Developing Performance Indicators for Managing Maintenance

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Preface

Competition is something that every company faces today. But do companies truly understand the definition of competition? Dictionaries define competition as the "rivalry between two or more businesses striving for the same customer or market." According to the dictionary, for a company to be competitive, it must "be inclined to compete." As in any competition, companies must constantly improve themselves in order to avoid being surpassed by competitors.

In most cases, companies today do not have exclusivity in their assets and processes when providing a product or service to the marketplace. In reality, most companies use the same raw materials and assets to produce their goods. Therefore, the question is "How do they differentiate themselves from their competitors?"

An example of organizations that compete with identical assets in a highly visible environment is NASCAR racing. If you consider the goal in racing, which is to finish first, you can see similarities to competitive companies. Competitive companies want to be the best in their respective markets. How do they achieve this? By focusing the entire organization (team) on doing their part to get the maximum capacity from the asset.

What if, during a NASCAR race, the driver dictated to the pit crew when and how to do things? What if the pit crew ignored the driver's input about how the car was performing? What if the setup engineers didn't consider what type of track they were running on during the race? How many races would this type of team win? In competitive companies, what if the maintenance organization did not listen to input from operations concerning how the equipment was performing? What if operations dictated to maintenance what to do to the equipment and when to do it? What if engineering bought and installed inferior equipment? How competitive would the company be?

When companies evolve from worst to best performers, they find that the process is a selective learning model. Biologically speaking, is a Darwinistic model in which managers strategically develop their vision for how the company's products and services will fill the need in the market. They select the Best Practices to achieve their vision, while changing or eliminating inferior practices or policies. The managers must set a clear direction, focusing on the company vision. They then require good navigational tools to help them steer the organization and monitor the progress.

These monitoring tools are performance indicators. Managers need to be able to monitor a "change" organization, one that is open to continuous and rapid improvements. Required improvements that are highlighted by the performance indicators should either strengthen best practices or eliminate poor practices.

The strategic approach to management focuses on effectiveness and results. Unfortunately, most of the traditional measures used to evaluate performance are financial based. Measures such as balance sheets, or monthly and quarterly profit and loss statements are, in effect, damage reports. They tell us that we performed poorly, after the fact. They give us little information about our status today or what we need to do to improve tomorrow.

In the current business climate, competitiveness requires measures that accurately predict our future business performance. These measures allow the organization to focus on priority items and not waste resources on non-value-added initiatives or programs. Once the priority processes are identified, then the proper performance indicators must be developed to insure organizational improvement.

This book is designed to provide details on how to measure and improve one of the most important functions in an organization today: Equipment or Asset Maintenance Management.

Many companies view maintenance as a necessary evil, an expense to the organization, or a non-value added function. These companies will not survive in business for another decade. Instead, they will be put out of business by companies that see the equipment or asset maintenance management function as a strategic market advantage. Competitive companies view maintenance as a means of reducing the costs of producing their product or providing their services. They use this cost advantage to lower prices, improve profit margins, and increase shareholder value.

What is the difference between the two types of companies? The ones that see no value in maintenance have never learned to measure it. This is particularly true when it comes to the financial aspects of maintenance. Although most companies understand the expense side of the maintenance ledger, they fail to understand the impact cost of maintenance. They fail to properly understand how Best Practices in maintenance and asset management can have an impact on the capacity of their plant. Because they don’t understand it and cannot measure it, they cannot manage it. They can't even understand what maintenance is or how their competitiveness in the future hinges on it.

This book provides organizations with a fresh look at the value of the maintenance/asset management disciplines in their organizations. If it accomplishes this one task, the time invested in reading it should provide individuals and their companies with dramatic returns on their investment of time.

I would like to give special thanks at this point to one person who has done much to increase the awareness of the maintenance function in organizations today: Robert Williamson of Strategic Work Systems. The NASCAR illustrations used in this text are based on his contributions to the industry in this area.

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CHAPTER 1

Developing Maintenance and Asset Management Strategies

Most companies in the late 1990s were focused on keeping up with market demands. They were also exploring the possibilities created by the explosion of information and telecommunications technologies, particularly the Internet. These technologies enabled entirely new ways to communicate with customers and suppliers, and facilitated internal communications as well. The 1990s marked the decade when everybody was developing new initiatives in B2C (business-to-consumer) communications and B2B (business-to-business) supply chains, installing ERP (enterprise resource planning) systems, and worrying about Y2K. The threat posed to the U.S. economy by Japan and Germany had eased, the stock market was rising rapidly, and everybody was pursuing dot-com start-ups.

In this climate, traditional plant operations were often relegated to a secondary concern. There were just too many new things to think about and explore; everybody's attention was focused on "breakthrough improvements." Therefore, the mandate for routine plant operations became "just keep up with business while we pursue the pot of gold."

In the first decade of the 2000s, the economic bubble burst. Easy money was gone and managers now worry about how to stay competitive in the new world-wide economy that has emerged. It is time, once again, for companies to concentrate on their core businesses, squeeze out the waste (lean concepts), and differentiate themselves from their competitors in meaningful ways. But the tools available to companies—and the challenges facing them—are now so much greater than before that managers have to evaluate many of the basic principles of good plant operations that they had previously utilized, then decide if these are still applicable in today's world.

It is becoming clear that there isn't one best way to do anything, whether it's creating an organizational structure or designing and managing a plant operations organization. The best way to do something depends critically on the characteristics and capabilities of the organization and the competitive context in which it finds itself. That is, lean manufacturing shouldn't necessarily be the goal for every company any more than mass production or mass customization should be.

In order to benefit from changing conditions, companies have to adopt a strategy for improvement that fits the specific needs of the organization at that point in its life. Slow, steady improvement is appropriate in some situations; attempts at dramatic breakthroughs through process reengineering are appropriate in others. Moreover, different improvement strategies require different resources, management styles, and support structures.

Developing Strategies

Companies need to ask and then answer the question, "What is our business?" Addressing this question is the single, most important step in crafting a corporate business strategy. The company must clearly understand not only who are its customers and its competitors, but also what it sees as its competitive advantage. It must clearly identify its key business strategies. However, it is not just individual strategies in isolation, but the combination of the individual business strategies that, when combined, produces the company's overall competitive strategy.

Companies must decide which competencies and organizational context it must develop to help implement its strategy. Even after deciding on the competencies, culture, structure, and incentives that are needed, the firm is still not done with strategy. The real challenge is to develop the individual pieces, then put them together in such a way that on the one hand they support and complement each other and on the other hand they collectively support and promote the chosen strategy. Thus, the task is not only to create the appropriate individual parts of the system, but also to put them together in a way that creates a strong and reinforcing system.

Core Competencies

One competency that must be developed by all organizations is the maintenance/asset management function. Although many companies believe that maintenance is not a core competency, it fits all definitions of core competencies. In fact, many texts, when defining core competencies, actually use the maintenance/asset management function as an example.

There are several definitions of core competencies, but all of them focus on processes that allow a company to differentiate itself from its competitors. A core competency may have an impact by lowering costs, increasing profits, providing improved service to a customer, improving product quality, and improving regulatory compliance.

Several authors have defined core competencies for businesses. In his 1997 text Operations Management, Richard Schonberger defines a core competency as a key business output or process through which an organization distinguishes itself positively. He specifically mentions expert maintenance, low operating costs, and cross-trained labor.

Meanwhile, Gregory Hines, in his text The Benchmarking Workbook, defines a core competency as a key business process that represents core functional efforts that are usually characterized by transactions that directly or indirectly influence the customer's perception of the company. He lists several processes, including:

Procuring and supporting capital equipment

Managing and supporting facilities

The maintenance function directly fits his definition of a core business process.

In The Benchmarking Management Guide, written by the American Productivity and Quality Center, core competencies are identified as business processes that should impact the following business measures:

Return on net assets (RONA)

Although some companies will use Return on Fixed Assets (ROFA)

Customer satisfaction

Revenue per employee

Quality

Asset utilization

Capacity

Again, the maintenance function in any plant or facility fits this definition as it does the previous two.

Still other sources defines a core competency as any aspect of the business operation that results in a strategic market advantage. The maintenance

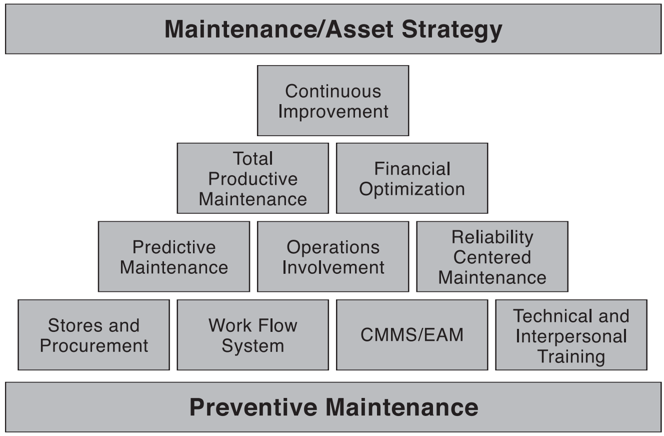


Figure 1-1 Highlights a comprehensive maintenance/ asset management strategy.

process in any company provides a strategic market advantage in many ways, including enhancing any quality initiative, increasing capacity, reducing costs, and eliminating waste.

Some executives use the argument that "maintenance is not one of our core competencies" as an excuse to outsource maintenance. They fail to realize that maintenance and management of assets is core to their business. In reality, it is how the company chooses to deploy the competency that is at issue. If a company's assets are not core to its business, then indicators such as return on assets would have no meaning. Yet Wall Street uses these types of indicators to evaluate all companies. Because maintenance/asset management is a core competency, we must examine its impact on a company's business strategy.

While the pyramid in Figure 1-1 will be explained in further detail in Chapter 2, it shows how a maintenance/asset management strategy, which involves all of the blocks in the pyramid, supports a company's overall business strategy. Although some blocks receive more emphasis in certain industries than others, all are required for a company to have a successful strategy.

The Impact of a Maintenance/Asset Management Strategy

The total impact of the maintenance/asset management strategy is illustrated in Figure 1-2.

Overall, the goal for any company is to increase profitability. This is true whether the company is public and has shareholders or is privately held by its owners. A complete maintenance/asset management strategy will increase

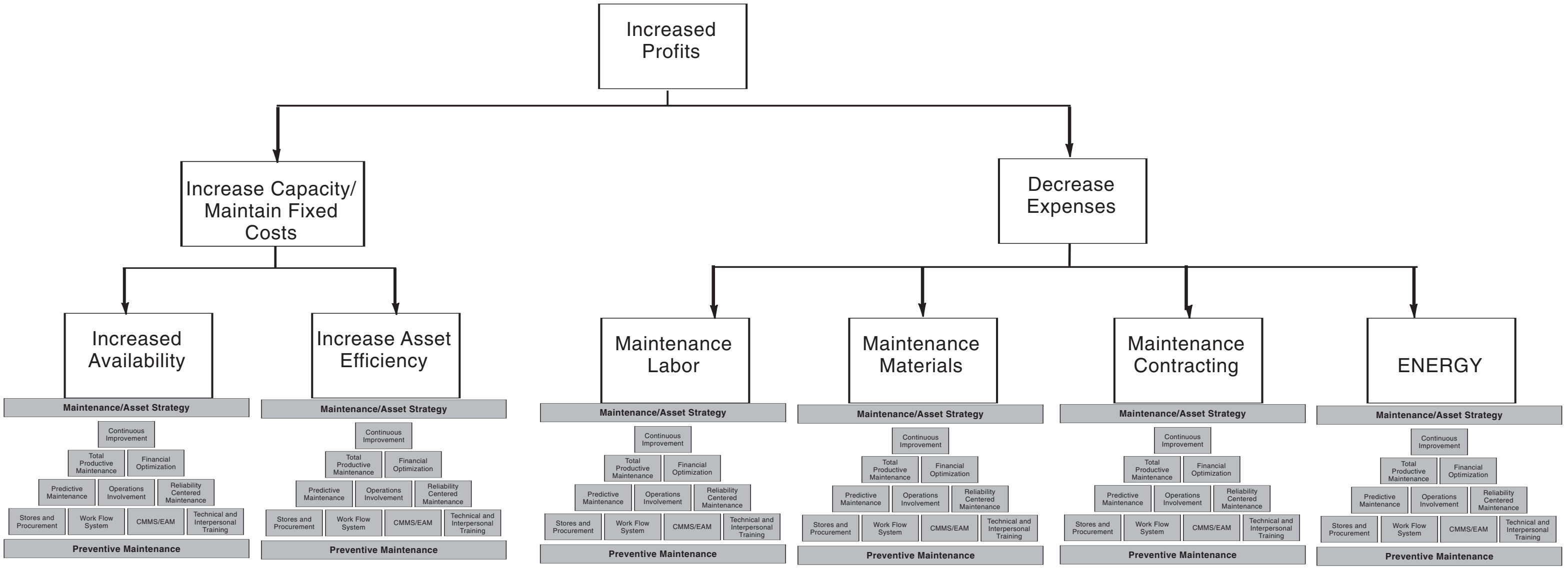


Figure 1-2 Maintenance / asset management strategy impact.
(Enhanced view of pyramid can be read from page 4.)

profits in two main ways: decreasing expenses and increasing capacity.

