Ensuring the Longevity and Successful Implementation Of Your Advanced Maintenance Strategy

(Predictive Maintenance)

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Introduction: This paper is focused on identifying and preventing the most common causes of advanced maintenance strategy implementation failure and more specifically predictive maintenance program implementations. The ideas presented are applicable, in most cases, to any advanced maintenance strategy implementation. A recent report stated the following as the top 2 reasons why new business opportunities fail.

32.1% Poor management of financial activities
14.6% Lack of management competence or experience

The design and implementation of any advanced maintenance strategy should be viewed as the start-up of a new business. This presentation/paper looks at the categories of People, Processes, Technology and Reporting and the root-cause failure mechanisms that hinder their progress. I believe that the major issues regarding failed advanced maintenance strategy implementations fit into these categories. Fishbone root-cause analysis diagrams are shown to identify leading problems. ROI/CB methods are specifically discussed to ensure proper reporting for management. Recommendations are also offered to predict and prevent these failure mechanisms from occurring, so that long-term program longevity can be assured.

Many of the activities outlined below that lead to business failure are prevalent in our facilities. But what are the root-causes for these problems? Poor management of financial activities can typically be boiled down to poor reporting practices. Lack of experience can usually be addressed through improved training. Economic conditions typically lead to difficulty in getting access to capital to acquire technologies that may improve performance. Poor books and records yield a questionable roadmap as to the "as-is" condition and the improvements you have made. Sales and Marketing can be directly correlated to quality (product) and price (influenced by many factors). Staffing problems can be equated to poor project scope and miscommunicated expectations. While there are many root cause catalysts regarding union problems, often times experience has shown us that individuals who are happy in their profession are more focused. The implementation of advanced technologies can sometimes cure these ills. Failure to use external advice is intuitive. Rely on your vendor and networking with people of like minds to pull you through the rough patches. I believe that by eliminating several of these issues we can reverse a trend that is plaguing corporations and keeping consultants very, very busy.

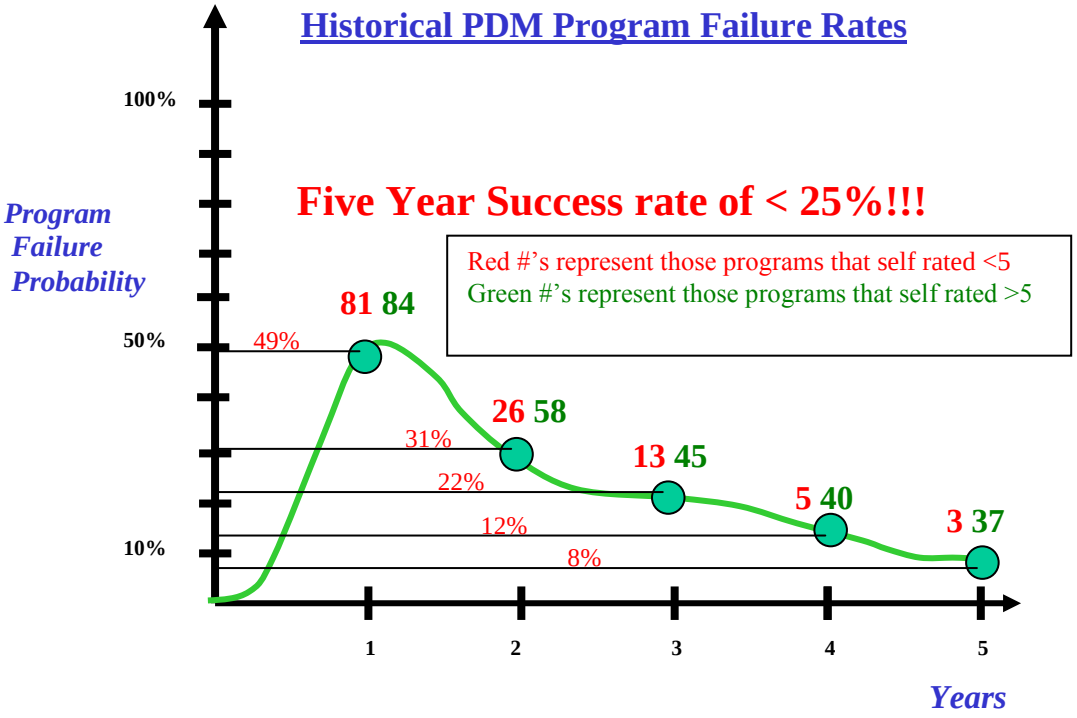
32.1% Poor management of financial activities
14.6% Lack of management competence or experience
12.4% Inflation and economic conditions
12.3% Poor books and records
10.7% Sales & marketing problems
9.0% Staffing problems
6.2% Union problems
2.7% Failure to use external advice
100.0%

Courtesy of Coleman Management Services Inc

The Pain: What is the Problem?

