Techniques for Improving Machinery Reliability

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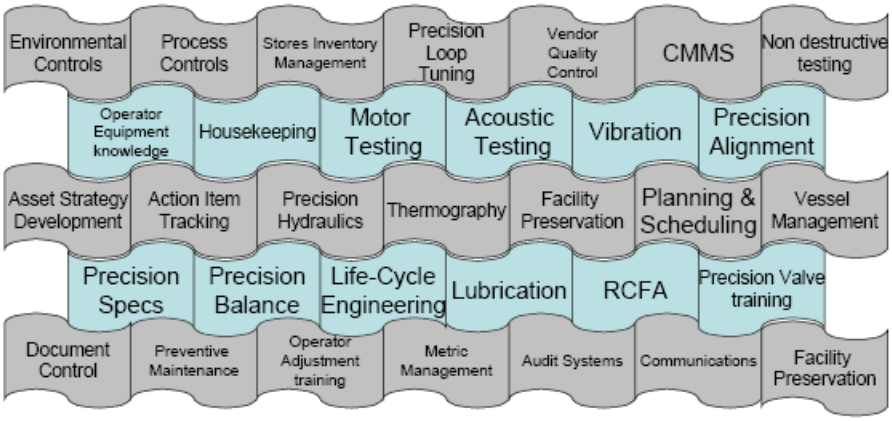
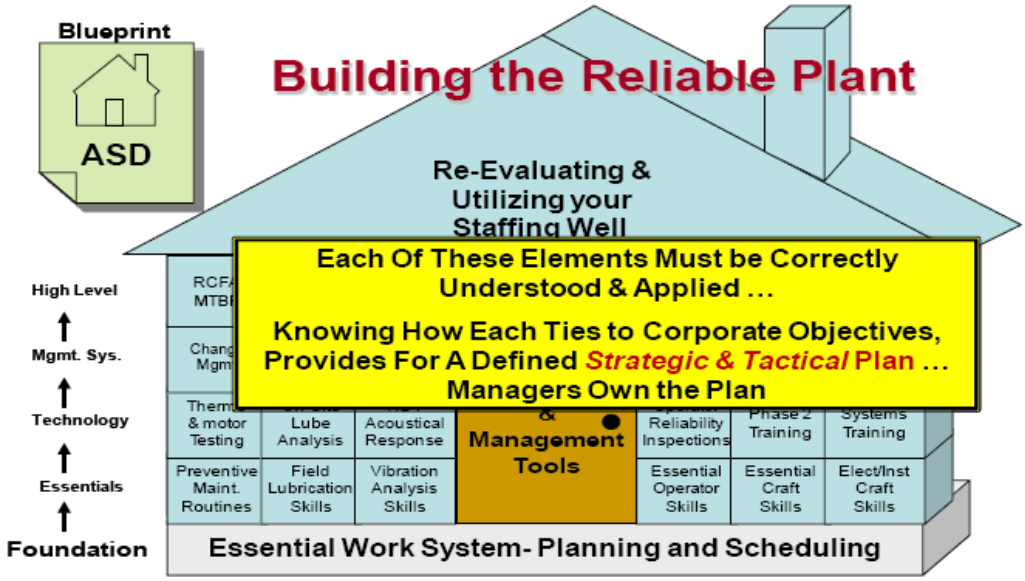
One of the biggest challenges facing industry today is taking the available reliability initiatives and creating an integrated a plan to institute the right processes at the right time. Although we know they can and have produced results, time and time again, programs seem to come and go with marginal returns and no sustainability. What is often found is that these processes are selected without thinking about how they should integrate with each other. In fact, many times they are even assigned to independent resources without a thought to how they build on each other to achieve the ultimate goal. To truly achieve a reliable and predictable plant and make it sustainable, you have to first start with a vision for what that should look like. Then you must take the "a la cart" list of the available possible initiatives and decide how each integrates with others and where the most value is per effort. Without the integration of all efforts toward the common goal of a long term predictable and reliable plant, sustainable results cannot be achieved.





In Re-Building the House of Reliability …

- Do you know where you are?
- Are you assessing your plants & are you developing action plans with timelines that drives continual improvement?
- Does your action plan move you forward … in an organized, disciplined, documented manner that has the correct metrics & measures to ensure implementation, sustainability & institutionalization?
- Do you now employ a process to share discovered best practices?
- Does your manufacturing thinking involve all organizations as partners in improvement?