Decreasing Expenses

Consider that 1/3 of all maintenance expenditures are wasted because of inefficient and ineffective utilization of the maintenance resources. The two main divisions of maintenance costs are labor and materials. If a maintenance labor budget for a company is $3M annually, and 1/3 of it is wasted, then $1M could be saved each year. This savings would not necessarily be in headcount reduction. It may come from a reduction in either overtime or use of outside contractors, or from performing deferred maintenance without additional expenditures.

When the maintenance labor budget is $3M annually, studies show that the materials budget is a similar amount. If the materials budget can also be reduced by 1/3, then the combined savings for improving maintenance efficiency and effectiveness can approach $2M per year. This savings represents actual expense dollars that are not required and instead translate to profit dollars.

When improving a reactive maintenance organization, these savings are not immediate. It takes time to realize the total savings because converting a reactive maintenance organization to a proactive, best-practice organization can take from 3-to-5 years. The transition itself may not be technically difficult; instead, time is required to change the corporate culture or paradigm from one of negativity towards the maintenance function to one that truly treats maintenance as a core business process.

Maintenance contracting will show similar savings because maintenance contractors also utilize maintenance labor and materials. However, the savings will not be quite as large because maintenance contractors are already usually more efficient than reactive in-house maintenance organizations.

Effective maintenance/asset management strategies also have a dramatic impact on the energy consumption for a plant or facility. Studies have shown that, once implemented, effective maintenance/asset management techniques will reduce energy consumption by 5-to-11 percent. One only has to document savings by companies that have instituted steam leak or air leak reduction programs to see sizable savings. Again, these savings represent expense dollars that are not required and, therefore, translate to profit dollars.

Increasing Capacity

The pure maintenance contribution to profitability is dwarfed when compared to the savings realized by increasing the capacity (availability) and efficiency of the assets being maintained. For example, in some companies, equipment downtime may average 10-to-20 percent, or even more. Equipment that is down, when it should be operating, restricts the amount of product that is deliverable to the market. Some companies have gone as far as purchasing backup or redundant equipment in order to compensate for equipment downtime. This expense has a negative impact on the return on net assets indicator, in turn lowering the company's investment ratings in the financial community.

Even in markets that have a cap on volume, downtime increases costs and prevents a company from achieving the financial results desired, whether the goal is to increase profit margins or to be the low-cost supplier. Some organizations refuse to calculate a cost of downtime and some have even said that downtime has no cost. However, they fail to consider the following factors as well as others:

Utility costs
Cost of idle production/operations personnel
Cost of late delivery
Overtime costs to make up lost production to meet schedules

The true cost of downtime is the lost sales dollars of product that is not made on time. This cost is significantly higher than the base costs mentioned previously, and most companies' finance departments use a compromise number. However, a company must understand this cost clearly to make good decisions about its assets and how they are operated.

For example, if the company discussed earlier under maintenance savings examines its unplanned downtime for the previous year, it may find a considerable amount of which only a part can be corrected by improving maintenance. Other causes for equipment downtime could be raw materials related, or due to production scheduling, quality control, operator error, etc. Suppose the maintenance downtime alone is valued at $38M and a 50 percent reduction is achievable if maintenance is improved. Savings could then be as much as $19M. If only 10 percent of this amount was spent improving maintenance, the total savings would still be $17M in throughput. This amount relegates the projected maintenance savings previously discussed to a relatively minor issue.

Beyond pure downtime is the cost of lost efficiency. One company examined the efficiency of its gas compressors on an off-shore operation. It found that due to age and internal wear, the compressors were operating at only 61% efficiency. The cost of this inefficiency was approximately $5.4M annually. The overhaul would cost $450K, including labor, materials, and downtime production losses. The decision was made to overhaul the compressors serially, to avoid total shutdown. The cost of the compressor overhaul was paid back in 28.1 days after restart and the $5.4M in increased production was realized in the next 12 months.

Many Japanese studies (related to TPM) have shown that efficiency losses are always greater than pure downtime losses. This fact becomes even more alarming when it is discovered that most efficiency losses are never measured and reported. This oversight leads to many chronic problems that are never solved until a breakdown occurs. Some chronic problems that have a dramatic impact on equipment efficiencies are never discovered. Only when accurate maintenance records are kept are these problems discovered. Then, utilizing the maintenance data combined with the financial data, the root cause of the efficiency problem can be solved.

If maintenance/asset management is a focus for an organization, it is then possible for this business process to make a significant contribution to overall plant profitability. Although it takes cooperation and focus of all departments and functions within an organization to be successful, an effective maintenance/asset management strategy will have a dramatic positive impact on ROFA.

Because maintenance is typically viewed as an expense, any reduction in unnecessary maintenance expenditures is viewed as a direct contribution to profits. By achieving maximum availability and efficiency from plant assets, a plant or facilities manager ensures that a company does not need to invest in excess assets to produce its products or provide its services. This efficiency contributes to overall improvement to the ROFA for any company.

Goals and Objectives of Maintenance Organizations

The goals and objectives of the maintenance organization determine the type of maintenance organization that is established. If the goals and objectives are progressive and the maintenance organization is recognized as a contributor to the corporate bottom line, variations on some of the more conventional organizational structures can be used.

The typical goals and objectives for a maintenance organization are listed in Figure 1-3.

OBJECTIVES OF MAINTENANCE MANAGEMENT

$ Maximum production at the lowest cost, the highest quality, and within optimum safety standards
$ Identify and implement cost reductions
$ Provide accurate equipment maintenance records
$ Collect necessary maintenance cost information
$ Optimize maintenance resources
$ Optimize capital equipment life
$ Minimize energy usage
$ Minimize inventory on hand

Figure 1-3

Maximize Production

Maximize production at the lowest cost, the highest quality, and within the optimum safety standards. This statement is very broad, yet maintenance must have a proactive vision to help focus its activities. The statement should be tied to any corporate objectives. It can be broken down into smaller components.

a. **Maintaining existing equipment and facilities**
This activity is the primary reason for the existence of the maintenance organization. The organization gains no advantage from owning equipment or facilities that are not operating or functional. This component is the "keep-it-running" charter of maintenance.

b. **Equipment and facilities inspections and services**
These programs are generally referred to as preventive and predictive maintenance (PM and PdM). These activities increase the availability of the equipment and facilities by reducing the number of unexpected breakdown or service interruptions.

c. **Equipment installations or alterations**
Installing and altering equipment are generally not the charge of the maintenance organization; they are usually performed by out side contract personnel. However, maintenance must still maintain the equipment, so they should be involved in any equipment installations or alterations.

Identify and Implement Cost Reductions

Reducing costs is sometimes an overlooked aspect of maintenance. However, a maintenance organization can help a company reduce costs in many ways. For example, a change in a maintenance policy may lengthen production run times without damaging the equipment. This change reduces maintenance cost and, at the same time, increases production capacity. By examining its practices, maintenance can usually make adjustments in tools, training, repair procedures, and work planning, all of which can reduce the amount of labor or materials that may be required to perform a specific job. Any time gained while making repairs translates into reduced downtime or increased availability. Downtime is more costly than maintenance expenditures. Before making adjustments to reduce costs, studies should be conducted to show the before-and-after results. This quantifying of improvements builds management support for maintenance activities.

Provide Accurate Equipment Maintenance Records

Providing accurate equipment maintenance records enables a company to accurately track equipment in such engineering terms as mean time between failure or mean time to repair. Success in this endeavor, however, requires accurate records of each maintenance repair, the duration of the repair, and the run-time between repairs. Larger organizations, for whom this activity produces a tremendous amount of paperwork, typically use some form of a computerized maintenance management system (CMMS) to track this information. But whether or not a computer is used, all of the maintenance data must be accurately tracked.

This objective seems almost impossible to achieve at times. Maintenance records are generally collected as work orders and then must be compiled into reports showing meaningful information or trends. The problem is finding enough time to put valuable information on each individual work order. Because excessive amounts of maintenance are performed in a reactive mode, it is difficult to record events after the fact. For example, recording how many times a circuit breaker for a drive motor was reset in one week might seem somewhat insignificant to record on a work order. But, if the overload was due to an increased load on the motor by a worn bearing inside the drive, it could be analyzed and repaired before the equipment experienced a catastrophic failure. Accurate record keeping is mandatory if maintenance is going to fully meet its responsibilities.

Collect Necessary Maintenance Cost Information

Collecting necessary maintenance-cost information enables companies to track engineering information. For example, by using life-cycle costing information, companies can purchase assets with the lowest life-cycle costs rather than lowest initial costs. In order to track overall life-cycle costs accurately, all labor, material, contracting, and other miscellaneous costs must be tracked accurately at the equipment level. This tracking is primarily an activity for the maintenance department.

In addition to life cycle costing is the need for maintenance budgeting. If accurate cost histories are not collected, how can the manager budget what next year's expenses will or should be? Maintenance managers cannot simply say to plant management, "We want to reduce maintenance labor by 10 percent next year." when they don't really know how the labor resources were allocated this year. Also if labor figures are only available in dollar amounts, the differences in pay scales may make it difficult to determine how much labor was used in total hours by craft. The information must be collected both in dollars and in hours by craft.

Where Is This Information Collected?

Collecting the cost information is again tied to work order control. Knowing the hours spent on the work order times the labor rates of the individuals performing the work allows a more accurate calculation of the labor used for the work order. Adding up these charges over a given time period for all work orders provides the total labor used. Adding up the hours spent by each craft provides an even clearer picture of the labor resources needed. Material costs can also be determined by tracking to each work order what parts were used on the job. Multiplying the number of parts times their dollar value (obtained from stores or purchasing) calculates the total material dollars spent for a given time period. Contractor and other cost information also must be collected at a work order level.

Each work order form should have the necessary blanks for filling in this information. Only by tracking the information at the work order level can you roll up costs from equipment to line to department to area and, finally, to total plant. Collecting the information at this level also provides cost information for equipment types, maintenance crafts, and cost centers. By utilizing the data gathered through the work order, detailed maintenance performance indicators can be developed.

Optimize Maintenance Resources

Optimizing maintenance resources includes eliminating waste through effective planning and scheduling techniques. In reactive maintenance organizations, up to one-third of maintenance expenditures are often wasted. By optimizing maintenance resources, organizations improve their effectiveness in eliminating this waste. For example, if an organization has a maintenance budget of one million dollars and operates in a reactive mode, it is possible that the organization is wasting $300,000. When 80-to-90 percent of all maintenance activities are planned and scheduled on a weekly basis, there is very little waste to the maintenance process. The goal for a reactive organization is to achieve this level of proficiency.

Optimizing maintenance resources also has an effect on maintenance manpower. For example, with good planning and scheduling practices, a reactive maintenance organization may increase the "wrench time" of their craft technicians from 25 percent to as much as 60 percent. This reduces the amount of overtime or outside contracting that an organization currently utilizes, reducing the overall maintenance cost. These types of reductions, while improving service, are essential to optimizing the present resources. Optimizing maintenance resources can only be achieved by good planning and scheduling practices.

Optimize Capital Equipment Life

Optimizing the life of the capital equipment means maintaining it so that it lasts 30-to-40 percent longer than poorly-maintained equipment. The maintenance department's goal is to keep the equipment properly maintained to achieve the longest life cycle. A preventive maintenance program designed for the life of the equipment is key to obtaining a maximum life cycle. The maintenance department will then need to perform the correct level of preventive maintenance, performing enough maintenance, but without performing excessive maintenance.

One way to determine a problem in this area is to examine new equipment purchases. Are equipment purchases used to replace equipment in kind? If so, could the purchase of the equipment have been deferred if proper maintenance had been performed on the older equipment? If long life cycles are not being achieved, then the proper level of maintenance is not being performed, and maintenance tasks should be revised.

Minimize Energy Usage

Minimizing energy usage is a natural result of well-maintained equipment, which requires 5-to-11 percent less energy to operate than poorly-maintained equipment. These percentages, established by international studies, indicate that maintenance organizations would benefit from constantly monitoring the energy consumption in a plant. Most plants and facilities have equipment that consumes considerable energy if not properly maintained. For example, heat exchangers and coolers that are not cleaned at the proper frequency consume more energy. HVAC systems that are not properly maintained require more energy to provide proper ventilation to a plant or facility. Even small things can have a dramatic impact on energy consumption. For example, equipment with a poor maintenance schedule will have bearings without proper lubrication or adjustment, couplings not properly aligned, or gears misaligned, all of which contribute to poor performance and require more energy to operate. The key to achieving this objective is having good preventive and predictive maintenance schedules.

Minimize Inventory On Hand

Minimizing inventory on hand helps maintenance organizations eliminate waste. Approximately 50 percent of a maintenance budget is spent on spare parts and material consumption. In organizations that are reactive, up to 20 percent of spare parts cost may be waste. As organizations become more planned and controlled, this waste is eliminated. Typical areas of waste in the inventory and purchasing function include:

1. Stocking too many spare parts
2. Expediting spare part delivery
3. Allowing shelf life to expire
4. Single line item purchase orders
5. Vanished spare parts

It is important for the maintenance organization to focus on controlling spare parts and their costs.