Historical data reviewed from surveys of PDM programs yielded the following results. The industry *"secret"* that no one bothers to tell you is that approximately one-half of all programs fail within the first year. There are a number of factors that drive this. The chart below shows the data from the survey. A questionnaire of 25 questions was sent to over 500, of which 165 responded. Those surveyed were asked to self rank themselves (it is agreed to be a little subjective) on a scale of 1-10. We considered an average of less than 5 over 25 questions as program failure. Our philosophy was that anything operating at 50% or worse may not be worth doing at all. I know there will be a number of purists that argue about subjectivity and a multitude of factors that could skew these results. I know. However, I believe that if we ask enough people the same questions, you will get fairly uniform resultant responses with a few errant data points. A modified Delphi approach, if you will. *In the data received, I rounded the number of years the program was in existence to the nearest year.*

The data is based on a survey performed in 1999.



In year one, of the 165 respondents, 81 individuals submitted data and ranked themselves low enough to suggest that their program had failed or was failing. This trend continued so that by year 5 (and older), only 37 respondents ranked the success of their programs as successful. That's a shocking 37 of 165. That is 22.4%. *Note: By year five, only 46 respondents said there program had truly gone away. By "gone away", I mean the equipment is sitting on the shelf collecting dust or being used as a door stop.*

Okay, So What? Well, the failed implementation of any advanced maintenance strategy or program at your facility costs money. In the case of a failed PDM program we can

conservatively estimate that $100k was spent between equipment, people, training, etc. That equates to some nice stuff:

- **2017 Dodge Ram Pickup 2500**
  4DR Quad Cab Laramie RWD SB (6.7L 8cyl) ***2of them***

- **5,555 Outback Special Steak Dinners**

Of course this does not include the intangible losses of credibility and trust. In short, if you are at the helm of a failed PDM program then you have probably committed a career limiting offense. It is unlikely that you will be given a second chance and it is likely that you may either loose your position or job.

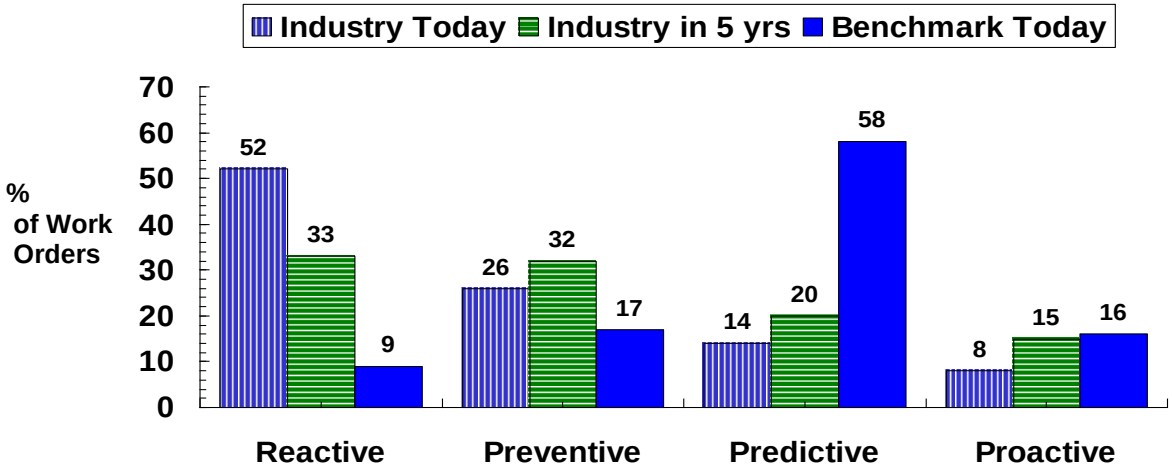
So, the question then becomes, "Why would I be adventurous enough to undertake an activity that has historically shown a propensity for failure?" You might say to yourself, "I am only a few years away from retirement; I'll just ride out my time here in my current position". If you're that individual, then you are right, DO NOT undertake an effort of this magnitude. I believe that the Risk-Reward ratio is actually quite low when the proper people, processes, technology and reporting are put in place.

WIFM-What's in it for me? I mean you.

We all must ask this, right? I mean anything worth doing is worth doing well. If you're like me, then you're probably saying if I am going to do it, I need to know how I am going to win. Well, here is how. Predictive Maintenance as an advanced maintenance strategy has saved companies millions of dollars. I have seen the results first hand. I have seen the leaders of successful programs glorified by fortune 500 CEO's at company meetings and PDM program managers mentioned in company 10-k reports. I even knew a guy who got a parking spot right next to the plant managers (I am not kidding). For those who know what they are doing, the accolades are numerous. Fame, glory and in some cases, big bucks were inevitable. Ask me off-line, and I'll tell you some guys I know/knew who did it well. What else? Well, the technologies (for the most part) and the trends they develop are mathematically sound, repeatable and have been around for a lot of years. The trends do not lie. I consider myself a youngster, but even my first experience goes back almost 25 years. I witnessed the application of Vibration Analysis for the first time while serving as a Machinists Mate aboard a United States Naval Vessel, (USS Mt. Whitney) in 1981. The technology, housed in large file cabinet size boxes was lowered into the ships engine room (11 decks down) and hooked up to the power plants main engines, auxiliary turbines, generators, feed pumps, and condensate pumps, etc. Data was collected by the team and helped the engineering team to focus resources on critical equipment during the up-coming outage and yard work. I asked a lot of questions during that cruise about the technology and knew then that someday I would learn more about it.