Defining & Driving Business Values

• Practical Thinking …

• Changing Cultures …

• Identifying Work Differently …

What guiding principles do you use to perform your work? For any work that you are about to undertake … give it the litmus test. Can it pass the three questions?

• **Will this work be … *sensible and defensible*?**

• **Is this … *technically feasible and worth doing*?**

• **Can this be accomplished … *effectively and efficiently*?**

If these cannot be answered adequately and without reservation or personal influence then are you really doing the right things for the right reasons at the right time?

Manufacturing Philosophies

Throughout the history of industry the requirement for profitable and reliable manufacturing has significantly increased in importance. Many manufacturers have yet to alter manufacturing, production and maintenance philosophies applied at their facilities and for many reasons. Some of these often include, the lack of knowledge of how to apply, the shortage of required funds to change philosophies, reduced manpower, fear to apply that which is new, managers who refuse to change from that which they have experience with and of course a host of others. All of these philosophies are all correct … it is where we place each that is important.

In your decision of which maintenance method or manufacturing philosophy to employ consider the following mindset of, what will be the failure consequences due to:

• Potential safety issues

• Environment and regulatory breaches

• Facility production concerns

• Associated maintenance repair costs

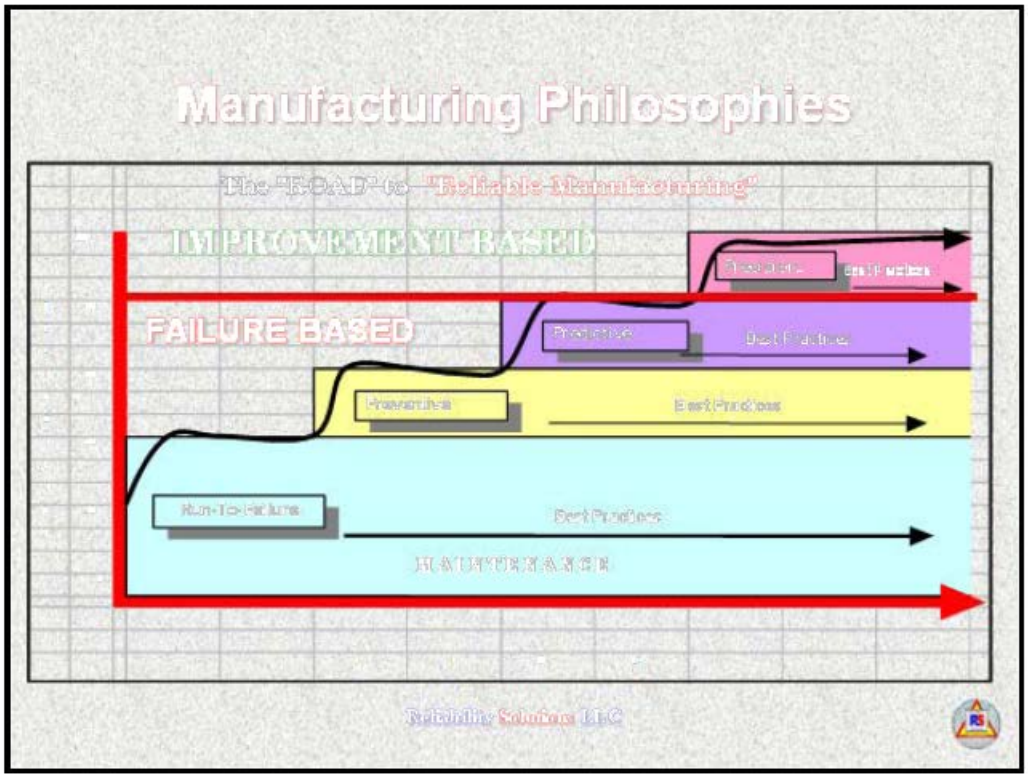
For each of these considerations ask yourself just a couple of simple questions:

• Has the asset failed in a similar manner in the past?

• What is the likelihood that it can or will fail in this manner in the future?

