The Business Impact of Improved Asset Reliability

A Whitepaper by Ivara Corporation

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Table of Contents

The Business Impact of Improved Asset Reliability

Asset reliability has become a hot topic at the executive level of most capital intensive companies. While the importance of reliability was first recognized in industries where equipment failure consequence could be catastrophic, the topic has now become popular throughout all capital intensive industries because of the many ways that reliability impacts competitiveness. In this whitepaper we'll look at the way that asset reliability has evolved to become an important element of corporate strategy, and the numerous business impacts connected to reliability.

Background – Reliability's evolution – From disaster-avoidance to competitive advantage

The topic of reliability was first seen as a necessary strategy for disaster-avoidance. First, in aerospace, submarines and nuclear plants, there was a clear recognition of the importance of reliability. While these first applications of reliability thinking generated huge advancements, including Reliability Centered Maintenance (RCM) and many predictive technologies, the impetus had less to do with strategic planning and competitive advantage, and everything to do with survival. For example, submarines don't just slow down when they have major equipment failures; they sink, killing all onboard. When nuclear generating units fail, they can fail in a big way. FirstEnergy Corp. is still feeling the far reaching consequences of a simple equipment failure that crippled the Davis-Besse plant reactor in the fall of 2001. FirstEnergy Corp.'s consequences have included the industry's biggest fine ($28 million), the negative publicity of an admission of a cover-up, and federal charges against its employees.

In other industries, where plant failures result in less public consequences, reliability has recently become an executive level topic for reasons other than disaster avoidance. Among steel mills, power generation plants, paper mills and mining companies, where success is directly linked to return-on-assets, reliability is now recognized as the umbrella strategy that will enable a wide range of mission-critical goals. Leading thinkers in each industry have recognized that they can no longer replace billion dollar plant assets and so the only path to increased competitiveness is to generate more output with the existing assets. While safety and environmental impact remain the most important categories of failure consequence, other factors such as plant profitability, output, quality, customer retention and, of course, costs have now become tightly linked to reliability.

As these companies have implemented solutions for reliability, they have found a number of unexpected benefits. Insurance rates can be lowered by millions per year when plant reliability improves. Reliability initiatives create an opportunity to capture the corporate knowledge that is locked up in the heads of an aging workforce. And reliability compliments other corporate initiatives such as Kaizen, Six Sigma and Lean Manufacturing.

The remainder of this whitepaper describes the specific business impacts of adopting asset reliability as a strategy for corporate success.

While the majority of industrial companies are 75% reactive, they are also 25% proactive. Proactive work is done prior to the equipment failing, with the goal of avoiding the failure. Unfortunately, most of that 25% ($10,000,000 per year in the case of the Paper Inc. mill) is devoted to time-based routines where, after a specific amount of operating time, components are replaced regardless of the health of the equipment. Most of us maintain our cars this way and so it's somewhat logical that we would also maintain our plants like this. But if the performance of the plant is not improving, then the selected proactive jobs are not effective in avoiding failures. In other words, whatever Paper Inc. is doing with that $10,000,000 of proactive work, they've proven it's the wrong things. And in this example, they spend $30,000,000 each year to correct those errors. In 2002, the David-Besse nuclear plant spent far more than $40,000,000 in maintenance and yet in early 2003, a pineapple-sized hole wore into the lid of the reactor. Clearly, these organizations have been doing the wrong work to maintain these plants.

Here lies the big financial opportunity. The financial opportunity comes from doing the right proactive maintenance work, so that we generate greater plant output and spend far less on reactive maintenance. But how do we determine the right proactive work?