Well, what about industry trends? I knew you would ask. A few years ago I read a report by one of the large consulting firms. It has been around the block so you may have already seen it. The report published in 2008 by Deloitte and Touche asked plant managers to assess the number of work-orders generated at the facility and to categorize them into the following bins:

Maintenance Practices



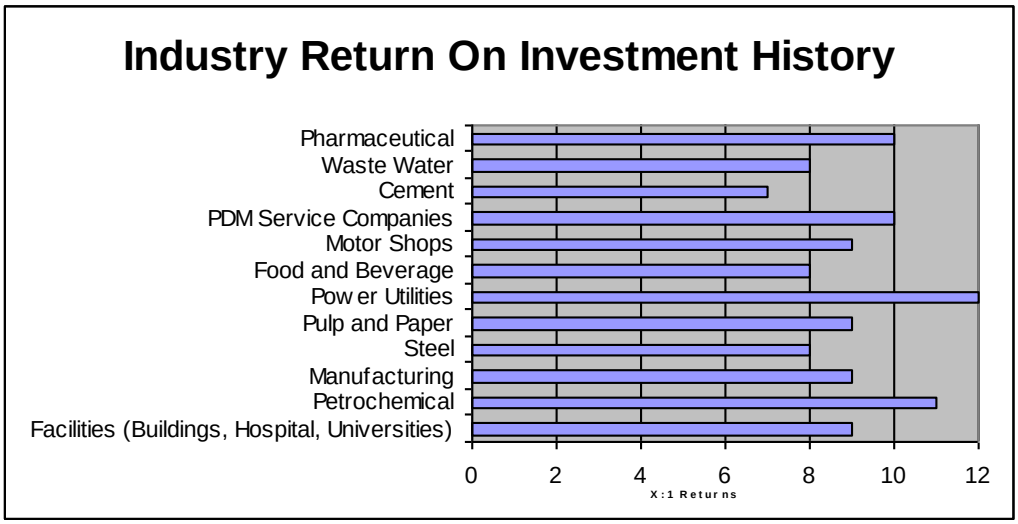
Survey Results: Deloitte & Touch 2008,

First, let me explain the bins. The bin of "***Reactive***" (sometimes referred to as corrective) represents a work-order that was generated independent of the preventive maintenance schedule. It typically is reactive in nature since it was not expected or planned for. The *"**Preventive**"* bin represents the preventive maintenance or time based scheduled tasks. These tasks are typically derived from the OEM's recommendation and are based on some schedule of time, e.g.; replace the bearing every six months. The *"**Predictive**"* maintenance bin is some task that is "predictive" in nature. In other words, some technology (non-intrusive) has been utilized to assess when maintenance should be done. An example is fitting: I replace the oil in my car every 3,000 miles since the manufacturer suggests it (***Preventive***). I replace the oil in my car when the temperature gauge is pegging and smoke is bleeding from the valve covers (***Reactive***). I install a reliable on-line oil sensor in the car's oil sump and it tells me (based on some magical correlation) that the viscosity, contamination and wear particle counts suggests, that based on my driving habits over the past several months, that I should change the oil next week (***Predictive***). The Pro-active bin represents root cause failure analysis. Determining the root cause of why things are failing and eliminating that condition. I will not say anymore about Pro-active maintenance (topic for another paper).

These plant managers were asked to assess on a percentage basis the number of work orders their site generates today (solid column with vertical stripes). They were then asked to assess where they would need to be 5 years from that point to stay competitive (solid column with horizontal stripes). Obviously, this is a subjective guess on their part; I am assuming that guess is based in part on experience, knowing coming trends and networking/benchmarking with their peers as to where their facilities needed to be.