While the goals discussed thus far do not form a comprehensive, all-inclusive list, they highlight the impact that a proactive maintenance organization can have on a company. Maintenance is more than a "fix it when it breaks" function. Unless the maintenance organization works with a proactive list of goals and objectives, it will always be sub-optimized.

Management and Maintenance

In the past twenty years, executive management has focused increasingly on short-term profitability, sacrificing their physical assets to do so. Best Practice companies have taken advantage of this trend to develop strategic plans, building strong, complete organizations. One of the foremost areas of focus for these companies has been the maintenance/asset management function. Maintenance is extremely important to being competitive in the world market. But have the majority companies followed their lead? The answer for the majority, sadly, is no. I have seen plants where one day the maintenance force is required to work on sophisticated electronic systems and the next day to perform janitorial service in the lavatories.

In this environment, it is difficult for maintenance personnel to develop a positive attitude of their value to the corporation. If the maintenance function is to become a contributing factor to the survival of companies, management must change their views toward maintenance. If they do, they can achieve world-class competitiveness. Achieving the goals necessary to have a strong maintenance organization—one that contributes to increased profitability—will require decisions concerning the maintenance organization and the type of service it provides.

Equipment Service Level

Equipment service level indicates the amount of time the equipment is available for its intended service. The amount of service required from the equipment, along with its resultant costs, determines the type of maintenance philosophy a company will adopt. These five philosophies are listed in Figure 1-4.

Figure 1-4

Maintenance Philosophies

- Reactive Maintenance
- Corrective Maintenance
- Preventive Maintenance
- Predictive Maintenance
- Maintenance Prevention

Reactive Maintenance

In far too many cases, equipment is run until it breaks down. There is no preventive maintenance; the technicians react, working only on equipment that is malfunctioning. This approach is the most expensive way to coordinate maintenance. Equipment service level is generally below acceptable levels, and product quality is usually impacted.

Corrective Maintenance

Corrective maintenance activities are generated from PM inspections, routine operational requests, and routine service requirements. These activities make up the maintenance backlog and should be planned and scheduled in advance. This approach is the most cost-effective way to perform maintenance, reducing performance costs by 2-to-4 times compared to reactive maintenance. When the majority of maintenance activities fall into this category, equipment service levels can be maintained.

Preventive Maintenance

Preventive maintenance includes the lubrication program, routine inspections, and adjustments. Many potential problems can thus be corrected before they occur. At this level of maintenance, equipment service levels enter the acceptable range for most operations.

Predictive Maintenance

Predictive maintenance allows failures to be forecast through analysis of the equipment's condition. The analysis is generally conducted through some form of trending of a parameter, such as vibration, temperature, and flow. Preventive maintenance differs from predictive maintenance in that it focuses on manual tasks whereas predictive maintenance uses some form of technology. Predictive maintenance allows equipment to be repaired at times that do not interfere with production schedules, thereby removing one of the largest factors from downtime cost. The equipment service level will be very high under predictive maintenance.

An extension of predictive maintenance is condition-based maintenance, which is maintenance performed as it is needed, with the equipment monitored continually. Some plants have the production automation system directly connected to a computer system in order to monitor the equipment condition in a real-time mode. Any deviation from the standard normal range of tolerances will cause an alarm (or in some cases a repair order) to be generated automatically. This real-time trending allows for the maintenance to be performed in the most cost-effective manner. Condition-based maintenance is the optimum maintenance cost vs. equipment service level method available. The startup and installation cost can be very high. Nevertheless, many companies are moving toward this type of maintenance.

Maintenance Prevention

Maintenance prevention activities focus on changing the design of equipment components so they require less maintenance. This type of maintenance uses the data gathered from the previous techniques to design out maintenance requirements. An analogy of an automobile can be used. If the current day auto is compared to a 1970s vintage auto, a reduction in the maintenance requirements can be clearly seen. Tune ups are one of the main areas. 1970s autos required tune ups every 30,000-to-40,000 miles. New models require tune ups at 100,000 miles, with no degradation in performance. These improvements were studied, reengineered, and implemented. Plant and facility equipment today are no different. Maintenance prevention activities usually are supported by the maintenance engineering group.

Maintenance Staffing Options

Staffing is an important component of any maintenance organization. Four methods are commonly used to staff the maintenance organization (see Fig.1-5).

Maintenance Staffing Options

- Complete In-House Staff
- Combined In-House/Contract Staff
- Contract Maintenance Staff
- Complete Contract Maintenance

Figure 1-5

Complete In-House Staff

Having a complete in-house staff is the traditional approach in most U.S. companies. Under this approach, the craft technicians who perform maintenance are direct employees of the company. All administrative functions for each employee, as well as salary and benefits, are the responsibility of the company.

Combined In-House/Contract Staff

Combined in-house/contract staff became a more common approach to maintenance in the 1980s. The in-house staff performs most of the maintenance, but contractors perform certain maintenance tasks such as service on air conditioners, equipment rebuilds, and insulation. This method can reduce the amount of staff required for specific skill functions. If the contract personnel are not required full time, this approach can contribute even further savings.

Contract Maintenance Staff

Contract maintenance staffs combine the company's supervisors with contract employees. This method, common in Japan, is gaining popularity in the United States. The contractor provides properly-skilled individuals, removing the burden of training and personnel administration from the company. The downside of the approach is not having the same employees all of the time. Contract employees may have less familiarity with the equipment, but the interaction between the in-house supervision and the contract personnel can help to compensate.

Complete Contract Maintenance

Complete contracting maintenance staff includes all craftsmen, planners, and supervisors. Supervisors generally report to a plant engineer or plant manager. This approach eliminates the need for any in-house maintenance personnel. Although not yet popular in the United States, this program, coupled with an operator-based PM program (explained in the PM section), can prove to be cost effective and a valid alternative to conventional maintenance organizations

In reality, any of the above options can work. In most companies, however, it is difficult to manage a contract work force. While some companies claim financial benefits from contracting out all maintenance activities, those benefits are imaginary. The perceived benefits occur because the contractor can manage its maintenance work force, whereas the company cannot manage its own. When companies claim large savings from contracting maintenance, it is typically because they were not efficient and effective in the way they managed their maintenance. After all, the same work gets done. But how can a contractor be cheaper than in-house? Only by planning, scheduling, and removing waste from the maintenance process can the contractor be more cost effective. Could not the company then, with an internal or in-house work force, achieve the same cost levels?

Another problem comes to light when one considers the typical attitudes companies have towards contractors. Most companies do not partner well with their contractors. Instead, they treat them as disposable entities. If a contractor makes a mistake, the company cancels the contract and hires a new contractor. This attitude makes it difficult for the contractor to partner with the company. If companies today are going to use contractors for maintenance, then they must learn to work closely with their contractors and develop a partnering arrangement.

The partnering arrangement with contractors must be developed to a point at which the contractor feels valued. Many contract firms today believe their technical input to a client company is not valued. In many cases, while doing a maintenance repair, the contract personnel discover other problems. The client company too often assumes that the contractor is just trying to create work, and disregards the contractor's input. In reality, the contractor is trying to save the company money. This example shows that poor partnering with a contractor is an expensive way to do maintenance.

Geographical Organizational Structures

Maintenance organizations may be organized geographically in three basic ways: centralized, area, and hybrid.

Centralized Organization

In a centralized organization, all personnel report to one central location from which they are directed to work locations. The central organization provides the benefit of more extensive use of the personnel. This better utilization is due to the fact that technicians can always be directed to the highest priority work no matter where its location is in a plant or facility. If properly controlled, a central maintenance organization reduces the amount of nonproductive time for maintenance.

However, the disadvantage of a central organization becomes more noticeable in large plants. The disadvantage is slower response time caused by increased travel time. If there is a problem in one area of the plant and the workers are in other areas of the plant, it takes time to find them, re-deploy them, correct the problem, and then return them to their original assignments.

Organization By Area

The second organizational scheme focuses on area. In this scheme, maintenance personnel are assigned to specific areas within a plant or facility. However, a small group of maintenance personnel is always kept in a central location for data collection, analysis, crew scheduling, work planning, etc. In the area configuration, organizations usually respond in a timely manner, because the maintenance personnel are close to the equipment. The disadvantage of an area organization is finding enough work to keep all the maintenance personnel in an area busy. The opposite problem can occur when excessive equipment breakdowns exceed the capabilities of the labor pool within an area. Thus, at one time, one area may have people engaged in lower-level activities, while other areas have equipment breakdowns waiting for personnel. The area concept makes it difficult to move people from one area location to another, due to specialty skills or just distance.

One of the biggest advantages of area organizations is that they help to instill in maintenance workers a sense of ownership of the equipment. In area organizations, the maintenance personnel usually work the same schedule as the operations and production personnel. This schedule allows them to develop better lines of communication with operations and production personnel. Maintenance and production personnel come to understand each other's strengths and weaknesses, and these are taken into consideration during the work cycle. Because both maintenance and production want the equipment to run, they tend to work more closely together to ensure that the equipment does run. The equipment is more likely to be operated correctly and maintained at higher levels than are typically found when maintenance is a centralized organization.

Hybrid Organization

A hybrid organization, or combination organization, is the third option. In a hybrid organization, some maintenance personnel are assigned to areas and the remaining personnel are kept in a central location. The area personnel care for the routine maintenance activities, build relationships with the operations personnel, and develop ownership. The central group supports the area groups during shutdowns, outages, major maintenance, etc.

Which is the best arrangement? The rules of thumb are that central organizations are more effective in smaller, geographically compact plants; area organizations usually perform well in midsize plants; and combination organizations are best for large plants. When developing any maintenance organization, one must give the plant size and organizational geographical structure careful consideration. If one uses the wrong geographical structure, excessive staffing may be required to properly service the equipment. If a central organization is used to service a large plant, the travel time to get to the equipment and the resulting downtime may create havoc, with production schedules constantly disrupted.

Reporting Structures

Another way to look at maintenance organizations is to consider their reporting structures. Maintenance organizations can use a variety of structures, including the maintenance-centric model, the production-centric model, and the engineering-centric model.

The Maintenance-Centric Model

In the maintenance-centric model, maintenance reports to a plant or facilities manager at the same level as production and engineering. This model provides a balanced approach, with the concerns of all three organizations weighed equally by the plant manager.

All maintenance personnel in the plant report through a maintenance manager. If the organization is larger, there may be levels of supervisors reporting to the maintenance manager. Maintenance-staff functions, e.g., planners and maintenance engineers, also report to the maintenance manager. Construction and project engineers report to the engineering manager, but no maintenance resources are deployed by engineering. Also, all production or operations personnel report through the production or operations manager, but no maintenance resources are under the control of the production or operations manager. This structure is optimum for organizations learning maintenance controls and philosophies. It is a good structure to start with and it can be developed to support world-class initiatives such as cross-functional teams

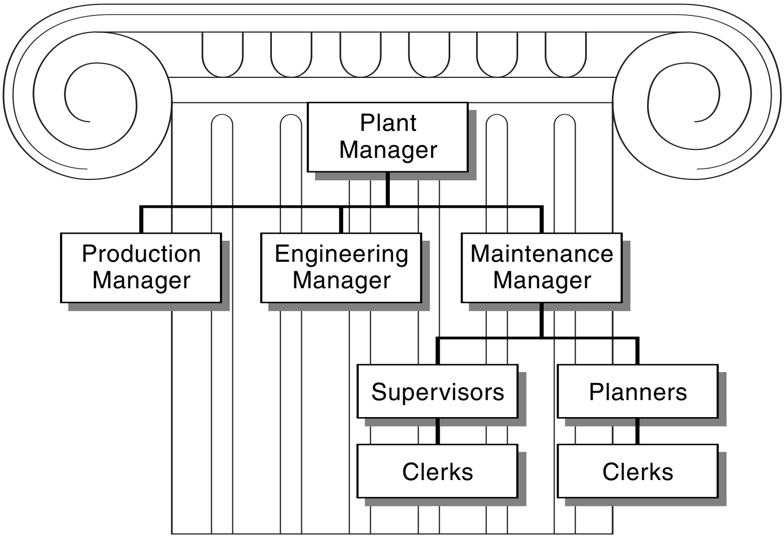


Figure 1-6 Typical Maintenance-Centric Organizational Structure.

and operator-based maintenance activities. This organization is shown in Figure 1-6.

The Production-Centric Model

A second model is the production- or operations-centric organization. In this model, maintenance resources are deployed by the production or operations managers. At first glance, this arrangement might seem to be a good idea. In reality, it rarely works because very few production or operations managers have the necessary technical skills to deploy maintenance resources properly. These cases usually lead to less use of the maintenance work force and, in turn, more equipment downtime. When maintenance resources report to production or operations, maintenance generally deteriorates into the role of "fire fighting" or "fix it when it breaks." The production-centric model is shown in Figure 1-7.

Another consideration when assessing production-centric reporting structures is the compensation structure for supervisors. In most cases, the production or operations supervisors are rewarded for meeting some level of production throughput or a capacity target-number. Because their compensation is based on output, they have little incentive to perform good maintenance on their equipment. In most cases, under production-centric reporting structures, good maintenance practices are sacrificed to meet production targets.