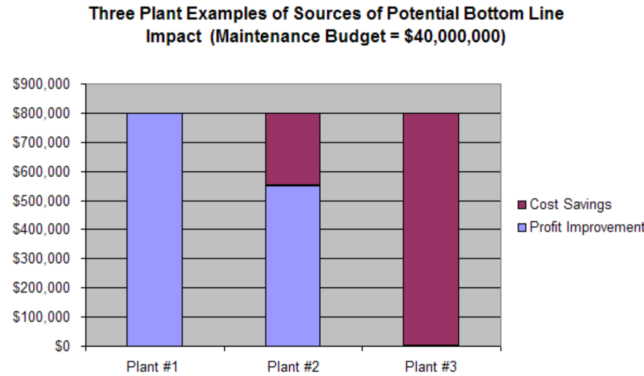
In the late 1960's, the largest industrial research project ever was undertaken to answer the above question for the civil aviation industry. The research study found that over 80% of failures are not related to operating age, but are in fact random. The same study found that less than 20% of failures are related to time, or operating age. These findings have since been substantiated in subsequent studies. If greater than 80% of failures are not related to time, then obviously 80% of our proactive maintenance should be triggered by something other than time. This research gave rise to major improvements in failure management, including Reliability Centered Maintenance (RCM), a formal methodology to define all of the ways that a given asset can fail, along with a prescription of the right proactive work tasks to mitigate the consequences of failure.

It is largely due to the application of RCM principles (together with the enhancements in aircraft design that have flowed from detailed RCM analysis) that the civil aviation industry has been able to improve its safety record from approximately 60 crashes per million take-offs in 1960, to less than 2 crashes per million take-offs today. And this improved performance has come at significantly reduced cost. The original Boeing 747 required 66,000 labor hours on major structural inspections before a major heavy inspection at 20,000 operating hours. In comparison, the DC-8 - a smaller and less sophisticated aircraft using Maintenance programs developed before the advent of RCM - required more than 4 million labor hours before reaching 20,000 operating hours.

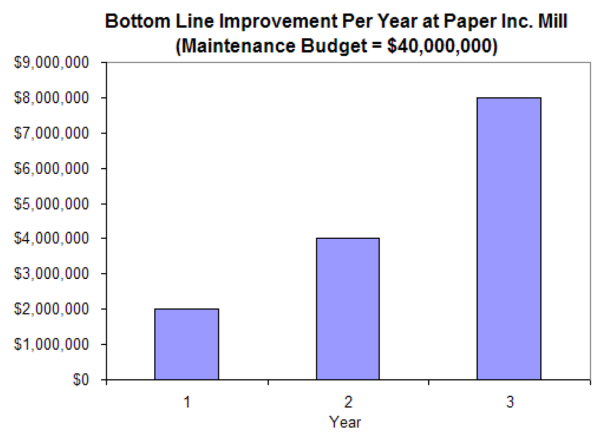
Improving plant reliability requires that, among other things, we utilize these well developed methodologies for identifying the "right work" for each asset. When we put the right proactive maintenance work in place for even just the few bad actor assets, we have an opportunity to significantly improve the plant's performance very quickly, resulting in a substantial financial improvement.

Financial Improvement – Big and Fast

If we spend some of this annual maintenance budget more effectively, and figure out the right work, would we see better plant performance or would we see reduced maintenance costs? The answer is: "it depends, but likely both". There are two extremes; those that far overspend on reactive maintenance to ensure great plant performance, and those that endure underperformance but limit their maintenance spending. Most plants are somewhere in between the two extremes, with potential benefits in terms of both profit improvement and cost reduction. In all cases though, whether the financial impact is mainly from increased output or from decreased costs, the size of the potential impact to the bottom line is surprisingly consistent.



In dozens of business cases completed across companies in capital-intensive industries, opportunity for reliability improvement in each plant is consistent. The annual bottom line impact, in the third year of a reliability improvement project, is equal in size to one-fifth of the annual maintenance spending. This figure provides a nice simple reference point for the magnitude of the likely financial impact of improved reliability, relative to the size of the maintenance budget, however it is not suggesting that maintenance spending will be reduced by 20%. But whether a plant's benefit is mostly in the profit associated with increased output, or mostly from reducing maintenance overspending, or somewhere in between, the total annual benefit amount is equal to at least 20% of the maintenance expense in the third year of the improvement project.