With these ideals well understood we can begin to explore which maintenance philosophy or methodology will be required for each site asset. When we consider what *reliable manufacturing* can

achieve let's review what manufacturing philosophies have been applied, what their advantages and disadvantages might be and where each can be viably applied in today's market place. Until each philosophy is understood, applied and correctly utilized the complete gain towards profitable and reliable manufacturing is significantly hampered.



Overall Health
Using vibration as an assistance tool to determine opportunities to improve and measure improvements made can be a valuable tool in our box. As can be seen from the graph these dollar to vibration comparisons must be made over significant amounts of time. The reason is that not all machines have the same failure rate nor has any single machine failed in the same manner or time. It is important to note though that as vibration decreased so to did parts and labour associated costs, and while this may have been intuitive the tracking and reporting of the dollar savings, tying ourselves to how management works, is that which will allow forward progression.

Where to Start?
Consider as you begin that the overall vibration levels should not exceed …
Precise State

• For machines that are 600 rpm and above <0.075"/sec

• For those that are less than or equal to 300rpm <0.02"/sec

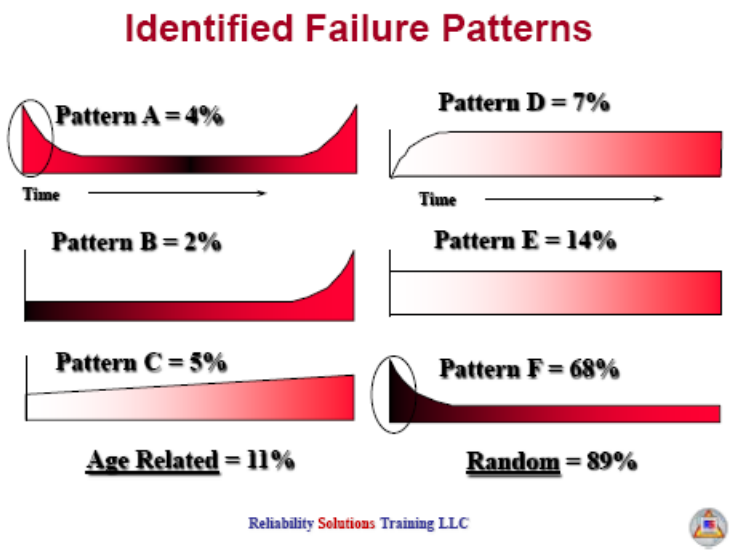
As you review these numbers don't forget the first guiding principle … "sensible and defensible."

How Things Fail

The first three, patterns A, B, and C, are all age-related failures. This means the older these components were, the more likely they were to fail by this failure mode for example, a car tire that fails due to loss of rubber over time on the road. The second three, patterns D, E, and F, are completely random in nature. A car tire could fail due to a nail penetrating the side wall, causing a slow leak of pressure. No amount of scheduled tire changes can eliminate or even decrease the possibility of that failure mode happening.

So for failure modes that fit into pattern D, E, or F, scheduled maintenance is not an appropriate solution. In fact, in the case of pattern F where there is a high probability of infant mortality, it can actually decrease the reliability of the system as a whole to perform scheduled maintenance. Further investigation into these patterns yielded the discovery that, although these failure modes are not time-based, they often give signs that they are failing prior to the failure event. Since the failure mode we were attempting to avoid was “due to a slow leak” we could easily catch the failure in progress before it failed completely.

This is the basis of condition-based maintenance. Inspection tasks are put in place to manage failure modes that fit patterns D, E, and F and repair tasks are only performed when the condition of the equipment identified that a failure was imminent. For failures that are instantaneous, let’s include a spare tire with the tools and procedures to complete the changeout.



Defining … Core Business Values

• Safety … Job 1

• Regulatory Compliance …

• Reliable ManufacturingSM … WHAT?

Reliable Manufacturing
Perhaps being simplistic but why are we in business … reliable manufacturing answers the question:

• The essence of being able to depend on your manufacturing system to run effectively and efficiently, in response to market demands, and without the insurance of inflated inventories

• … with an *unequivocal knowledge* that we will create the *best possible product* … at the *optimal cost* ... that delights our customers

• While providing an *equitable* return for stockholders … and a *viable* future with security maintained …

Precision Maintenance
If maintenance is to support the business value then how must it be applied?