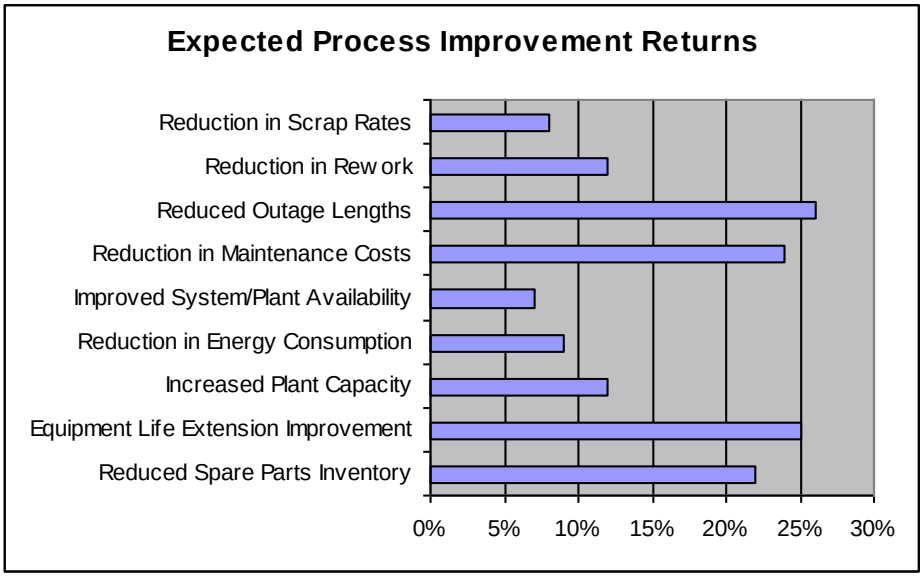
Finally, the surveyors took the surveyed companies and based on operations and maintenance costs, plant/equipment availability, MTBF (mean time between failures) and unplanned downtime, ranked them. They extracted the top 10% and called them "benchmark" facilities. These top 10% of facilities and their breakdown of work order generation is represented by the solid bar. The results are somewhat predictable. Do less reactive maintenance (do not want to wait until smoke is coming from underneath the hood). Do more preventive maintenance (I believe this comes from years of pounding by maintenance consultants). Preventive maintenance has its roots in Airline and military industry. Breakdown is typically not an option here. Also, for the average facility, preventive maintenance costs a lot of money and is sometimes over done. Finally, the survey reveals that these plant managers agree that they should be doing a lot more predictive maintenance. The good news for us is that we probably do not need to do much evangelizing to senior management. The word is certainly out. Predictive maintenance works. There are a number of other reasons plant managers would like to move towards non-intrusive ways of monitoring their equipment to ensure better reliability. They know that their senior level executives are not going to allow them to invest capital dollars into installing redundant systems (would not want to do this anyway). They know they need to find non-intrusive ways to monitor the equipment. They have limited talented craft resources that are over extended as it is. Their maintenance staff some times introduces more errors by open-inspecting and fixing things (did I say that out loud). They are pressured to reduce outage lengths and therefore must stop the blanket approach of performing preventive maintenance on all equipment during an outage. They must find ways to perform maintenance on a "condition" basis. Predictive Maintenance offers that solution. Therefore, it's not a surprise that these plant mangers responded this way.

How about another chart? We have some other data based on feedback from customers regarding their return on investment in predictive technologies. Again, it's no surprise that the heavy industries with extremely critical equipment operating 24-7 showed the best returns.



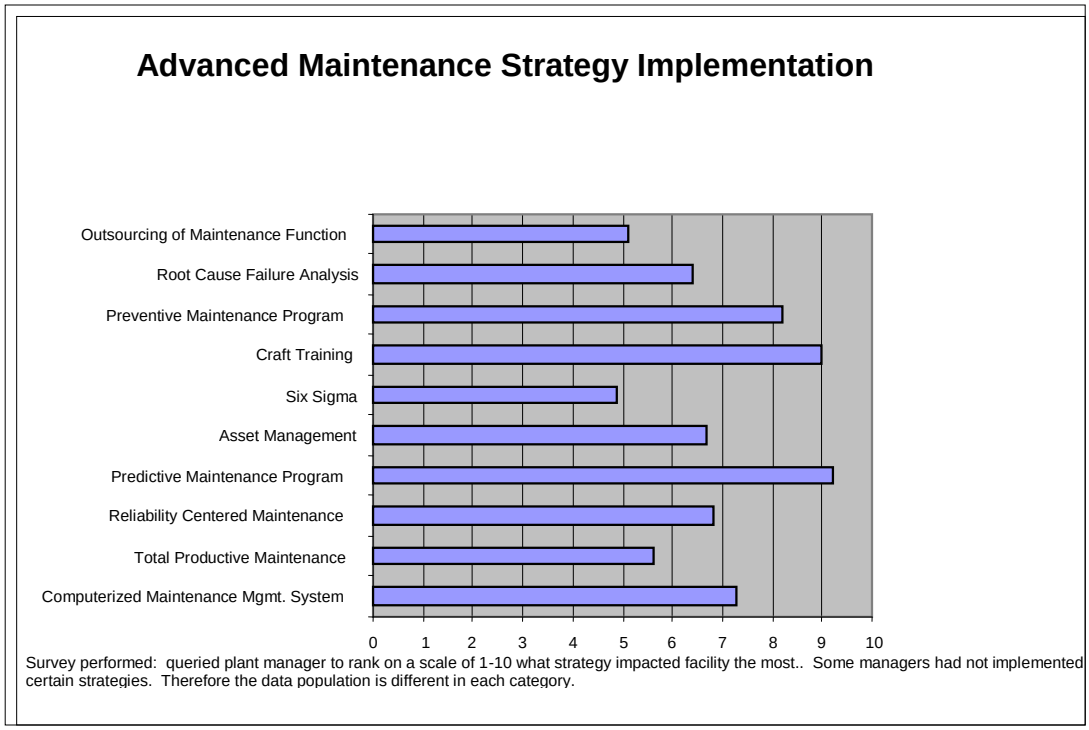
Data collected from PDM users 2008-2012

Now for one of my favorites. Imagine, if you will, a maintenance strategy that returns eight to twelve dollars for every dollar invested. There are few if any other advanced maintenance tools that provide a similar return on investment. These savings are realized in a number of different areas of the facility. They are: improved reliability, availability and capacity that leads to greater revenues. The "predictability" afforded the engineering, operations and maintenance teams allows for better planning of outages. Outage planning is enhanced by the simple fact that you can better predict MTBF (mean time between failure) rates. Replacement of Time based schedule preventive maintenance tasks with non-intrusive predictive maintenance tasks allows for a reduction in the PM program without risk of higher failure rates. Additionally, with so few qualified journeymen rising up through the ranks, the qualified maintenance resources can now be focused on those critical tasks that must be done right. The less harried environment leads to less rework issues, a reduction in the back log and a much better environment to work in. Other benefits are captured in the chart below.