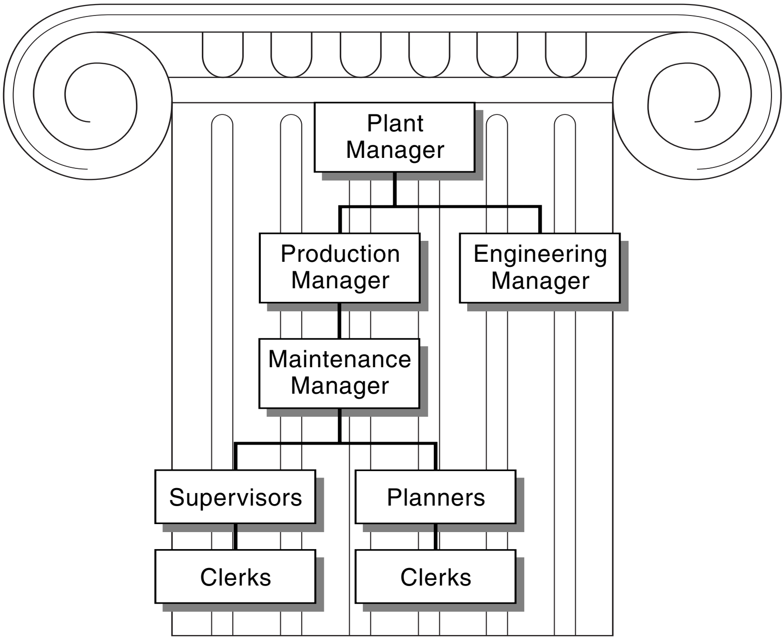


Figure 1-7 Typical Production-Centric Organizational Structure.

However, if equipment availability or life-cycle costing numbers are included as part of their compensation, then maintenance may be properly managed in this kind of environment.

The Engineering-Centric Model

A third structure commonly found today is an engineering-centric organization. In this structure, maintenance reports to engineering. Thus, construction engineering, project engineering, and maintenance all have the same supervision, e.g., the plant engineer. On the surface, this arrangement appears workable. However, it typically leads to problems. The main problems arise because of projects. Typically, the performance of engineering supervisors is assessed based on their completing projects on time and under budget. If a project gets behind, maintenance resources often are diverted from preventive maintenance and other routine tasks to project work. Although assigning maintenance resources to a project may help complete the project on time, existing equipment may suffer from a lack of maintenance. This structure is shown in Figure 1-8.

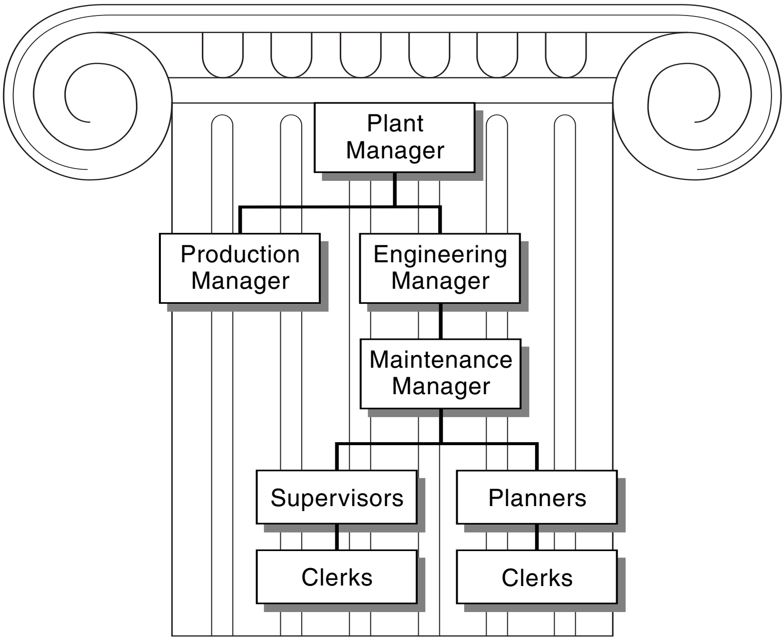


Figure 1-8 Typical Engineering-Centric Organizational Staff.

Then, a second, more long-term problem develops. The attitude of the work force is affected. Maintenance personnel enjoy working on projects, because all of the equipment is new. Over time, they tend to develop less of a maintenance attitude and more of a project attitude. This shift in attitude leads to their wanting to perform less maintenance work and more replacement work. The maintenance personnel become, in effect, parts replacement specialists rather than maintainers or repairers. This situation can lead to excessive inventory and new equipment purchases.

Whatever the structure of a maintenance organization—and structure does vary from organization to organization—it must have the proper focus. Maintenance is a technical discipline. Maintenance personnel are the stewards of the technology in a plant or facility. If the maintenance organization does not have a technical focus, the assets and equipment will be sub-optimized. Therefore, if maintenance is sacrificed to achieve short-term production goals or to support engineering construction projects, the maximum return on investment in the existing assets is never achieved. This situation weakens a company's competitive position in its marketplace. If any organizational redesign is proposed for maintenance, both short-term and long-term issues must be examined.

Roles and Responsibilities

In order for maintenance organizations to be effective, certain roles and responsibilities must be defined and assigned. While it is beyond the scope of this material to consider all possibilities, the following are general guidelines that can be used. Although an organization may not use each of the individual job titles listed in this section, each of the task lines must be assigned. Thus, an organization may not specifically have a first-line maintenance foreman or supervisor who has a responsibility for each individual line item. Nevertheless, the line-item task descriptions are essential if maintenance is to be managed and, ultimately, the company's assets cared for.

First-Line Maintenance Foreman or Supervisor

The following tasks are typically the responsibility of a first-line (or front-line) maintenance foreman or supervisor:

1. Directs the maintenance work force and provides on-site expertise.

When maintenance craft workers are working on an assignment and have questions or need clarification about how to perform a task, the first-line maintenance foreman or supervisor should be able to provide the guidance. The first-line maintenance foreman or supervisor is also responsible for making individual job assignments and tracking the progress of individual craft assignments.

2. Ensures that work is accomplished in a safe and efficient manner.

The first-line maintenance foreman or supervisor is also responsible for seeing that each craft worker for whom he or she has responsibility works safely and is provided the information, tools, and direction to work efficiently.

3. Reviews work planning and scheduling with the planner.

The first-line maintenance foreman or supervisor is also responsible for providing feedback to the maintenance planner to ensure that job plans are efficient and effective and that scheduling is accurate.

4. Ensures quality of work.

While most maintenance craft workers will perform quality work, on occasion they are pressured to take shortcuts. The first-line maintenance foreman or supervisor is there to ensure they have the proper time to do a quality job the first time.

5. Ensures equipment availability is adequate to meet the profit plan.

Quite plainly, this task assigns responsibility for the equipment or asset uptime to the first-line maintenance foreman or supervisor.

6. Works with plant or production supervision to ensure first-line maintenance is being performed by operators.

If the production or operations group is performing first-line maintenance on their equipment, the first-line maintenance foreman or supervisor has a responsibility to ensure the work is really being performed, is being performed safely, and is being performed to the appropriate standards.

7. Verifies the qualifications of hourly personnel and recommends training as needed.

When making individual work assignments and observing the craft workers performing these assignments, the first-line maintenance foreman or supervisor should be able to observe training needs. As these training needs are identified, it is up to the first-line maintenance foreman or supervisor to see to it that the appropriate training is provided as required.

8. Enforces environmental regulations.

As part of the management team, the first-line maintenance foreman or supervisor has the responsibility of ensuring that all maintenance craft workers observe all environmental regulations. This includes ensuring appropriate documentation, work practices, and procedures.

9. Focuses downward and is highly visible in the field.

It is a responsibility of the first-line maintenance foreman or supervisor to manage the maintenance craft workers at least six hours per day, with no more than two hours per day spent on paperwork or meetings. This is known as the 6/2 rule. It is not cost-effective to have the first-line maintenance foreman or supervisor performing clerical paperwork as the major part of his or her work.

10. Champions proactive maintenance vs. reactive maintenance.

The first-line maintenance foreman or supervisor also has a responsibility to encourage all production or operations personnel to turn in work to be planned and scheduled. Doing this is designed to prevent production or operations personnel from requesting work in a "do it now" or reactive mode and helps to ensure that maintenance is planned, scheduled, and performed in the most cost-effective manner.

11. Administers the union collective bargaining agreement.

As a management representative, the first-line maintenance foreman or supervisor is responsible for seeing that the components of any collective bargaining agreement are carried out

12. Monitors the CMMS.

It is also the responsibility of the first-line maintenance foreman or supervisor to ensure that all data collected by the hourly employees assigned to him or her is accurate and complete when being entered into the CMMS, if the company uses one.

13. Implements preventive and predictive maintenance programs.

The first-line maintenance foreman or supervisor is responsible for ensuring that the craft workers are qualified, and that the crew has the skills necessary, to perform the appropriate preventive and predictive maintenance tasks. In addition, the first-line maintenance foreman or supervisor and the crew have a responsibility to improve the preventive and predictive maintenance program constantly. This responsibility may range from improving the individual steps on a preventive maintenance task to implementing new technology for predictive maintenance.

It is not the purpose of this text to determine organizational structures for every company. However, each of the thirteen task items just described must be assigned and performed if maintenance is to be properly supervised. The question each organization must ask it is: Who has the responsibility for each of these task items?

The Maintenance Planner

Another individual in a maintenance organization is the maintenance planner. The maintenance planner is different from a supervisor or foreman. Whereas the supervisor manages the maintenance craft workers, the planner provides logistic support to them. The following are the typical responsibilities for a maintenance planner:

1. Plans, schedules, and coordinates corrective and preventive maintenance activities.

A planner accomplishes this task by studying and managing work requests; analyzing job requirements; and determining materials, equipment, and labor needs (such as blueprints, tools, parts, and craft workers' skill requirements) in order to complete maintenance economically and efficiently. The maintenance planner is the logistics person. He or she has the responsibility for removing nonproductive time from the maintenance work force. His or her basic responsibility is to ensure that when the maintenance work is ready to be performed, there will be no delays during the execution of the work.

2. Develops a weekly schedule and assists the maintenance first-line maintenance foreman or supervisor in determining job priorities.

The planner will make changes and adjustments to the schedule and work package after reviewing them with the first-line maintenance foreman or supervisor. The planner maintains a complete and current backlog of work orders. As work is requested, the request is given to the planner. The planner examines the request, plans the job, and reviews the job with the foreman or craft workers. Once the job is planned and approved, it is placed on the schedule. The planner reviews the weekly schedule with the first-line maintenance foreman or supervisor before the start of the work week. The first-line maintenance foreman or supervisor's recommendations that require changes are incorporated into the schedule, and the schedule is then published by the planner.

3. Ensures that the CMMS software data files are complete and current.

The planner does this task by gathering equipment and associated stores information for the entire plant or facility. The planner develops standardized codes for the equipment, stores, and task craft assignments for all maintenance activities. In short, the planner is the keeper of the CMMS software data files. The planner constantly reviews information being input into the CMMS for accuracy and completeness.

4. May assist with stores and purchasing functions.

At smaller sites, where the planner does not have a full-time work load—typically planning for 15 to 20 craft workers—the planner may assist with stores and purchasing functions. For example, he or she may be involved in controlling the inventory by ordering, issuing, returning, adjusting, and receiving stores items.

5. Identifies, analyzes, and reviews equipment maintenance problems with maintenance engineering.

The planner revises the maintenance management program as necessary to improve and enhance plant and facilities operations. Since the planner maintains the work order system, any repetitive problems should be apparent to the planner. He or she then reviews repetitive problems with maintenance engineering to find a resolution. At this level, the resolution typically will be adjustments in the preventive or predictive maintenance program. By adjusting these programs, the planner provides a solution to the problem. If the problem is not related to the preventive or predictive maintenance program, then the planner refers it to the maintenance engineer for resolution.

6. Assists in educating operations or facilities personnel in maintenance management.

Because the planner is so well versed in maintenance tools and techniques, he or she should participate in training other company employees in maintenance management fundamentals.

This list highlights the typical responsibilities of a planner. Again, if the organization does not have planners, who, then, is responsible for each of these task items? If maintenance is to be performed economically and efficiently, each of these task items must be assigned. In many organizations, a common mistake is to make the first-line maintenance foreman or supervisor supervise and plan. However, when a first-line maintenance foreman or supervisor has a full load (typically 8 to 12 craft workers), that first-line maintenance foreman or supervisor will not be able to properly supervise and plan. Because a first-line maintenance foreman or supervisor cannot do both jobs correctly, maintenance will not be performed as efficiently and effectively as it could be.

Up to this point, the focus has been on managing the maintenance work force and providing the support needed to make them efficient and effective. However, the transition is now made to managing assets or equipment. If the first two task lists are properly assigned and completed, then the organization is collecting data through the work order system and the CMMS. The next task list entails making this data effective in the maintenance of management.

Maintenance Engineer

The following tasks are typically the responsibility of the maintenance engineer:

1. Ensures that equipment is properly designed, selected, and installed based on a life-cycle philosophy.

Many companies today consistently purchase equipment based on the low bid. Quite simply, if they are not performing the tasks listed for the maintenance foreman and maintenance planner, the company lacks the data to purchase equipment based on the life-cycle philosophy. Without the data, the purchasing and accounting departments will purchase the lowest cost items, which may or may not be the best long-term decision. Thus, collecting maintenance-cost data is important.