• Where maintenance and troubleshooting is always performed in a known, precise, disciplined and documented approach.

• Where a sequential methodology of machinery improvement *is* the routine and not the exception …

• Where application "strategy" moves from implementation to sustainability and becomes institutionalized …

• Where a correct set of "tactical" measurements and metrics *evolve* with "Application" work …

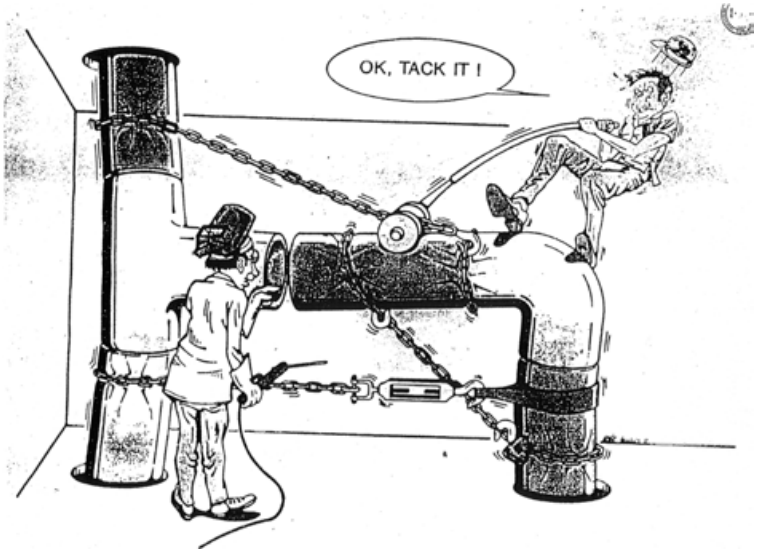
• Where the basics of work are not abandoned nor forgotten, but where work moves to the next level … – the essentials required for the performance desired

The Mechanical Failure Pie
As a result of studying the reasons for machinery failures over many years it is apparent that machines typically fail "mechanically" for just a few essential reasons. Now this chart doesn't consider incorrect operation of machines, nor those that are pushed beyond what they could do or even those that are in the wrong application. This graph only represents mechanical failure. Let's take a look at what each might include from a quick perspective.

Misalignment

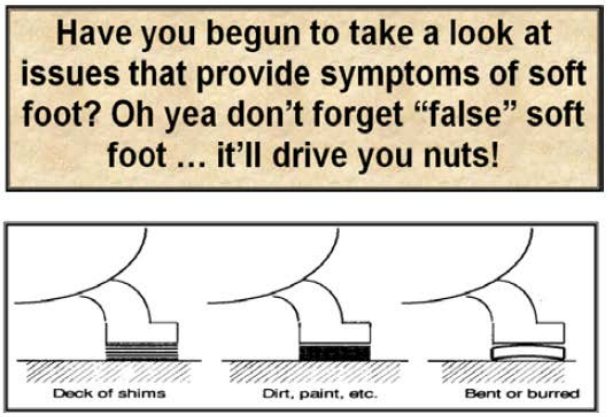
When most folks consider this subject a typical response includes, “We have lasers at our plant certainly this doesn’t refer to us”. We align everything in our mill we get “smiley faces” all the time. “Our instrument is accurate to within 1 micron”, and of course the list goes on. The fact of the matter though is that while we concentrate on readings from our instrumentation we rarely look at all the other things that can happen in the aligning process. What are some of the most common of these missed errors?

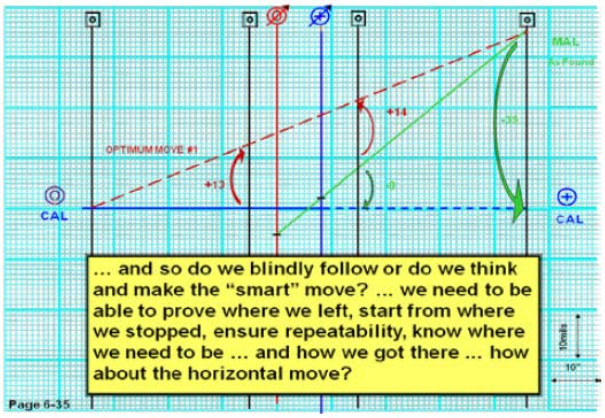
- Pipe stain
- Angled and short foot/leg
- Improper torque and torque sequence
- Loss of bearing radial internal clearance
- Couplings will accept the Misalignment
- Thermal growth on smaller machines doesn’t matter
- Other machines in the area will not affect
- Natural Frequencies will not affect
- Published Tolerances are all that is required
- Case deflection is equal in all directions
- Several Others