With so many advanced maintenance strategies to choose from the question becomes, "Are there easier battles to conquer?" Perhaps so. Predictive Maintenance in and of itself is not an easy implementation. The barriers to success are numerous, as we will discuss later. The fact remains, however, that the biggest bang for the buck amongst potential maintenance strategies comes from predictive maintenance implementations. So, with the type of returns and improvements documented above, it is no wonder that for those who have been successful the paybacks have been nothing short of remarkable. A survey performed in the 2014 timeframe queried managers who had managed the implementation of multiple advanced maintenance strategies over the past ten year period. They were asked to objectively rank the impact of implementation. The results (See below) show that a properly implemented PDM program achieved better results then such heavy weights as RCM (Reliability Centered Maintenance), and CMMS (Computerized Maintenance Management Systems). Interestingly, craft training (good old wrench turning skills) ranked

nearly as high as predictive maintenance. The chart below captures the results of a survey of users during the 2014timeframe.



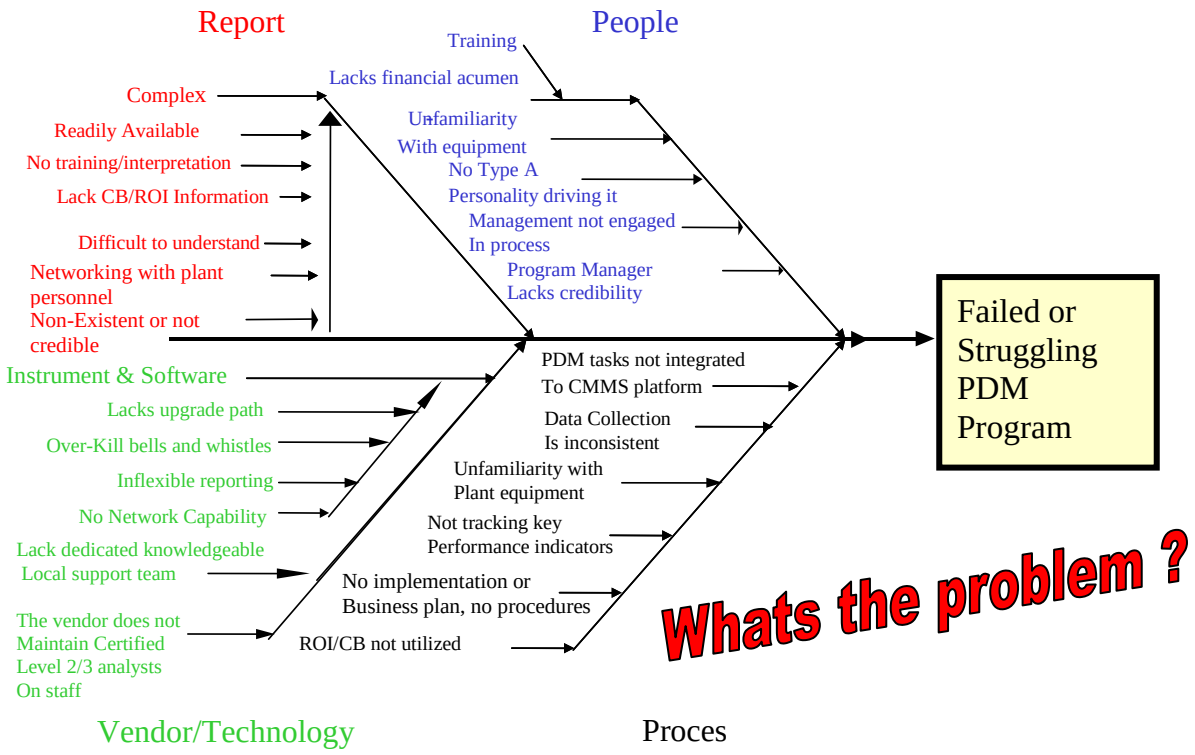
Okay, so there exists a pretty good story why this strategy is worth pursuing for personal and company reasons. There is a multitude of objective data collected by third parties that validates it. We know it is worth doing and that not many people do it well. The remainder of this paper addresses those issues of why people do NOT do it well and offers recommendations for improvement. This will not be highly subjective content. I promise you.

