready know, but need to be better at passing along to my superiors in order to improve our plant's program."

– Craig Pindell, Maintenance Program Specialist, Dyno Nobel Inc.

"Thanks for the information; this has become invaluable in my goal of pushing a sound PdM program here. Although we are still far away, we are making some progress. We finally had our reliability forum with the site leadership team, and I presented the last paper you sent me."

– John Roach, Reliability Engineer, Huntsman Corp.

"It's hard to put a price value on the information you have in the *PdM Secrets Revealed: How to Improve Your PdM Program Or Start One from Scratch* report. We have been in the process of developing a successful PdM Process for three years. Our down time has been reduced from 15% to an average of 4%. Unexpected failures are rarely happening, compared to 8-10 times a month or more. We have reduced our maintenance budget by 20% and are using a lot of the funds in upgrades to equipment."

– Byron H., Maintenance Manager, Mining and Metals Industry

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