While the size of the financial impact is very attractive, the speed with which it can be achieved is also compelling. Within the typical plant, there are a handful of "bad actor" assets or systems that represent the majority of the maintenance problems. Rather than attempting to determine the right proactive maintenance work for all assets, we have an opportunity to first focus on just the few bad actors. Typically, we address these systems within the first year. Working with just the few operators and maintainers that best understand the first of these systems, we can quickly determine and implement the right proactive maintenance work. The result is that we significantly improve the plant's performance very quickly, covering the cost of the project in the first year. With this one-system-at-a-time approach, benefits to the bottom line are typically seen as follows: 25% in year one, 50% in year 2 and 100% in year 3. So at the end of three years, the plant will see an improvement to the bottom line equal in size to 20% of the maintenance budget. The Paper Inc. mill, with an annual maintenance budget of $40,000,000, would see improvements of $2 million, $4 million and $8 million in years 1 through 3 respectively. Since the cost of a project to achieve this benefit is typically equal to a one-time cost of about 7 percent of the maintenance budget, the 3-year ROI is usually about 5 times. The size of the financial impact and the speed with which it can be attained are both so compelling that these projects quickly rise to the top of the priority list for most companies.

Sources of Financial Improvement

There are two main sources of financial improvement – the profit associated with increased output, and the reduced costs associated with fewer failures.

Increased Output

Rapid economic and population growth rates in China and India are now driving significantly increased demand for minerals and metal products. This overseas demand along with North American population increases are driving increased need for power generation. The result is that currently, in mining, metals and power, the more companies can produce, the more they can sell.

In order for improved reliability to result in improved plant output, the current level of plant output must first be less than ideal. In most companies, there is an opportunity to increase output. In these cases, increased reliability of equipment will result in increased availability, which can usually be converted to increased output. The profit associated with this increased output will contribute to the financial improvement.

In some instances though, there is no obvious financial opportunity for increased output because either output is already considered maximized, or there is no market in which to sell the increased output.

The utility industry is a great example where there is ample opportunity to increase output in many plants, but in other plants output is already maximized despite poor asset reliability. Many utility companies measure themselves against others in their industry based on capacity factor - the extent to which a plant maximizes output for its physical rated capacity. Some of the highest capacity factor ratings today are being achieved in utility plants that are also highly reactive in maintenance. Surprisingly, many nuclear plants are included in this group. How do they accomplish high capacity factor ratings while being highly reactive in maintenance? They overspend in maintenance in order to achieve high output from an unreliable plant. These companies throw everything they can at each major failure or outage (shutdown), focusing on minimizing outage duration at any cost. Rather than focusing on avoiding failures these plants put their energy into quickly repairing failed equipment. To meet their output targets, these companies are literally consuming their plants. In these situations, we consistently find that the financial benefit of improved reliability will be measured in terms of reduced costs.

Costs Savings

There are many sources of cost savings that result from improved plant reliability, the main one being the reduction in labor and materials associated with fewer repairs of broken equipment. When equipment fails, the unplanned downtime adds a high sense of urgency that causes the repair costs to escalate. When failures impact uptime there are many secondary impacts such as increases in payroll overtime, outsourcing, expediting of parts, and even purchase costs. In addition, failures often result is secondary damage. When a simple pump seal fails, you may have damage to the impeller and the housing, and depending on the fluid being pumped, clean up costs can be extensive. While the cost of a simple component failure may by tolerable, the total cost including secondary damage could easily be many orders of magnitude higher. The cooling pump that failed in the Davis-Besse incident could have been fixed for a thousand dollars. Instead, FirstEnergy's secondary damage included the $28 million fine and the enormous legal fees. In fact, FirstEnergy is still writing daily checks to cover the additional third-party oversight mandated by the nuclear regulators. Those people will be on site through at least 2008.