2. Ensures that equipment is performing effectively and efficiently.

This task is different from tracking uptime. It means ensuring that the equipment, when it is running, is at design speed and capacity. When focusing only on maintenance, many companies set goals in terms of uptime. However, many companies do not realize, as they move into this aspect of maintenance, that the equipment may be running at only 50-to-60 percent of capacity. Thus, understanding design capacity and speed ultimately is more important than measuring uptime.

3. Establishes and monitors programs for critical equipment analysis and condition monitoring techniques.

The maintenance engineer is responsible for ensuring that the appropriate monitoring techniques are used for determining equipment conditions. This information is then given to the planner so that effective overhaul schedules can be determined. These techniques should also help eliminate unplanned maintenance downtime.

4. Reviews deficiencies noted during corrective maintenance.

As mentioned in task #5 for the maintenance planner, the engineer and the planner periodically review equipment maintenance records. If they observe continual problems with equipment, and the problems are not with the preventive or predictive maintenance programs, then the maintenance engineer will be responsible for finding solutions to the problems.

5. Provides technical guidance for CMMS.

The maintenance engineer also reviews the data in the CMMS. He or she makes recommendations about the types of data and the amount of data being collected. The maintenance engineer may also recommend problem, cause, and action codes for properly tracking maintenance activities.

6. Maintains and advises on the use and disposition of stock items, surplus items, and rental equipment.

The maintenance engineer reviews spare parts policies for plant equipment. This review is to ensure that the right parts are in stock—in the right amounts.

7. Promotes equipment standardization.

The maintenance engineer will help to ensure that the company is purchasing standardized equipment. Equipment standardization reduces the number of spare parts required and the amount of training necessary. It also reduces the overall maintenance budget. Standardization requires data from the CMMS. If the organization is not collecting data through the maintenance foreman and maintenance planner, then the maintenance engineer will not have the data required to implement equipment standardization.

8. Consults with maintenance craft workers on technical problems.

The maintenance engineer consults at a technical level with maintenance craft workers concerning equipment or work-related problems. This consultation may be about advanced troubleshooting or even equipment redesigns.

9. Monitors new tools and technology.

The maintenance engineer is responsible for staying abreast of all the tools and technology that are available in the maintenance marketplace. Therefore, the maintenance engineer is responsible for reading books and magazines, attending conferences, and interfacing with other maintenance engineers to gather this data.

10. Monitors shop qualifications and quality standards for outside contractors.

The maintenance engineer is responsible for insuring that all outside contractors are qualified and that the work performed by the contractors is of the proper quality.

11. Develops standards for major maintenance overhauls and outages.

The engineer is responsible for examining outage and overhaul plans for completeness and accuracy. He or she then makes appropriate recommendations to the planner for adjustments in the plans or schedules.

12. Makes cost-benefit reviews of the maintenance programs.

Periodically, the maintenance engineer reviews maintenance programs for his or her areas of responsibility and determines whether the work should be performed by operators, maintenance craft workers, or outside contractors. In addition, the engineer reviews what work needs to be done, what work can be eliminated, and what new work needs to be identified and added to the maintenance plan.

13. Provides technical guidance for the preventive and predictive maintenance programs.

The engineer periodically reviews the preventive and predictive maintenance programs to ensure the proper tools and technologies are being applied. This review is typically in conjunction with the maintenance planner.

14. Monitors the competition's activities in maintenance management.

The engineer is also responsible for gathering information about competitor's maintenance programs. This information may come from conferences, magazine articles, or peer-to-peer interfacing and should be reviewed for ideas for potential improvements in his or her company's maintenance program.

15. Serves as the focal point for monitoring performance indicators for maintenance management.

The engineer is responsible for developing performance indicators for maintenance and reviewing those with the maintenance manager.

16. Optimizes maintenance strategies.

The maintenance engineer is responsible for examining maintenance strategies and ensuring that they all are cost effective.

17. Responsible for analyzing equipment operating data.

The maintenance engineer ensures that equipment is operating as close to design parameters as possible. Doing this ensures that there is no wasted production from less-than-optimal equipment capacity.

In brief, the maintenance engineer is responsible for properly managing assets. The engineer is a key individual if a company is going to maximize asset utilization. A maintenance engineer is different from a project engineer. A project engineer concentrates on new construction and new equipment. The maintenance engineer concentrates on optimizing existing equipment or assets. Ultimately, it is the maintenance engineer's goal to ensure that his or her company gets as much or more production from its assets than any other company does that has the same kinds of assets.

Maintenance Manager

The following list describes the tasks for the maintenance manager, or the individual responsible for managing all of the maintenance functions for a company:

1. Responsible for the entire maintenance function, including the planning, supervising, and engineering staffs.

This one individual has the responsibility for all maintenance activities within the company. The maintenance planners, supervisors, and maintenance engineers report directly to this individual. This structure produces one-point accountability for the entire maintenance program.

2. Coordinates closely with counterparts in other in-house organizations.

The maintenance manager coordinates with other organizations to ensure that company objectives are being met. The maintenance manager communicates closely with production or operations, project or construction engineering, accounting, purchasing, and other organizations. As a result, the organization maintains its focus on optimizing the company's assets.

3. Promotes proper understanding of the maintenance function to other organizations.

The maintenance manager educates other organizations within the company regarding the value of maintenance management. This education is intended to help other organizations understand the impact that their functions have on the maintenance organization's efforts to properly maintain the company's assets.

4. Ensures that all supervisors, planners, technicians, and maintenance engineers are properly educated and trained.

To be able to fulfill their responsibilities, other maintenance personnel need to be educated and trained. Ensuring that education and training takes place is one of the most overlooked responsibilities of the maintenance manager. Technology is constantly changing. The entire maintenance organization's skills must be kept up-to-date if it is to fulfill its responsibilities correctly.

5. Takes responsibility for planning, cost control, union activities, vacation planning, etc.

The maintenance manager is responsible for all the logistics and personnel activities for the maintenance organization. The maintenance manager also administers the maintenance budget and ensures that the maintenance function meets its budgetary requirements.

6. Has responsibility for delegating assignments to the appropriate personnel.

The maintenance manager has a responsibility to ensure that the appropriate personnel are in the proper staff positions within the organization. In other words, the manager has the responsibility to see that the organization is staffed correctly and operates smoothly.

Maintenance Organization and Staffing

In this age of downsizing, organization and staffing are among the most critical issues affecting maintenance. How is the maintenance organization staffed? While companies have tried many different staffing formulas over the years, the only perennially successful one is staffing the maintenance department based on work backlog. A maintenance work backlog is the amount of work currently identified as needing to be performed by the maintenance department. This amount of work is measured in hours. Many have tried to measure backlog by the number of work orders, percentage of production hours, etc., but these measures never work. The only true measure of backlog is based on hours of work to be done. When calculating the backlog, it is necessary not only to know the hours of maintenance work needed, but also to understand current work force capacity.

The formula for calculating backlog is as follows:

Backlog = identified work (in hours) ÷ craft capacity per week (in hours)

For example, a backlog contains 2,800 hours of work that is currently identified. The current work force has ten technicians who each work 40 hours per week plus 8 hours of overtime per week. Total hours worked per week by the technicians, then, is 480 hours. The company also uses two outside contractors for 40 hours each per week—another 80 hours. Therefore, the total capacity for the work force is 560 hours. If the 2,800 hours in the backlog is divided by the 560 hours of capacity, this produces a backlog of five weeks. An optimum backlog is considered to be between two and four weeks of work.

At first glance, the five-week backlog does not seem to be too far from the optimum. If, however, an organization scheduled 560 hours of work from the backlog for their crews next week, it would be virtually impossible to accomplish that 560 hours of planned work. The reason is the amount of emergency or reactive work that occurs on a weekly basis. In some companies, emergency and reactive work makes up as much as 50% of the maintenance department's work-allocation each week. If this is the case, then only 280 hours of additional work can be done. In addition, the technicians have routine assignments—lube routes, re-builds, and other routine activities. There are also meetings, absenteeism, vacations, and training. When all of these factors are considered, the actual hours available to be scheduled might be about 200. If only 200 hours are available to be scheduled, then the backlog is actually 14 weeks, an unacceptable amount. One can only imagine the reaction of the production department when it submits a work order that it expects to be completed within two-to-four weeks, but is told may take as long as three-and-a-half months to complete.

Although this scenario is bleak, there is a second, more important problem.

That problem is the proper identification of work that needs to be performed by the maintenance organization. The maintenance department is staffed based on identified, not actual, work. For example, if someone today performed an equipment walk-down throughout your entire plant, how much work could be identified that needs to be done, but is not yet recorded? Hundreds, if not thousands, of hours of work may need to be performed. This unrecorded work, along with the previously described factors, lead to underestimating the backlog and, ultimately, to insufficient staffing of the maintenance department. The organization would revert to a reactive condition because current staff can never accomplish the required work in a proactive mode.

Another common practice in industry further compounds the problem. This practice, which is identified by many companies as a backlog purge, occurs when all small jobs are removed from the backlog or deferred to another time. The jobs are those perceived to be noncritical and to be done at another time. This is a mistake! Work should be identified and performed before it becomes critical. The attitude is "It's only a small job, not to be worried about." However, over time, small jobs become big jobs. In reality, then, the organization is saying, "We only want to work on big jobs," or "We will wait till it becomes a critical problem before we address it."

Backlog purges are used by companies to justify downsizing or reductions in staff. It would be quite unusual for any company to defer or cancel small orders from customers and make the customers wait until after the company fills the big orders before accepting and running the small orders. The parallel with maintenance is clear. If a work order is turned in, approved, and put in the backlog, then it is a legitimate request. It should never be canceled or deferred until it becomes an emergency.

The goal should be to maintain the backlog in the two-to-four-week range. If the backlog begins to increase or trend above four weeks, then more resources should be added. From the formula, one can see that there are three options for resources. A company can contract out more work, its employees can work more overtime, or it can hire more employees. Conversely, if the backlog begins to trend or drop below two weeks, the company can reduce resources. The company could reduce the amount of outside contract work, reduce the amount of craft overtime, or ultimately reduce the size of the maintenance work force. If the backlog is calculated weekly and tracked annually, seasonal trends and other spikes can be clearly seen. By reviewing these types of records, a manager can ensure that the department is properly staffed.

In conclusion, developing a comprehensive maintenance/asset management strategy is a fundamental step in developing performance indicators. If the strategy is not defined, then what do the performance indicators measure? Companies need to dedicate proper resources to insure that the strategy is clearly defined and approved, before any attempt to develop performance indicators for maintenance/asset management is undertaken.

CHAPTER 2

Developing The Maintenance Function

What is Maintenance Management?

In order to insure consistency within the text, it will be beneficial to define the following terms:

Maintenance
1. The work of keeping something in proper condition; upkeep

Maintain
1. To keep in a condition of good repair or efficiency

Manage
1. To direct or control the use of; handle
2. To exert control over
3. To direct the affairs or interests of
4. To succeed in accomplishing or achieving, especially with difficulty

Management
1. The act, manner, or practice of managing; handling, supervision, or control
2. The person or persons who control or direct a business or other enterprise
3. Skill in managing; executive ability

Manager
1. One who handles, controls, or directs, especially
   a. One who directs a business or other enterprise

Measuring
1. To estimate by evaluation or comparison
2. To bring into comparison

Indicator
1. Any of various statistical values that together provide an indication of the condition or direction of an entity

Performance
1. The way in which someone or something functions

Perform

1. To take action in accordance with the requirements of; fulfill
2. To fulfill an obligation or requirement; accomplish something as promised or expected

In today's business environment, terms like Best Practices, Benchmarking, World Class and others continuously bombard us. Two other terms to recently emerge are performance indicators and performance measurement. These indicators or measures can be applied to any function within an industrial plant or facility, public or private organization, or even non-profit organization.

There are performance measures for quality, production, processes, and even financial departments. However, one function within organizations that is beginning to emerge as a key to future competitiveness is the maintenance function. The focus of the maintenance function is to insure that all company assets meet and continue to meet the design function of the asset. What is Maintenance Management (sometimes referred to as Asset Management) and of what importance is it for managers in corporations today?

Maintenance (Asset) Management can be defined as "the management of all assets owned by a company, based on maximizing the return on investment in the asset." This definition encompasses the philosophies contained in many of the more popular techniques currently being utilized by companies today.

What techniques would fall under the definition of maintenance (asset) management? The list would include, but not be limited to, the following:

Preventive Maintenance
Stores and Procurement
Work Flow Systems
Computerized Maintenance Management Systems (CMMS) and
Enterprise Asset Management Systems (EAM)
Interpersonal Training
Operational Involvement
Predictive Maintenance
Reliability-Centered Maintenance
Total Productive Maintenance
Statistical Financial Optimization
Continuous Improvement

Each of these initiatives is a building block for the maintenance (asset) management process. A brief examination of each will show its importance to the (asset) management process.

1. Preventive Maintenance

The preventive maintenance program is the key to any successful asset management program. The preventive maintenance program reduces the amount of reactive maintenance to a level low enough that the other initiatives in the asset management process can be effective. However, most companies in the United States have problems keeping their PM program focused. In fact, surveys have shown that only 20% of the companies in the United States believe their PM programs are effective.