Assessing the Problem (As-Is Condition)

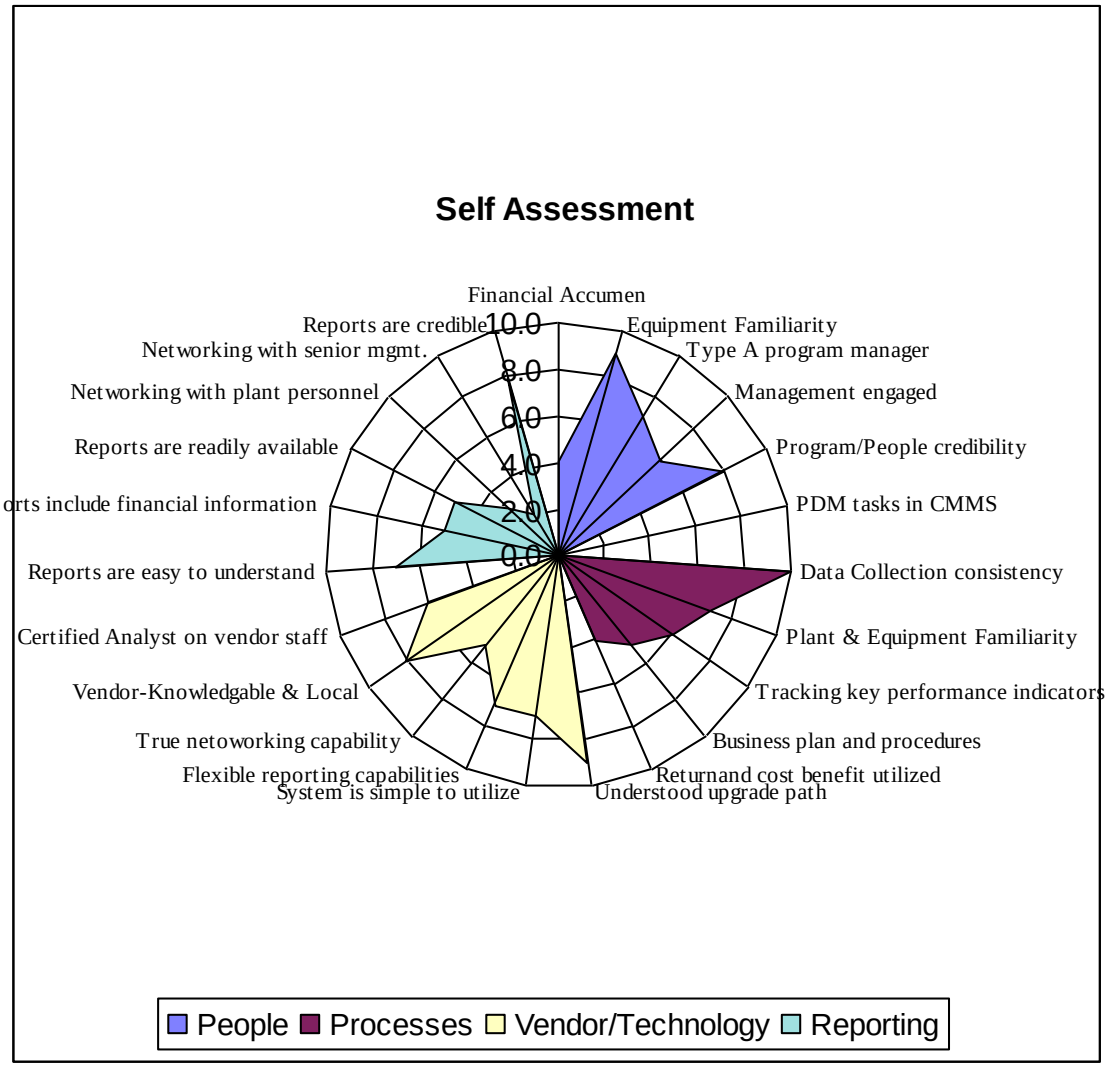
During the nineties, I had many opportunities, while working for a major vendor, to tour facilities around the world and assess their predictive maintenance programs. The assessments were part of a process whereby the individual facilities we were assessing were competing for a coveted Predictive Maintenance Program of the Year Award this vendor awarded. To be honest, it was strategic marketing at its best. During the years I was involved with all of these assessments, and visited and reviewed several hundred predictive maintenance programs around the world. The majority of these companies were considered benchmark in their respective vertical markets. In all cases they had shown a unique capability to implement successful predictive maintenance programs. Some of the programs had been in existence for 16+ years. While evaluating them, the participants shared their failures, and the pitfalls and issues they had faced over the years in excruciating detail. I began to see common threads that ran through all of these successful programs. I saw the same challenges conveyed to me time and time again. I realized that their success was not based on luck or some magical formula but sound successful business practices that

on the surface seemed simple and obvious. Remarkably, the problems fell into four predictable categories: People, Processes, Technology/Vendor and Reporting. I decided to perform the standard fishbone analysis on the problem, remembering the issues, challenges and pitfalls my interviewees had suffered through. The following diagram states the most commonly heard problem in a succinct one liner. I will elaborate further on some of the key issues and discuss potential solutions.

Root Cause Analysis-Fishbone



The outright solutions to these issues is why benchmarking with successful peers is so important. These items in and of themselves may not torpedo a predictive maintenance program. But several combined together, in the aggregate are a recipe for failure. The chart reflects years of program manager experience. You can perform a very simple "as-is" exercise by ranking yourself (objectively) in each of these categories on scale of 1-10 (ten being best). Lay the results out in a Spider Chart (see below) That 360° look should lay the groundwork to begin stream-lining your program.



I could write a book on these roadblocks and perhaps one day, I will. For now, I will hold my comments to several points per category. Let's begin with the all important People.