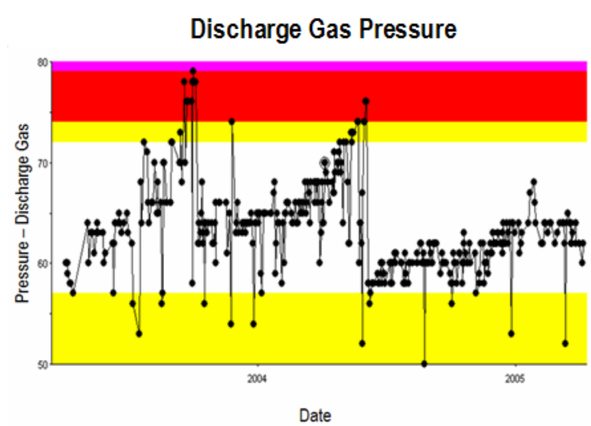
A simpler example of the high cost of secondary damage was found in an RCM analysis Ivara conducted on a belt conveyor system in a coal fired power plant. One of the belt's failure modes is "torn belt from a jammed and worn idler". The belt is supported every few feet by an idler rack (an idler is a roller) and if an idler becomes seized by either a seized bushing or a jammed piece of material the belt will wear down the surface of the idler. As idlers are hollow rollers, the surface of the idler will eventually wear right down leaving sharp edges. As these edges are in contact with the belt, the belt will quickly wear until it is cut. A very inexpensive inspection task can be performed by the Operator to ensure that the idlers rotate freely and are not excessively worn. Idler replacements are also very inexpensive, whereas the cost of replacing a belt and the resulting production loss is high. For example, the belt alone costs $100K.

When conducting the business case for improved reliability, we do not try to quantify the avoided secondary damage costs. We do however capture the impact of better failure management practices on avoided costs such as the portion of maintenance related downtime that can be avoided, reduced overtime, reduced material consumption and either reduced scrap or reduced rework of substandard quality products.

In some companies there is another opportunity for cost reduction – avoided market purchases of committed production. Some utility plants for example, commit through contracts to supply a specific level of power each day to their customer(s). On days when the plant is unable to supply the contracted amount of power, these companies must purchase power to make up the difference. Usually, the cost of purchasing power is many times the cost of producing it. In a typical coal plant for example unplanned plant outages may require the company to spend millions of dollars per year purchasing power to fulfill contract commitments. In business cases performed in a number of these situations, we have found that with a conservative estimate of the impact of improved reliability, we can eliminate enough purchased power costs to increase the overall bottom line benefit from the typical 20% of the maintenance budget (annually after 3 years) to 30% or 35%.

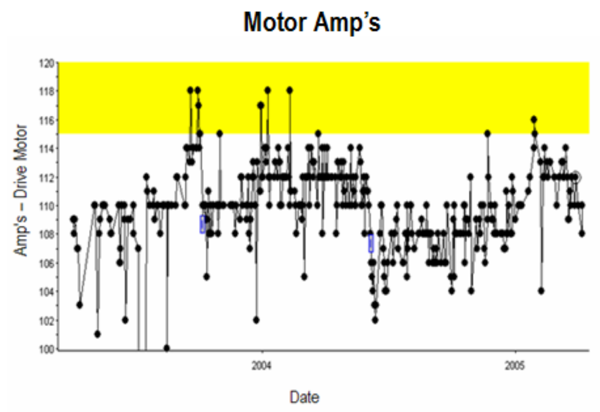
Reduced insurance rates can be another source of costs savings associated with improved asset reliability. This benefit is particularly relevant in cases where asset failure creates significant risk of environmental impact. Examples include nuclear power plants, ocean shipping, oil drilling platforms and water treatment plants. These companies often spend tens of millions of dollars per year on insurance against environmental mishaps. An oil drilling company saved between $3 million and $4 million per year by demonstrating to their insurance company that they had implemented a sound proactive approach to asset reliability, complete with audit trails showing that proactive work was being done on time.

Plants that consume significant amounts of energy (electricity, gas, steam) will see these costs significantly reduced as they improve the reliability of their assets. Energy consumption is very high in industries such as pulp & paper, primary steel, aluminum smelting and mining – particularly in open pit mining where electric draglines and electric shovels are used. Improved reliability reduces the need to frequently stop and start up these big electricity-consuming assets, as it's the startup process that often demands the highest electricity. Dave Leslie, Reliability Specialist in the utility division of Dofasco Inc., one of the largest steel companies in Canada, and the largest electricity consumer in the province of Ontario, described an example where they saved $150,000 per year in electricity costs just on their air mist compressors.



The top graph to the right represents the second stage discharge air pressure on the aftercooler of one of the air mist compressors. In this case the aftercooler is plugging causing a higher than normal discharge air pressure. The compressor is still discharging 2000 cfm and all temperatures are normal, so to the operators, everything looked normal.