This finding indicates that most companies need to focus on the basics of maintenance if they are to achieve any type of asset management process. Effective preventive maintenance activities would enable a company to achieve a ratio of 80% (or more) proactive maintenance to 20% (or less) reactive maintenance. Once the ratios are at least at this level, the other initiatives in the asset management process become more effective. From the financial perspective, reactive maintenance typically costs 2-to-4 times what proactive maintenance costs, due to its inherent inefficiencies. Because the asset management process is focused on Return on Investment (ROI), it is critical for all companies to have a successful PM program as a foundation.

2. Stores and Procurement

The stores and procurement programs must focus on providing the right parts at the right time for the asset repairs and maintenance. The goal is to have enough spare parts, without having too many spare parts. However, the interdependency between the asset management initiatives becomes apparent: No stores and procurement process can cost effectively service a reactive maintenance process. However, if the majority of maintenance work is planned several weeks in advance, the practices within the stores and procurement process can be optimized.

What level of performance is typical in companies today? Many companies see service levels below 90%, which means stockouts run greater than 10% of requests made. This service level leaves customers (maintenance) fending for themselves, stockpiling personal stores and circumventing the standard procurement channels to obtain their materials. These actions are not done for personal reasons, but rather because they want to provide service to their customer (operations or facilities). It is really a self-defense mechanism.

In order to prevent this situation, it is necessary to institute the type of stores controls that will allow the service levels to reach 95-to-97% with complete accuracy of the data. When this level of stores and procurement performance is achieved, then the next step in asset management is ready to be taken.

3. Work Flow Systems

This initiative in asset management involves documenting and tracking the maintenance work that is performed. A work order system is used to initiate, track, and record all maintenance and engineering activities. The work may start as a request that needs approval. Once approved, the work is planned, then scheduled, performed and finally recorded. Unless the discipline is in place and enforced to follow this process, data is lost and true analysis can never be performed.

Unfortunately, many organizations record only a small part of their maintenance and engineering actions; so much data is lost. When it comes time to perform an analysis of the data, the analysis is incomplete and inaccurate. Management does not support the decisions made, based on the data, and further degradation of their confidence in the maintenance department occurs.

The solution requires complete use of the work order system to record all maintenance and engineering activities. Unless the data is tracked from work request through completion, the data is fragmented and useless. If 100% of all maintenance and engineering activities are tracked through the work order system, then planning and scheduling can be effective.

Planning and scheduling require someone to perform the following activities:

Review the work submitted
Approve the work
Plan the work activities
Schedule the work activities
Record the completed work activities

Unless a disciplined process is followed for these steps, the productivity increases and reduced equipment downtime never occur. This leaves the perception that maintenance planning is a clerical function. In turn, the planning function becomes vulnerable to the first cuts when any type of reduction in overhead costs is examined. At least 80% of all maintenance work should be planned on a weekly basis. In addition, the schedule compliance should be at least 90% on a weekly basis.

4. Computerized Management Maintenance Systems(CMMS) and Enterprise Asset Management Systems (EAM)

In most companies, sufficient data is accumulated by the maintenance and engineering functions to require the computerization of the data flow. This computerization facilitates the collection, processing, and analysis of the data. The use of Computerized Maintenance Management Systems (CMMS) or Enterprise Asset Management Systems (EAM) has become popular in most countries around the world. This software manages the functions discussed previously, and provides support for asset management.

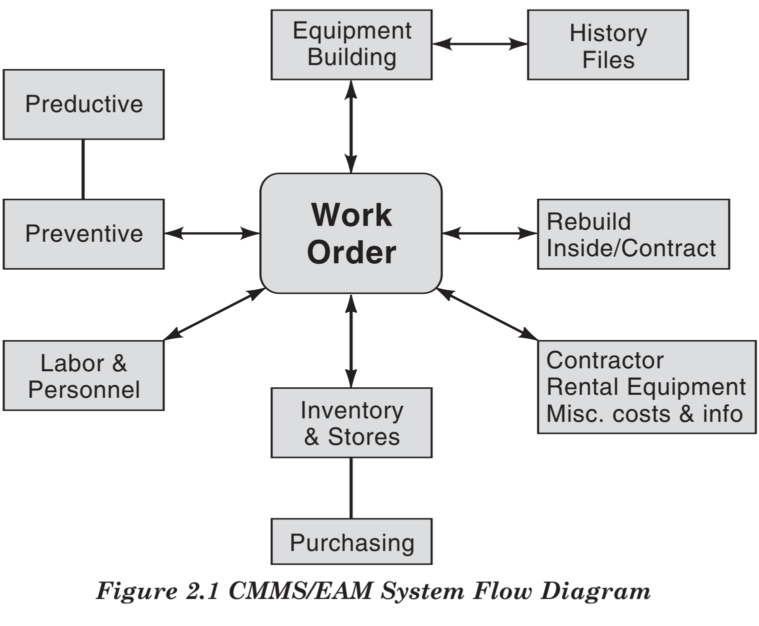


Figure 2.1 CMMS/EAM System Flow Diagram

CMMS/EAM systems have been utilized for almost a decade in some countries with mixed results. A recent survey in the United States showed the majority of companies utilizing less than 50% of their CMMS' capabilities. What this means for these companies is that the data they collect is highly suspect and probably highly inaccurate. Unless this is corrected, the companies will never be able to achieve true asset management because there will be no method of tracking asset costs and calculating ROI. Figure 2-1 highlights the information flow in a CMMS/EAM system.

5. Technical and Interpersonal Training

The training function of maintenance insures that the technicians working on the equipment have the technical skills that are required to understand and maintain the equipment. Additionally, those involved in the maintenance functions must have the interpersonal skills to be able to communicate with other departments in the company. They must also be able to work in a team or natural work group environment. Without these skills, there is little possibility of maintaining the current status of the equipment. Furthermore, the probability of ever making any improvement in the equipment is inconceivable.

While there are exceptions, the majority of companies today lack the technical skills within their organizations to maintain their equipment. In fact, studies have shown that almost one-third of the adult population in the United States is functionally illiterate or just marginally better. When these figures are coupled with the lack of apprenticeship programs available to technicians, the specter becomes reality of a work place where the technology of the equipment exceeds the skills of the technicians that operate or maintain it.

6. Operational Involvement

Operational Involvement requires the operations, production, or facilities departments to take ownership of their equipment to the extent that they are willing to support the maintenance and engineering department's efforts. The aspects of involvement vary from company to company. The involvement activities may include some of the following:

Inspecting equipment prior to start up
Making out work requests for maintenance
(includes building occupants requesting work)
Recording breakdown or malfunction data for equipment
Performing some basic equipment service (e.g., lubrication)
Performing routine adjustments on equipment
Performing maintenance activities
(supported by central maintenance)

The extent to which operations, production, or facilities is involved in maintenance activities may depend on the complexity of the equipment, the skills of the individuals, or even union agreements. The goal should always be to free up some of the maintenance and engineering resources to concentrate on more advanced asset management techniques.

7. Predictive Maintenance

Once the maintenance and engineering resources have been freed up by the involvement, they should be refocused on the predictive technologies that apply to the assets. For example, rotating equipment is a natural fit for vibration analysis, electrical equipment for thermography, and so forth. In some cases, the devices monitoring the asset may be connected to a building automation system, a distributed control system, or a PLC (Programmable Logic Controller) system and all parameters are monitored in a real-time environment.

The focus is not to purchase all the technology available, but to investigate and purchase technology that solves or mitigates chronic equipment problems that exist. The predictive inspections should be planned and scheduled utilizing the same techniques that are used to schedule the preventive tasks. All data should be recorded in or interfaced to the CMMS.

8. Reliability-Centered Maintenance

Once the data is recorded, Reliability-Centered Maintenance (RCM) techniques are now applied to the preventive and predictive efforts to optimize the programs. If a particular asset is environmentally sensitive, safety related, or extremely critical to the operation, then the appropriate PM/PDM techniques are decided upon and utilized.

If an asset is going to restrict or impact the production or operational capacity of the company, then another level of PM/PDM activities are applied with a cost ceiling in mind. If the asset was allowed to fail and the cost is the expense to replace or rebuild the asset, then yet another level of PM/PDM activities is specified. There is always the possibility that it is more economical to allow some assets run to failure. This option is considered in RCM.

The RCM tools require data to be effective. For this reason the RCM process is utilized after the organization has attained a level of maturity that insures accurate and complete asset data.

9. Total Productive Maintenance

Total Productive Maintenance (TPM) is an operational philosophy, under which everyone in the company understands that in some way their job performance impacts the performance of the asset. For example, operations must understand the true capacity of the equipment and does not run it beyond design specifications, creating unnecessary breakdowns. The purchasing department must always buy the spare parts to the correct specifications and not try to save a small amount, creating breakdowns because the parts did not last as long as they should.

TPM is like Total Quality Management. The only change is that instead of companies focusing on their products, their focus shifts to their assets. All of the tools and techniques used to implement, sustain, and improve the total quality effort can be utilized in TPM.

10. Statistical Financial Optimization

Statistical financial optimization is a statistical technique that combines all of the relevant data about an asset, such as:

Downtime cost
Maintenance cost
Lost efficiency cost
Quality costs

The technique then balances out financially optimized decisions, such as:

When to take the asset offline for maintenance
Whether to repair or replace an asset
How many critical spare parts to carry
The maximum-minimum levels for routine spare parts

Financial optimization requires accurate data, because making these types of decisions incorrectly could have a devastating effect on a company's competitive position. By the time a company reaches a level of sophistication where this technique can be utilized, it is approaching the pinnacle of the asset management pyramid.

11. Continuous Improvement

Continuous Improvement is best epitomized by the expression, "Best is the Enemy of Better." Continuous improvement in asset care is an ongoing program of evaluation, constantly looking for the little things that can make a company more competitive.

One of the key tools for continuous improvement is benchmarking. Process benchmarking is one of the most successful types of benchmarking. It examines specific processes in maintenance, compares the processes with companies that have mastered those processes, and maps changes to improve the specific process.

The key to benchmarking is self-evaluation. A company must know its current status before it tries to benchmark with other companies. Without this knowledge, getting an accurate comparison of the benchmarked process is impossible.

Maintenance (Asset) Management Structure

The structure of the maintenance (asset) management function can best be compared to a pyramid (see Figure 2-2). In this figure, it is apparent that a foundation must be in place to build the maintenance management process. The basics of preventive maintenance must be in place for any other part of the process to be successful. Once the PM foundation is in place, stores, work flow, CMMS/EAM, and training form the next level. The operational involve-

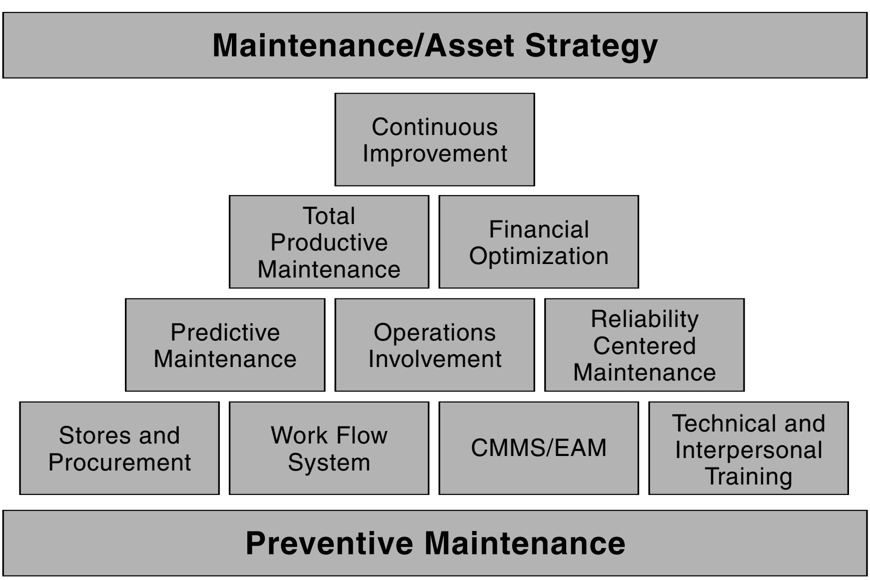


Figure 2.2

ment, along with predictive and RCM techniques, build on this foundation, with a focus on equipment availability.. With sufficient data, the organization can focus on its asset strategy in TPM and optimize its financials, which both focus on equipment effectiveness. Once that level is achieved, all that is left is the continuous improvement loop of self-evaluation and benchmarking.

Many companies are taking advantage of the competitive position that achieving Best Practice maintenance (asset) management can bring to their market. However, how does a corporation begin to improve the maintenance management process? The following discussion suggests a flow for companies beginning to develop their own maintenance/asset management strategies.

MAINTENANCE MANAGEMENT DECISION TREE

Good, sound maintenance practices are essential for effective maintenance management. But what exactly are "good, sound maintenance practices?" This section explains the Maintenance Management Implementation Decision Tree" designed to help develop a best practice" maintenance management process (see Figure 2-3). The practices described in this decision tree are intended to serve as a general model to guide the maintenance management development process. The pyramid (see Chapter 1) and the decision tree will subsequently be used to develop the performance indicators required to be effective in managing the maintenance process.