Precision alignment is a process not an instrument and it is still the technician who determines when we have achieved what is required. While we could look at this as a negative it really very quickly points out that improvement can be accomplished quickly. Of course from facility to facility and from area to area

within the facility this percentage may change but industry as a whole has a great opportunity to utilize these fantastic measurement systems in such a way that the final alignment is based on what the machine has to do and how long we want it to do it and the failures we wish to control.

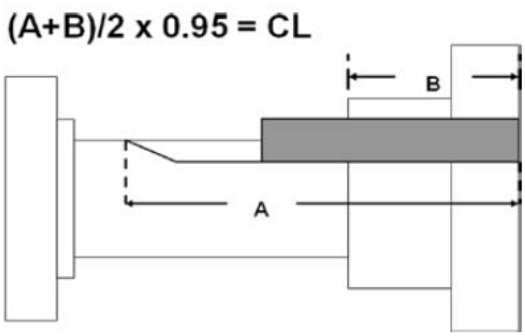




Imbalance

Balance is an issue that a typical floor craft technician has had little formal education on and yet something that all of us intuitively understand every day. For a moment let's look at what this unbalance is, where it might come from, and how to control it but let's do that first of all in a very practical manner. Most of us who own a vehicle may easily spend $100.00/tire and then spend another $6.00 to $8.00 to balance each of those tires. Isn't it interesting that we will "invest" another 6% to 8% of the purchase cost for that tire but when it comes to machines that can easily cost $25000.00 we find that a cost of $150.00 to provide a precision balance is much too expensive? Remember that this $25000.00 machine is the same machine that enables you to buy those tires that you put on that vehicle of yours. There are many things of course that can affect the balance quality as received or as placed in the machine that you are working on and let's look at a few.

So now that we've talked about what balance is we need to understand that the force of unbalance is directly related to the speed of a machine and that we as technicians on the floor can remove or retain or improve this quality by what we do.



Assembly Errors

Don't throw the baby out with the bathwater but don't wash the baby after you've done the dishes. As with misalignment and imbalance another area that we don't spend as much time as we should on is that of assembly errors. A huge opportunity exists at most sites to improve this area. Often the assembly source provides symptoms that appear as imbalance or misalignment and many times some real investigation may be required to ferret out the true source but the value is usually worth the work. As

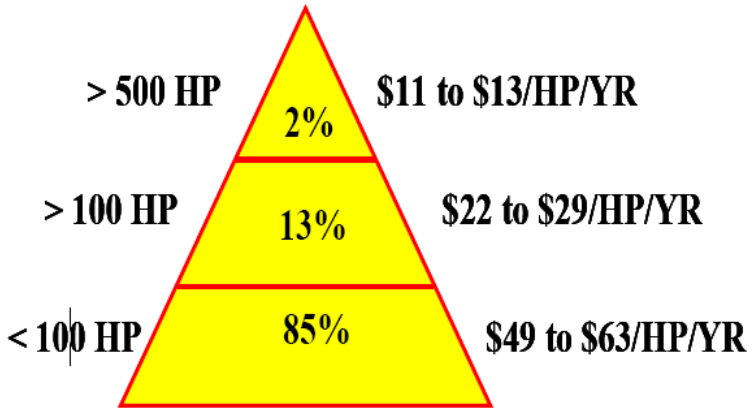
an example has anyone ever lost a bolt or washer and replaced it with one that's close? The result is a subtle change but all of these changes add up to cause a machine not to run in a precise state. Even worse is the fact that many times technicians chase errors in machines that could be corrected ever so simply. Other assembly errors as a sample could include:

- Key length and positioning – unbalance
- Bolt torque pattern & sequence- misalignment
- Electrical termination box hard piping - misalignment
- Setscrews - unbalance
- Pulled threads – misalignment
- Offset collars - unbalance
- Grease quantities - unbalance
- Position of the grease in couplings - unbalance
- Applied lubricant torque changes – bearing life, unbalance, misalignment
- and there are way too many more to name here … just think of a few.