The second graph represents the current draw on the motor driving the compressor. There is a definite relationship between the aftercooler plugging and the increased load on the motor. These motors normally draw about 105-108 amps. Because of the compressor problem this motor was occasionally drawing 115-120 amps. The motor is rated at 130A, so again the situation looked normal.



Once Dofasco discovered the relationship between discharge pressure and motor amps draw, they were able to adjust the procedure for cleaning the aftercooler, improving the efficiency of the compressors by 15%. With 64 of these units in operation, electricity consumption has been reduced by $150,000 per year.

Quality improvement is another area touched by asset reliability. In companies that recognize that asset reliability touches virtually every strategic operational aspect of the business, the topic of reliability has been elevated above the topic of product quality. In these companies, the quality initiative is well integrated into the reliability improvement initiative. In fact, we've recently seen a number of companies that have elevated the strategic importance of reliability to the pint where unexpected shutdowns, or unexpectedly extended shutdowns both result in discussions at the board level.

In companies where regulatory compliance is a major issue, improved asset reliability can play a significant role. In US nuclear plants for example, the maintenance process must be performed in accordance with INPO's (the Institute of Nuclear Power Operations) guidelines. The operator of a nuclear station must show in the INPO audit their capability to comply with this and other guidelines. A successful INPO audit is as important to a nuclear station as a profitable year to most commercial plants in other industries, as the audit rating affects bond ratings and other commercial considerations. In nuclear plants, the guidelines require proof that as maintenance work is done, recommended procedures were followed. In addition, as each condition inspection value is recorded, there are recommended procedures for the fool proof steps that must be taken and documented. After having previously run his company's coal fired plants, the Vice President of Operations at a nuclear plant was astounded by the fact that to conduct the repair of an asset that existed in both the nuclear plant and one of the coal plants, took four times as much work in the nuclear plant. All of the increased effort was required to comply with the process guidelines for nuclear plants, including documenting and storing all of the proof of compliance. Every dollar of cost savings opportunity in a non-regulated environment is worth multiple dollars in a regulated environment.

In all of the examples of cost savings cited above, it's important to capture just the portion that would be achieved through improved reliability of the equipment. It's also important to recognize that each plant will be unique in terms of its sources for financial improvement. This statement is especially true of multiple plants within a company. The unique history and cast of employees will combine to create very unique strengths along with unique improvement opportunities. But while the source of improvement will vary across plants, the overall magnitude of the potential financial impact will be roughly the same as a percentage of the maintenance budget. The goal therefore when dealing with multiple plants within an enterprise, should be to leverage the unique strengths of each plant to build a solution that fits the unique opportunity for each plant.

Non-quantifiable Benefits

While it is often necessary to project the financial benefits of improved reliability in order to get executive support for the project, the non-quantifiable benefits are equally impressive. Examples of benefits that are hard to quantify financially are improved safety, increased protection from environmental damage, improved regulatory compliance and the retention of employee knowledge.

Safety is a critical issue to the viability of all companies in capital-intensive industries. As heavy equipment operates, it creates situations that could endanger the plant personnel involved in operations and or maintenance. When the equipment operates as designed, the potential for safety incidents is minimal. But by its nature, equipment degrades as it runs, creating an ever-increasing likelihood that a failure will occur. There are many causes of safety related incidents, but a reliability improvement initiative should only be credited with the avoidance of safety issues related to improved reliability. There are many challenges to quantifying the financial value of improved safety – not the least of which is that we would need to put a dollar figure on a saved life or an avoided personal injury. But in cases where we have experienced human safety consequences to equipment failures, the non-quantified benefit can carry significant weight for executives.

The difficult-to-quantify value of an avoided environmental impact can also be worth noting in a business case supporting a reliability improvement initiative. These mishaps tend to carry not only extensive fines and clean up costs, but long term public relations impacts as well. When the Amoco Cadiz oil tanker ran aground, the press had a field day with photos like the one at right, showing Amoco's company logo on the vessel's hull projecting from the oil soaked ocean. Environmental disasters are impossible to forecast and very difficult to quantify, but improved asset reliability reduces their likelihood of occurring.