1. Develop the PM Program

Preventive maintenance is the core of any strategy to improve the equipment maintenance process. All plant equipment, including special back up or redundant equipment, must be covered by a complete, cost-effective preventive maintenance program. Such programs are designed to eliminate all unplanned equipment failures.

2. Evaluate the PM Program

The preventive maintenance program should be evaluated to insure proper coverage of the critical equipment of the plant or facility. The program should include a good cross section of inspections, adjustments, lubrication, and proactive replacements of worn components. The goal of the program is to insure there will be no unplanned equipment downtime.

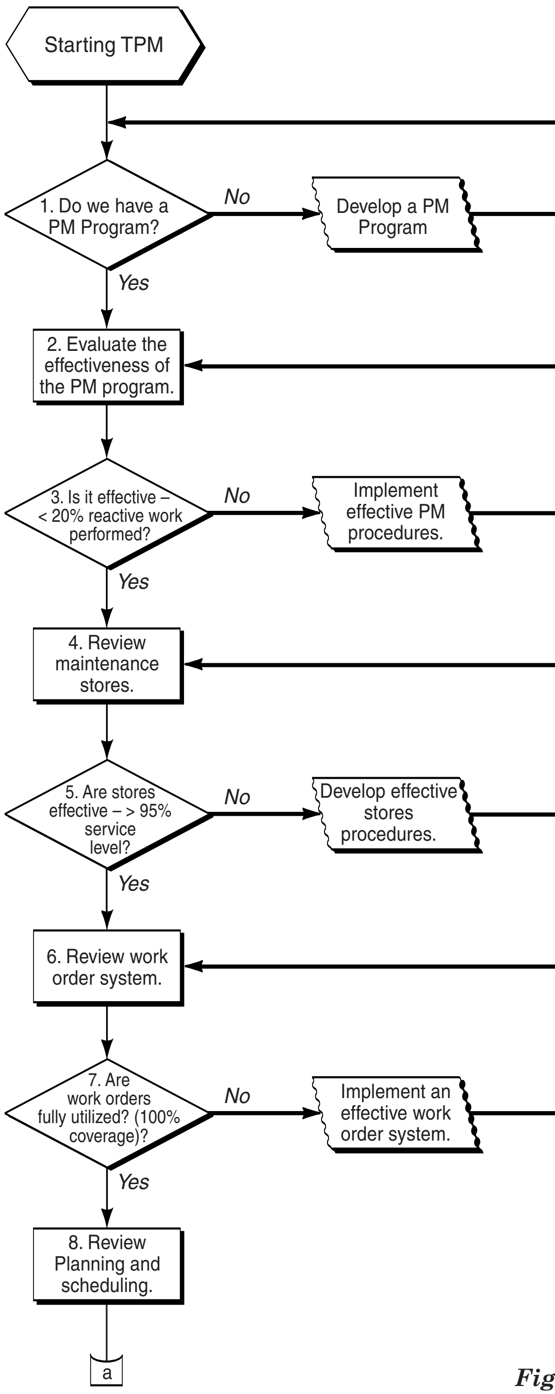

Starting TPM
1. Do we have a PM Program?
No
Develop a PM Program
Yes
2. Evaluate the effectiveness of the PM program.
3. Is it effective – < 20% reactive work performed?
No
Implement effective PM procedures.
Yes
4. Review maintenance stores.
5. Are stores effective – > 95% service level?
No
Develop effective stores procedures.
Yes
6. Review work order system.
7. Are work orders fully utilized? (100% coverage)?
No
Implement an effective work order system.
Yes
8. Review Planning and scheduling.
a

Figure 2.3a

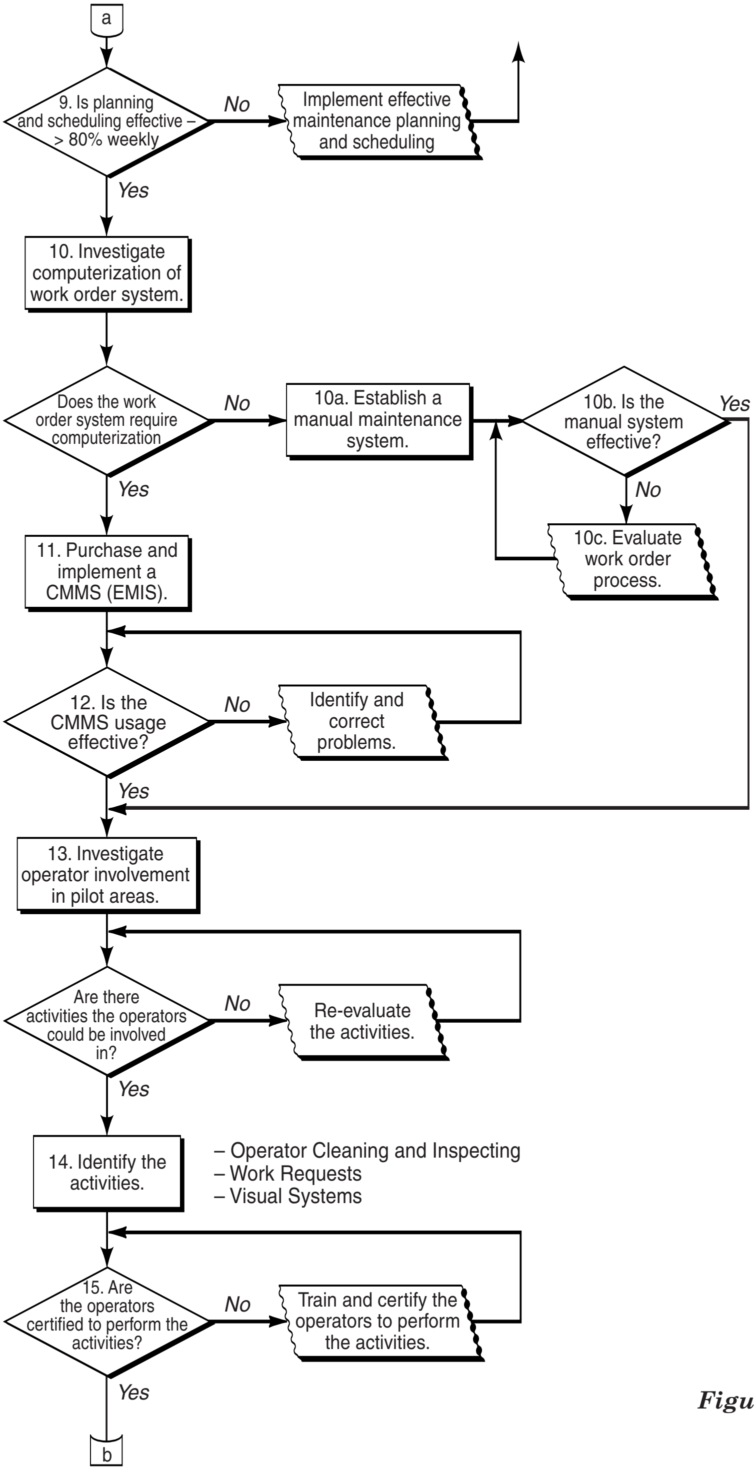

a
9. Is planning and scheduling effective – > 80% weekly
No
Implement effective maintenance planning and scheduling
Yes
10. Investigate computerization of work order system.
Does the work order system require computerization
No
10a. Establish a manual maintenance system.
10b. Is the manual system effective?
Yes
No
10c. Evaluate work order process.
Yes
11. Purchase and implement a CMMS (EMIS).
12. Is the CMMS usage effective?
No
Identify and correct problems.
Yes
13. Investigate operator involvement in pilot areas.
Are there activities the operators could be involved in?
No
Re-evaluate the activities.
Yes
14. Identify the activities.
– Operator Cleaning and Inspecting
– Work Requests
– Visual Systems
15. Are the operators certified to perform the activities?
No
Train and certify the operators to perform the activities.
Yes
b

Figure 2.3b

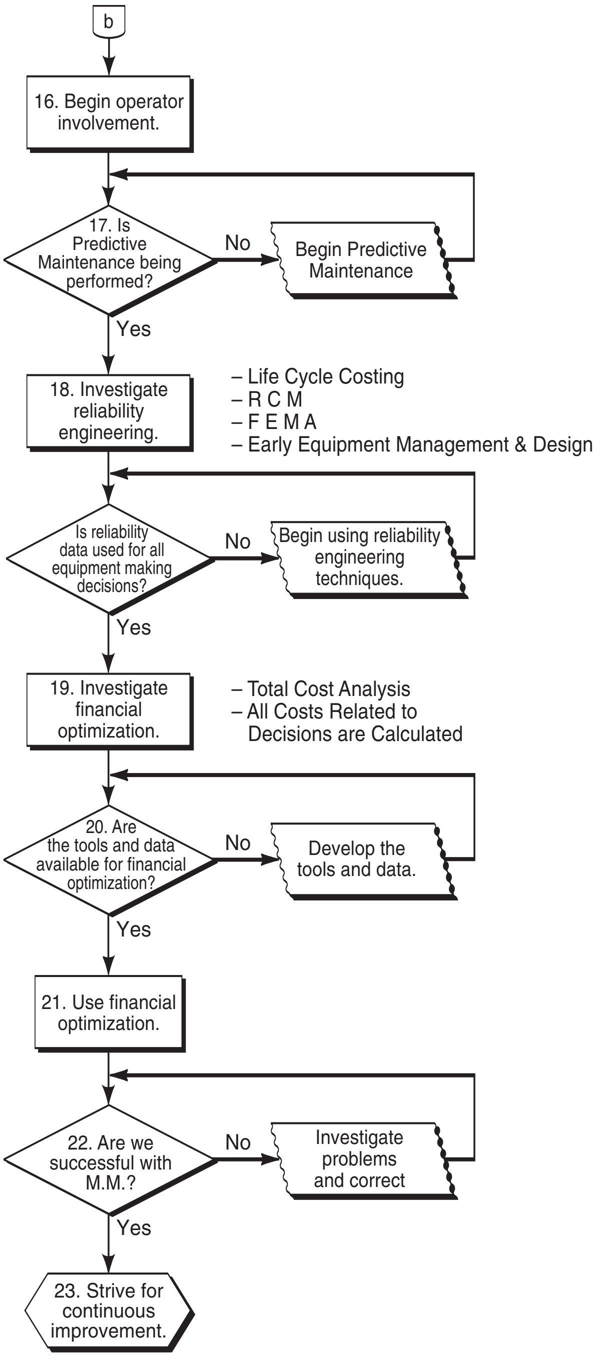

b
16. Begin operator involvement.
17. Is Predictive Maintenance being performed?
No
Begin Predictive Maintenance
Yes
18. Investigate reliability engineering.
– Life Cycle Costing
– R C M
– F E M A
– Early Equipment Management & Design
Is reliability data used for all equipment making decisions?
No
Begin using reliability engineering techniques.
Yes
19. Investigate financial optimization.
– Total Cost Analysis
– All Costs Related to Decisions are Calculated
20. Are the tools and data available for financial optimization?
No
Develop the tools and data.
Yes
21. Use financial optimization.
22. Are we successful with M.M.?
No
Investigate problems and correct
Yes
23. Strive for continuous improvement.

Figure 2.3c

3. Is PM Effective? (<20% Reactive Work Performed?)

The effectiveness of the preventive maintenance program is determined by the level of unplanned equipment maintenance that is performed. Unplanned equipment maintenance, which is defined as any maintenance activity that is performed with less than one week of advanced planning, is commonly referred to as reactive maintenance.

An effective PM program will reduce the amount of unplanned work to less than 20% of the total labor expended for all equipment maintenance activities. If more time is being spent on unplanned activities, then a reevaluation of the preventive maintenance program is required. It will be difficult to make progress in any of the following areas unless the PM program is effective enough for the equipment maintenance to meet the 80%/20% rule.

4. Review the Maintenance Stores

After the preventive maintenance program is effective, the equipment spares, stores, and purchasing systems must be analyzed. The equipment spares and stores should be organized, with all of the spares identified, tagged, and stored in an identified location, with accurate on-hand and usage data. The purchasing system must allow for procurement of all necessary spare parts to meet the maintenance schedules. All data necessary to track the cost and usage of all spare parts must be complete and accurate.

5. Are the Stores Effective? (> 95% Service Level)

The service level measures what percent of the time a part is in stock when it is requested. Spare parts must be on hand at least 95% of the time for the stores and purchasing systems to support equipment maintenance activities. On the other hand, unless maintenance activities are proactive (less than 20% unplanned weekly), it will be impossible for the stores and purchasing groups to be cost effective in meeting equipment maintenance spare parts demands.

6. Review the Work Order System

The work order system is designed to track all equipment maintenance activities. The activities can be anything from inspections and adjustments to major overhauls. Any maintenance that is performed without being recorded in the work order system is lost. Lost or unrecorded data makes it impossible to perform any analysis of equipment problems. All activities performed on equipment must be recorded to a work order by the responsible individual.

Thus, maintenance, operations, and engineering will be extremely involved in utilizing work orders.