PEOPLE:

I know I will catch some heat for this, but here goes any way. If you are not a "Type A" personality then it is unlikely you will be successful in driving a predictive maintenance program. The program needs an extroverted sales type person who is continually selling the benefits of predictive maintenance. Some will say, yes, but shouldn't the results sell themselves? Well, no. I cannot think of any process (inevitable aging and death) or program (taxes-they will find you), etc., that is assured. Power (management) likes dealing with power (credible strong extroverted people). Show me a program manager that has the capability to present to tough crowds, has unique visionary capability and the ability to instill passion and I'll show you a solid program. You must be steadfast to the programs success, and people in the facility must realize your commitment to its success. The self fulfilling prophecy of any successful program is to reduce the very problems for which it was initiated. It is sort of like working your way out of a job. Over time you will have eliminated the low hanging fruit. You will see improvement in availability, reduction in

unplanned failures and a multitude of other benefits. Three to five years into your successful program, new people/management (probably MBA's-I can say this cause I is one) will begin to ask, "What is it that the PDM group does?" Your knowledge and historical perspective of the successful past and persistent tree stump sermons of your successes will ensure that people are aware of who deserves some of the credit for the current status in the facility. Your persistent selling, to management, of the future work you plan to do will solidify in their minds the programs value. They must understand that doing anything short of increasing the funding for the coming year, could easily plunge them into a downward spiral on key indicators of plant, system and equipment reliability. It takes a strong person to defend these positions when things are even keel. It takes an even stronger person to convince an operations manager to shut a plant down. People forget. You do not get many chances to screw up. Therefore my recommendation, made strenuously, is that those who will lead the Predictive Maintenance Effort should also be capable of running a political campaign. Some recommendations that will ensure you have what it takes:

- Read the book "How to Win Friends and Influence People" by Dale Carnegie
- Take the plant manager to lunch monthly.
- Buff up on your financial acumen (know how to get access to capital-understand hurdle rates; cost of capital, expense budgets etc.). Take your chief financial officer/accountant to lunch monthly.
- Do not over state your successes (maintain your credibility).
- Take a course on "how to present". (video-tape yourself).
- Find a successful coach. Someone that has the tee shirt.(or stayed at a Holiday Inn Express last night!)
- Benchmark with other facilities
- Ensure your manager is in the field frequently observing your contribution.
- Develop a personal education plan for yourself and your people.

I could go on for several more pages, but that should get you started.

Technology/Vendor

Ask your sales guy if the vendor has knowledgeable analysts on their staffs that reside in the country. If the answer to that question is NO, then run-away very fast. If this is the case, you will not be able to get detailed help and you will always be relying on your sales guys ability to link up with the foreign vendor in another country six to twelve hours apart. They must have a local presence, independent of their sales channel. Does their software have true network capability? How about open in architecture? NO? You're locked for life then. Get used to buying only from them. By the way, a great test for the sales guy, to ensure open architecture (future ability for you to share information with other systems), is to ask them to demonstrate opening up two different unique databases and drop and drag one data sub-set (system, plant, and equipment) to the other database. If the system is truly open the data will copy straight over. If not, do yourself a favor and tell them to have a nice day. Please, please, make sure you ask what they charge for upgrades (software and hardware) over the next 8 years. Ensure you understand the overall cost of ownership. There are quite a few vendors that make a good living (residuals) on this. A rule of thumb

is 10% (of hardware and software) per year after three years. You get 3 years and 36k miles from your auto manufacturer, so why not from your software vendor? What about reporting? You should be able to easily copy and paste reports from their software into Word documents, PowerPoint, Excel, etc. Do not be fooled with all the bells and whistles. Simplicity is important to your long-term success. Look for the basics. For example, if you're investing in a vibration analysis solution then ask yourself the following: Does the box (data collector) collect data and easily transmit that data to the software? Is the software user friendly and does it provide a flexible reporting interface (get data easily in and out)? Does it weigh something less than a small car, and can you work it with one hand?

Some recommendations to ensure that you get the best return for your invested dollar:

- Do not over Pay. These systems are not that expensive to manufacture. You can use the money you save to get yourself more training.
- Require that all vendors cost justify their systems to you. They should provide you with a spreadsheet that shows ROI and Cost Benefit.
- Ensure that you spend time getting to know your vendor. Participate, where possible in providing them feedback in product development.
- Network with your peers; attend tradeshows, e.g.; Vibration Institute meetings.
- Split up your purchases between vendors. Do not rely on one vendor to provide your every need. They will become arrogant and un-responsive. Where are you going to go, when you've bought everything from them?
- Ask your vendor to network you with other folks in similar industries with similar equipment.
- Insist that some degree of high level local support is available from your vendor (especially in the beginning) to ensure that you are making the right calls, even if you must pay a fee for that support.

Reporting

The single most important task that one can perform in ensuring the successful longevity of a predictive maintenance program is proper reporting. This would include detailed reporting of the "as-is" condition. This will remind people where we came from. Metrics should be chosen and "reach" goals set. You will have to identify performance metrics that need to be recorded/measured so that you can begin to track your improved results. Several key items that your reporting process should include are:

- Plant & System Availability (3 year trend).
- Total Preventive and Corrective Maintenance dollars spent by system.
- Top 5 equipment problems (Based on unplanned failures). Maintain a list and track costs associated with this equipment.
- Rank equipment by Safety, Single Point Failure (SPF) capability, known bad actors.
- Saves. The preempting of a sure functional failure (assuming nothing was done) by some predictive technique that prompted corrective action based on condition.
- Quantify the savings (be conservative). Know the costs of downtime, estimate labor overtime, spare parts, etc.