The "Practical" Application of Precision

In working within industry we've found that a typical plant or site many have thousands of rotating pieces of equipment working at any given time. We've also found that in certain areas the placement of a spare identical piece of equipment is an unquestionable decision while other machines within the process even critical machinery has no spare at all. The amount and placement of spared equipment not only changes with process types but also with the risk the owners are willing to accept, the consequences of failure and required production quality and output.

In each process we've looked at large machinery which has severe failure consequences has already had a great amount of engineering, production and of course maintenance attention and in most cases is running extremely well. A second group of machinery which is still of significant horsepower and size and importance has less of an effect on the process but is expensive enough to warrant significant efforts in the above-mentioned areas. A third type of equipment is that which small in horsepower demand, of little immediate effect on production and was cheap enough to have a spare in place. For these assets little attention was given other than what the asset was intended to do. The percentages for each and the cost of each in maintenance alone opened eyes in a new way.



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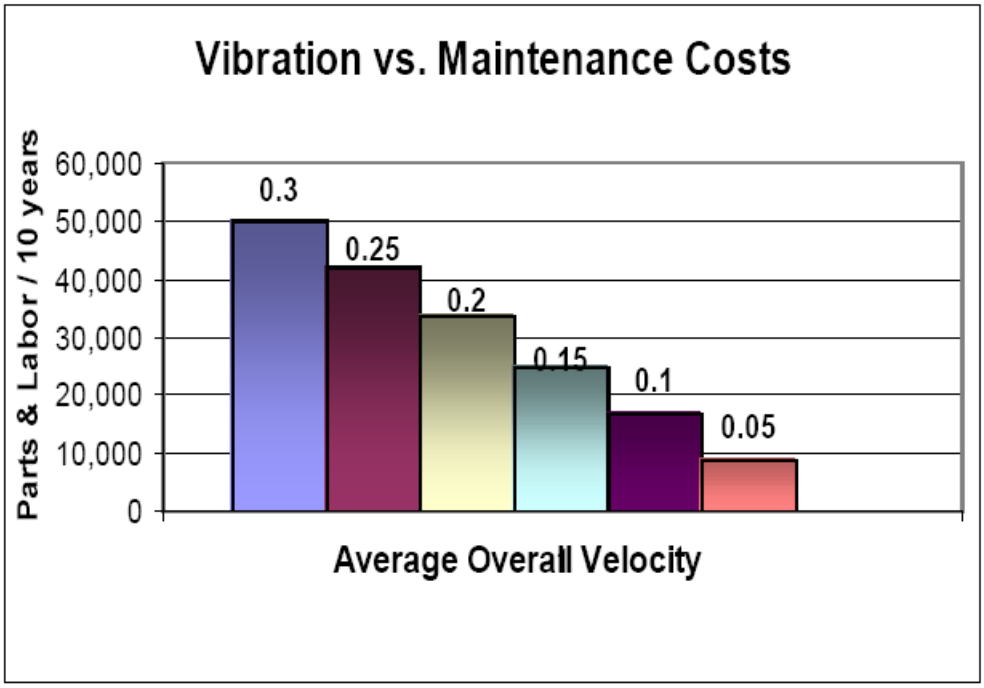
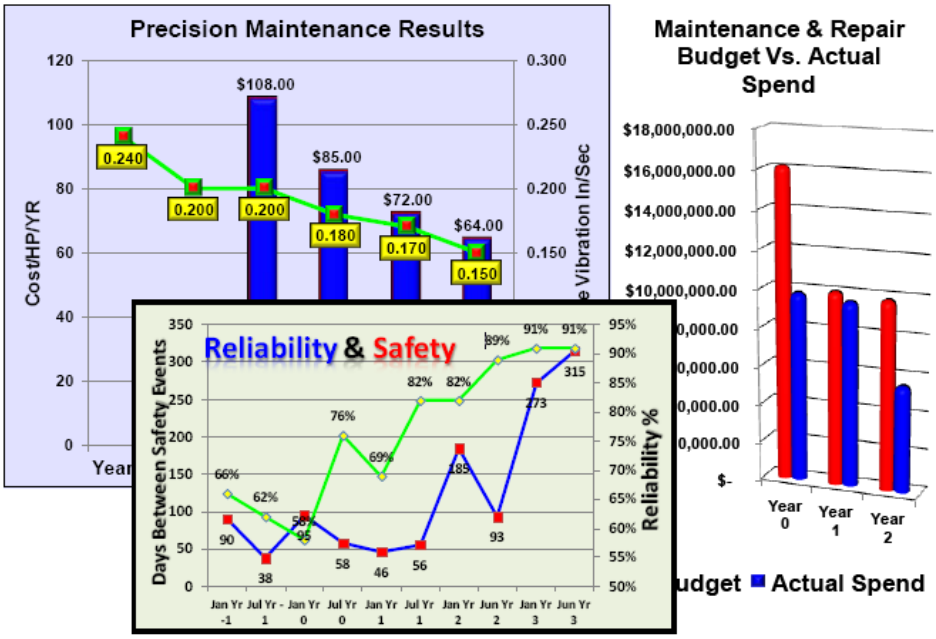