The Amoco Cadiz

One last non-quantifiable opportunity associated with improved asset reliability is the retention of employee knowledge. The employees who best know the equipment possess enormous knowledge about how the equipment fails, how to watch for failures, how to perform condition inspections, and even how to perform corrective work the right way. The secret to improving asset reliability is to capture this knowledge in a systematic way that it can become a permanent corporate asset. This knowledge can then be used by all employees, rather than being the personal expertise of individual employees. Companies that capture t his knowledge find that recruiting and training employees is much simpler. And by making this valued knowledge available, a company can ensure that each new employee does not have to experience each of the mistakes of his/her predecessor in order to become competent.

All of the above noted benefits are well worth describing in a business case to support the new reliability improvement initiative, but in most cases they are difficult to quantify financially.

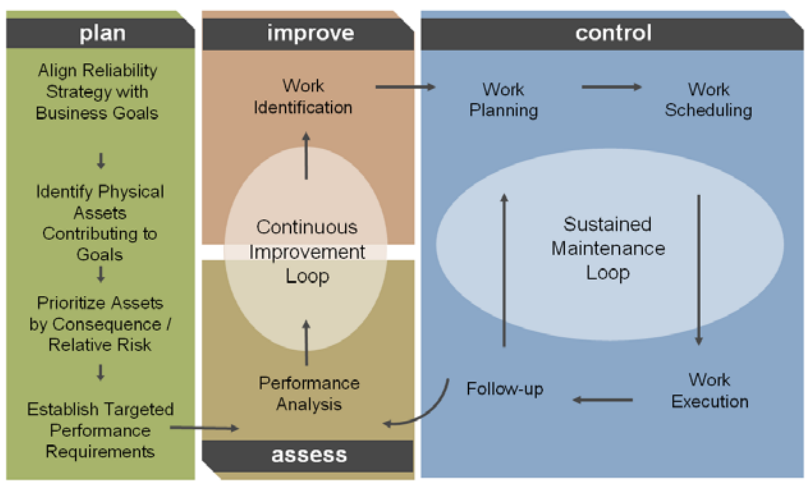
Key Elements to Achieving and Sustaining Optimal Asset Reliability

There are a small number of elements to achieving optimal asset reliability at optimal cost. They are a business process for reliability, reliability best practices, supporting technology and an implementation approach that focuses on people and change management.

Key # 1 – A Business Process for Asset Reliability

Companies that have been successful in achieving optimal plant reliability all have one ingredient in common – they are following a formal business process to govern the work done to maintain their assets. The reason for this fact is that the reliability of assets is far more related to the things people do than it is to anything else. With the right process in place, we can ensure that people are doing the right things to maintain the plant assets. The proactive asset reliability process is the first and most important key to achieving optimal asset reliability.

While most plants have in place a process to govern the work done in maintenance, the typical process includes only the following process elements: planning, scheduling, work execution and follow-up. These process elements, shown in the blue box of the process example graphic below, are necessary elements but they do not represent a complete process.



An Asset Reliability Process

Before we discuss the other required elements, we should first understand the definition of "optimal asset reliability". Optimal asset reliability means that for the least possible cost, we achieve the level of performance we need from our equipment in order to meet our business goals (plant or company level goals). Equipment performance in this case is not production output, but should be described instead in terms of the required level of uptime (such as Mean Time Between Failure, or MTBF) and or in terms of the maintenance cost needed to assure the desired performance. Given that we need to understand the business goals to be supported by the equipment, the asset reliability process must include this connection to business goals, as shown in the green box of the process diagram.

Next, we determine the assets that are most critical when they fail, and where the risk is highest in terms of impact on business performance. For these assets, we establish specific performance targets. This stage focuses maintenance reliability improvements on the performance targets of critical assets that contribute most to the company's success.

The Assess stage then compares the asset performance targets to the maintained asset's actual performance which is learned in the blue box as we execute work. This stage identifies and prioritizes gaps in performance by performing specific Performance Analyses. In this process, functional failure is defined as the inability to meet performance requirements, and so a performance gap is really a functional failure.