- Ensure lessons learned are incorporated back into processes and procedures (learn from your mistakes).
- Understand how to show Return on Investment and Modified Internal Rate of Return. *(See me for a personal demonstration—I will send you my own worksheet if you give me your card).*
- When you get the equipment problems under control, go to the warehouse and see if you can reduce some of the spare parts inventory. You'll be surprised how people bulk up for those incipient failures. Report your success.
- Review the Preventive Maintenance program (target OEM assigned tasks). Look for tasks that are time based and intrusive in nature. Try to define a predictive maintenance task (non-intrusive) that could replace those tasks. Does a technical justification even exist for the PM task?
- Track rework (PM or corrective action tasks that recur, may be due to poor workmanship, wrong parts, complex maintenance, procedures, etc.).
- Do correlate your predictive findings to Process information. Review operations logs for Pressure, Flow and Temperature anomalies that match your data.
- Post your data in conspicuous places (shop entrance, mess areas etc.). Pictures, graphics and trend charts work best. Avoid lengthy, verbose chapters regarding your findings (no one will read them). Red lights, yellow lights, and green lights get people's attention.
- Have two brown bag lunches annually to discuss your results. Invite Everyone.
- You need to attend plant management meetings. Get on their agenda to discuss results (be conservative). Remember Power likes power.
- Write an article for the company newsletter (as many times as you can stomach).

Processes

An extremely important piece comes together when we streamline the business through the implementation of repeatable processes or procedures. Ensuring we are collecting the right information, at the right frequency and in the same locations is extremely important to the long term success of any program. Inevitably, you would like to get the program to the point, where fresh faces could come in, take over the program with very little questions asked and be as successful as you are. Your success will hinge on your ability to integrate the predictive maintenance efforts into the day to day business of plant maintenance. PDM should be discussed at the morning meetings, be included as tasks in the Computerized Maintenance Management Systems, and be understood or proceduralized in the department manuals, etc. Do not forget to get operations on your side. They can be your eyes and ears while you're away from the plant. Successful PDM programs have outfitted their operations folks with low cost tools that can identify a problem. Their procedures then instruct them to notify the predictive maintenance group who can then perform a more detailed analysis. A successful example might be outfitting operations with vibration pens (providing an overall value) and then notifying the predictive group if they see anything out of the ordinary. One facility I worked with gave their operations personnel portable non-contact thermometers. Understand the bottlenecks in the plant. The problems may not be poorly designed equipment. Some thoughts to consider:

- Ensure predictive maintenance procedures are implemented into plant processes (An example might be, that maintenance knows (and CMMS maintenance requirement card says it) to call the PDM group after replacing bearings on a piece of equipment so that they can come and grab a baseline vibration spectrum before start-up).
- Review operations procedures. Ensure operators are running the equipment within recommended tolerances.
- Study the quality charts. What equipment is producing the largest amount of scrap or waste?
- The bottlenecks in the facility will usually be identified by midstream inventory bulk. Focus on eliminating bottlenecks by improving system and equipment reliability. There is quite a bit of capital tied up in that inventory.
- As a rule of thumb, do not invest in add-on technology until the systems you already own has paid for itself (3X-5X). Ask your vendor to help you prove that.
- Recruit a few potential replacements (succession planning).
- Obtain more training.
- Ensure a feedback mechanism exists during the maintenance process to allow personnel to offer suggestions for improvement.
- Ensure that maintenance/operations (all personnel for that matter) have been well versed in how to enter data regarding a work order into the CMMS system. The symptoms they experienced may be different by the time you are notified. You'll need the complete story. In a perfect world they will call you as they are generating the work order to come have a look. There is nothing more frustrating than reading poorly filled out maintenance work orders.
- Cross train some operations folks on what you do. Hang out in their world for a few days each quarter also.

The purpose of this paper was to identify and bring to light a pain that has personally bothered me for the last decade. I also wanted to motivate the reader that he or she is capable of implementing an advanced maintenance strategy (more specifically predictive maintenance) if they are willing to do the necessary work. Common pitfalls have been identified in four key areas, namely; People, Processes, Reporting and Technology. Recommendations for improvement have been suggested. My suggestion is that you take the grocery store approach. Take that stuff off the shelf that fits and leave everything else alone. I do not pretend to know more about your facility, or style. If what you're doing works and doesn't align with what I've said then do not change a thing. If not then maybe you should take a closer look.

This document is not a substitute for an advanced maintenance strategy implementation business plan (I can also get you one of these if you leave me with a card).

I am certain there are many different other reasons programs/implementations fail. So my intent was not to create an all inclusive document. I do not know that many people.

I apologize in advance to anyone I might have offended. I am sure there is some introverted engineer that mumbles and looks at his shoes when he talks and was still able to implement and run a successful predictive maintenance program (I iz an engineer also ☺

, and I also often resemble my own comments).

Please feel free to call and comment or ask questions at the following address:

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