Real Results

We do realize of course that the real the value of work is applied through time with real effort, sponsorship and many key and best practice learning's with discovery. The results though are completely dependent on you and your efforts … from the most senior levels of corporate management right to the operation and maintenance floor. Remember Safety and reliability go hand in glove!



Essential Craft Skills a Strategic Initiative

So what should precision maintenance using essential craft skills be all about? Consider the following*:* It would be a strategic initiative focused on a results driven process utilizing consensus driven expectations and responsibilities with a defined training and field application process. Asset performance improvement would be measured and documented with further improvement actions planned and scheduled to ensure further improvement and sustainability. This would be a starting point and a great beginning toward reliable manufacturing and not another "flavor of the month" … nor just another training course … and not a "silver bullet." And this work sets up the operators to be more successful with machines that are in an improved, better functioning state, assisting in bringing life to their new roles.

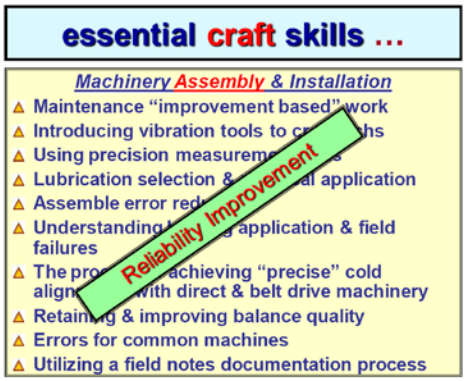
Integrating Operators into Reliability

Consider the following as an initial and essential thought toward operational excellence.
Where asset operation and troubleshooting are always performed in a known, understood, disciplined and documented approach:

- Where machine operating context and its effects on Reliability of Process and Reliability of Equipment are taken into account …
- Where application of new field inspection techniques allows for the complete assessment of equipment …
- Where a correct set of "Tactical" measurements and metrics evolve with "Application" work …

Precision Maintenance … Essential Craft Skills Series

Understanding Pre and Post Work … Establishing a Path Forward
In the same manner as we discussed for essential asset care we must also apply a similar process from strategic to application with pre and post work, measures and tactics. A typical starting point is illustrated below.



If we fail to define the behaviors we seek to change and the measurable results we expect to return, then training becomes busy work with "tick-mark" boxes checked…

Within Business Today
We realize the need for and importance to improve performance while continually improving with …

- Visionary management leadership and development
- Self-assessment and correct benchmarking
- Identifying training and human performance
- Correct continuous improvement actions

Where each site is a business enterprise with a focused-based perspective

- Training and development is a key element to the core production of business

We recognize the need and value of creating and employing a process network where skill set improvement is correctly postured in strategic, tactical and field applied work.

Creating a Learning & Improvement Culture

- Correct skill sets and attitudes positively support conservative decision making and performance assessment
- Data based decisions determine needs and utilize process management for continuous improvement
- Personal and personnel improvement plans incorporate the need for technical skills placement and systems to improve the net worth of yourself and your organization

We understand this as an application matrix from the top of a corporation to the manufacturing floor with a systemic improvement process … and hence the need for another discussion.
Apply well and be the lead sled dog!