One of the toughest challenges on the road to improved asset reliability is to determine the prescription of proactive work that should be done to maintain the assets so that they deliver the reliability we need (at optimal cost). This topic is also known as “work identification”, and it represents the cornerstone of an effective asset reliability process. The right work is defined in terms of the tasks and the timing for conducting them – hence we often hear the phrase “the right work at the right time” to describe the output of a work identification effort.

In the Improve stage, the team selects an appropriate Work Identification strategy in order to understand and address all causes of failure for the specific asset under consideration. The typical maintenance plan for an asset will include some mix of preventive maintenance, detective maintenance, predictive maintenance and some run-to-failure decisions. The outcome of the Work Identification element (the right work at the right time) is then fed to the Control stage or the blue box in the process diagram.

Most organizations today are most effective in the control stage - the planning, scheduling, execution and follow-up of the work. Almost all companies today use a CMMS to maximize the efficiency of work this work execution phase. The blue box on the right shows the areas that a CMMS addresses. This control stage of the process provides valuable information to the Asses stage in terms of the actual performance. Managing feedback in the assess stage, the control area, and the Assess and Improve cycle results in a continuous improvement loop that optimizes asset reliability.

Key # 2 – Reliability Practices

The next key to achieving optimal asset reliability is to develop the skills necessary to support this asset reliability process. These skills, or reliability practices, include work identification capabilities, like Reliability Centered Maintenance, as well as a number of skills to ensure that the process is described at the level at which roles are defined. From there, individual employees can be assigned responsibilities, training needs can be assessed to allow employees to fulfill their roles, and training can be developed and applied. Finally, measures can be implemented to allow management to monitor the performance of the process, and each of its elements.

Key # 3 – Technology Support to Manage the Asset Reliability Process

The work identification element of the asset reliability process will enable companies to define the best proactive tasks to maintain each asset. As stated above, the outcome will be a mix of predictive tasks, detective tasks and preventive tasks. The predictive tasks will require the collection of an enormous amount of condition data. This data will be supplied by a variety of sources – fed from online sources, manually collected through visual inspections and some data will be driven from predictive technologies such as vibration analysis and thermography. With potentially many thousands of inspection points to be monitored, the resulting data management challenge can quickly become overwhelming. With appropriate software to manage this data, companies can develop an online picture of the health of their equipment. Proactive decisions can then be based on actual asset health.

Key # 3 – Implementation Approach to Sustain Asset Reliability

One of the most important keys to success in asset reliability improvement projects is the implementation approach. The implementation approach can both assure improved reliability, and it can also be the key to sustaining the improvement. An effective implementation approach focuses on one major asset or system at a time.

The ideal implementation approach starts by ranking all critical assets by their level of risk to the business. Assets that are high risk are those that matter a lot when they fail, and they're failing a lot. By selecting the system that represents the highest risk to the business, the company will be working on the system that has the highest potential to improve the performance of the plant.

With this approach, the company will apply the entire asset reliability process, but just to the one system at the top of the risk ranking. Involving the operators and maintainers that best know the target system, the company will conduct a failure analysis to define all failure modes, and the appropriate asset reliability program – the complete set of proactive tasks by which to manage the asset's potential for failure. The next step is to implement these new tasks, coaching and mentoring employees in the new activities. Once the new tasks are n place, the implementation approach is repeated for the next highest risk system.

This approach to implementation not only creates the biggest bang for the buck, it also creates a sustainable change. As management sees the performance of each high risk asset improve, and as the plant's performance also improves, executive commitment to the initiative will solidify. Similarly, as employees see their colleagues being involved in projects that substantially enhance equipment performance, these employees will want to become involved. This approach to implementation has proven very effective in creating and sustaining momentum for reliability improvement projects.

Summary

Among capital-intensive companies, where success is directly linked to return-on-assets, reliability is now recognized as the umbrella strategy to enable a wide range of mission-critical goals. Leading thinkers in industries such as power generation, mining, steel and paper recognize that they can no longer replace billion dollar plant assets. Instead, they seek out ways to generate more output at a lower cost with existing assets while meeting or exceeding safety and environmental regulations.

The strategy is to focus on improving the reliability of the company's capital assets. They take action because they realize that every day they spent thinking about, but not acting on, an improved asset reliability process actually means up to hundreds of thousands of dollars wasted per day –bottom line.