7. Are Work Orders Fully Utilized? (100% Coverage)

This question should be answered by performing an evaluation of the equipment maintenance data. The evaluation may be as simple as answering the following questions:

How complete is the data?
How accurate is the data?
How timely is the data?
How usable is the data?

Complete data is necessary for performing any meaningful analysis of the equipment's historical and current condition. Accurate data is needed to correctly identify the root cause of any equipment problems. Timely data is needed to correct equipment problems before they cause equipment failures. Data that is not usable cannot be formatted in a manner that allows for any meaningful analysis. Unless the work order system provides data that passes this evaluation, further progress is impossible.

8. Review Planning and Scheduling

This review examines the equipment maintenance planning and scheduling policies and practices. The goal of planning and scheduling is to optimize any resources expended on equipment maintenance activities, while minimizing the interruption the activities have on the production schedule. Equipment maintenance activities must occur like a pit stop in a NASCAR race, insuring optimum equipment uptime, with quality equipment maintenance activities being performed. Planning and scheduling pull together all of these activities (maintenance, operations, and engineering) and focus them on obtaining maximum (quality) results in minimum time.

9. Are Planning and Scheduling Effective? (>80% Weekly)

Although this question is similar to that asked in step 3, the focus is on the effectiveness of the activities performed in the 80% planned mode. An effective planning and scheduling program will insure maximum productivity of the employees performing any equipment maintenance activities. Delays, such as waiting on or looking for parts, rental equipment, equipment to be shut down, drawings, or tools, will all be eliminated. If these delays are not eliminated through planning and scheduling, then it will be impossible to optimize equipment utilization. These inefficiencies will be the same as a NASCAR pit crew taking too long for a pit stop; the race is lost by not keeping the car on the track. Similarly, the equipment utilization is lost by not properly keeping the equipment in service.

10. Investigate the Computerization of the Work Order System

A considerable volume of data must be generated and tracked to properly utilize the work order system and to effectively plan and schedule. If the data becomes difficult to manage using manual methods, or if the workforce is burdened with excessive paper work and is accumulating file cabinets of equipment data that no one has time to look at, it is best to computerize the work order system. If, however, the number of pieces of equipment is relatively small, and data tracking and analysis are not a burden, then it may be best to keep the manual work order system.

10a. Establish a Manual Equipment Maintenance System

A manual system can be a simple as a card file with cards for each equipment item, with notations of all repairs and services on the cards. Other methods include a visual white board with markers and spaces for notations, a magnetic board with tags that can be moved as each service is complete, and a log book, which may be a three-ring notebook, with pages for notations of each service or repair that is performed on the equipment. The method does not matter as long as the equipment data is complete and in a format that can be analyzed.

10b. Is the Manual System Effective?

The manual system should meet the equipment management information requirements of the organization. Some of the requirements include complete tracking of all repairs and service, and the ability to develop reports such as top ten equipment problems, most costly equipment to maintain, percent reactive vs. proactive maintenance, and cost tracking of all parts and costs. If the manual system does not produce this level of data, then it needs to be re-evaluated. (If the system is effective, then go to Step 13.

10c. Evaluate the Work Order Process

The reevaluation of the manual work order system tries to determine where the weaknesses are in the system so that they can be corrected and good equipment data can be collected. Several questions for consideration include:

Is the data we are collecting complete and accurate?

Is the data collection effort burdening the work force?

Do we need to change the methods we use to manage the data?

Do we need to reevaluate the computerization decision?

Once problems are corrected and the equipment management information system is working, then constant monitoring for problems and solutions must be put into effect. (Go to Step 13.)

11. Purchase and Implement a CMMS or EAM System

The computerized maintenance management system (CMMS) [Enterprise Asset Management (EAM)] is a computerized version of a manual system. Currently over 200 commercially-produced CMMS/EAMs are in the North American market. Finding the correct one may take some time, but through the use of lists, surveys, and word of mouth, not more than three to six months. for any organization to select a CMMS/EAM system. When the right CMMS/EAM system is selected, it must then be implemented. CMMS/EAM system implementation may take from three months for smaller organizations to as long as 18 months for large organizations.

Companies can spend much time and energy selecting and implementing a CMMS/EAM system. Remember that CMMS/EAM system is only a tool to be used in the improvement process; it is not the goal of the process. Losing sight of this fact can curtail the effectiveness of any organization's path to continuous improvement.

12. Is the CMMS Usage Effective?

If the correct CMMS is selected, then equipment data collection is faster and easier. Analysis of the data should also be faster and easier. The CMMS should help enforce world class maintenance disciplines such as planning and scheduling, and effective stores controls. The CMMS should provide employees with usable data with which to make equipment management decisions. If the CMMS is not improving these efforts, then its usage needs to be evaluated. Some of the problems encountered with CMMS include:

Failure to fully implement the CMMS
Incomplete utilization of the CMMS
Inaccurate data input into the CMMS
Failure to use the data once it is in the CMMS

13. Investigate Operational Involvement

As the equipment management system becomes effective, it is time to investigate whether operator involvement is possible in some of the equipment management activities. Many issues need to be explored, from the types of equipment being operated, the operators-to-equipment ratios, and the skill levels of the operators to contractual issues with the employees' union. In most cases, there will be some level of activity at which the operators can be involved within their areas. If there are no obvious activities for operator involvement, then a reevaluation of the activities will be necessary.

14. Identify the Activities

The operators may be involved in basic or complex activities. The activity is partially determined by their current operational job requirements. Some of the more common tasks for operators include:

Equipment Cleaning. This task may involve simply wiping off equipment when starting it up or shutting it down.

Equipment Inspecting. This task may range from a visual inspection while wiping down equipment to a maintenance inspections check list used when making operational checks.

Initiating Work Requests. Operators may make out work requests for any problems (either current or developing) on their equipment. They then pass these requests to maintenance for entry into the work order system. Some operators will directly input work requests into a CMMS.

Visual Systems. Operators may use visual control techniques to inspect and determine the condition of their equipment.

Whatever the level of operator involvement, it should contribute to the improvement of the equipment effectiveness.

15. Are the Operators Certified to Perform the Activities?

Once the operator activities have been determined, their ability to perform these activities must be examined. The operators should be properly trained to perform any assigned tasks. Their training should be developed in a written and visual format. Copies of the training materials should be given to the operators for their future reference. This will contribute to the standardization required for operators to be effective while performing these tasks. Note that certain regulatory organizations (e.g., OSHA and EPA) require documented and certified training for all employees in areas such as Lock Out Tag Out.

16. Begin Operational Involvement

Once the operators are trained and certified, they can begin performing their newly assigned tasks. It is important for the operators to be coached for a short time to insure they have the full understanding of the hows and whys of the new tasks. Some companies have made this coaching more effective by having the maintenance personnel assist with it. In this way, background knowledge can be transferred to the operators that they may not have gotten during the training.

17. Is Predictive Maintenance Being Performed?

Once the operators have begun performing some of their new tasks, some maintenance resources may be available for other activities. One area that should be explored is predictive maintenance. Some fundamental predictive maintenance techniques include vibration analysis, oil analysis, thermography, and sonics.

Plant equipment should be examined to see if any of these techniques will help reduce downtime and improve service. Predictive technologies should not be utilized just because they are technically advanced, but only when they contribute to improving the equipment effectiveness. The correct technology should be used to monitor and solve the equipment problems encountered.

18. Investigate Reliability Engineering

Reliability Engineering is a broad term that includes many engineering tools and techniques. Some common tools are:

Life Cycle Costing. This technique allows companies to know the cost of their equipment from the time it was designed to the time of its disposal.

RCM. Reliability-Centered Maintenance is used to track the types of maintenance activities performed on equipment to insure that they are the correct activities.

FEMA. Failure and Effects Mode Analysis examines the way the equipment is operated and any failures incurred during its operation to find methods of eliminating or reducing the numbers of failures in the future.

Early Equipment Management and Design. This technique takes information about equipment and feeds it back into the design process to insure that any new equipment is designed for maintain ability and operability.

These and other reliability engineering techniques improve equipment performance and reliability help to insure competitiveness.

19. Investigate Financial Optimization

Once the equipment is correctly engineered, the next step is to understand how the equipment or process impacts the financial aspects of the company's business. Financial optimization considers all costs impacted when equipment decisions are made. For example, when calculating the timing to perform a preventive maintenance task, is the cost of lost production or downtime considered? Are wasted energy costs considered when cleaning heat exchangers or coolers? In this step, the equipment data collected by the company is examined in the context of the financial impact it has on profitability.

20. Are the Tools and the Data Available for Financial Optimization?

Although financial optimization is not a new technique, most companies do not properly utilize it because they do not have the data necessary to make it effective. Some of the data required includes:

MTBF (Mean Time Between Failure) for the equipment
MTTR.(Mean Time To Repair) for the equipment
Downtime or lost production costs per hour
A Pareto of the failure causes for the equipment
Initial cost of the equipment
Replacement costs for the equipment
A complete and accurate work order history for the equipment

Without this data, financial optimization can not be properly conducted on equipment. Without the information systems in place to collect this data, a company will never have the accurate data necessary to perform financial optimization.

21. Use Financial Optimization

If the data exists and the information systems are in place to continue to collect the data, then financial optimization should be utilized. With this tool, equipment teams will be able to financially manage their equipment and processes.

22. Evaluate the Success of the Maintenance Management Program

Are the results achieved by maintenance reaching the goals that were set for the improvement program when it was started? If they are not, then the maintenance improvement program needs to be examined for gaps in performance or deficiencies in existing parts of the process. Once weaknesses are found, then steps should be taken to correct or improve these areas.

23. Strive for Continuous Improvement

Continuous improvement means never getting complacent. It is the constant self-examination with the focus on how to become the best in the world at the company's business.

Remember:

Yesterday's Excellence
is
Today's Standard
and
Tomorrow's Mediocrity

Introduction to Functional Performance Indicators

A function is defined as the activities assigned to, required of, and expected of a person or department. Functional indicators derive their name from the word function. These indicators show how the function is performing. Earlier, this chapter discussed the functions of the traditional maintenance organization. To review, the following is a list of functions required by most maintenance departments.

Preventive Maintenance
Stores and Procurement
Work Flow Systems
Computerized Maintenance Management Systems (CMMS) and
Enterprise Asset Management (EAM) Systems

Technical and Interpersonal Training
Predictive Maintenance
Operational Involvement
Reliability-Centered Maintenance (RCM)
Total Productive Maintenance (TPM)
Statistical Financial Optimization
Continuous Improvement

Chapters 3 through 13 highlight the 11 main functions of maintenance management. Each chapter begins with a brief overview of the function, followed by common performance indicators used for each function. The strengths and weaknesses of each indicator will be presented. The last section in each chapter covers the eight most common problems leading to low indicators in the function with suggested solutions to each problem.

CHAPTER 3

Preventive Maintenance

Preventive Maintenance is the foundation of the entire maintenance philosophy. Unless the PM program is effective, all subsequent maintenance activities will be sub-optimized.

In short:

Unless the PM program is successful, nothing else will be.

How can the success of the PM program be determined? The following indicators can be applied to the preventive maintenance program. Each indicator has its strength and weakness.

1. Equipment Downtime Caused by Breakdowns

The first indicator highlights the impact the preventive maintenance program has on the plant or facility. It focuses on what the PM program is designed to eliminate: equipment breakdowns.

$$\frac{\text{Downtime Caused by Breakdowns}}{\text{Total Downtime}} \qquad \text{expressed as a \%}$$

This indicator takes the total downtime caused by the breakdown of a piece of equipment, a department, an area, or even an entire plant or facility, and examines it in the context of all downtime. It may be common at some plants or facilities to refer to breakdowns as unplanned downtime. Total downtime represents all lost time, whether due to maintenance, operations, purchasing, transportation, or even an external supplier.

Strengths

This indicator identifies whether the breakdown or unplanned downtime is actually a problem at the plant or facility. It may be that downtime is caused by another problem, rather than the preventive maintenance program.

Weaknesses

This indicator's largest weakness is the proper classification of downtime and the accurate record keeping required. Downtime must be closely tracked and categorized. If an equipment-related breakdown is not closely tracked, then the time the operator is taking a break, procuring raw materials, or even eating lunch may be included in the breakdown time. Such tracking inflates the downtime and obscures other problems. Unless accurate records are kept, the breakdown downtime becomes a "catch all" and is not useful as a management tool.

2. Emergency Man Hours

This indicator highlights the resources being allocated to plant or facility breakdowns. When the level of resource consumption for emergency or breakdown activities is high, then the productivity rates for the labor resources, whether in-house or contract, is low. This indicator may be used at a department, area, or even a plant level. It may be used to examine resources by trade or craft line.

This indicator is also useful for examining work distribution. A typical distribution would examine the resources used in at least four categories:

Preventive maintenance
Emergency or breakdown maintenance
Repair or corrective maintenance
Routine (or standing) maintenance

$$\frac{\text{Manhours Spent on Emergency Jobs}}{\text{Total Manhours Worked}} \quad \text{expressed as a \%}$$

This indicator takes the time spent on emergency or breakdown work and divides it by the total man hours expended. The indicator, which is then expressed as a percentage, should examine total resources, not just maintenance. If there are operators or contractors involved, their time should be included as well.

Strengths

This indicator is useful for examining if maintenance labor is being consumed by emergency or breakdown work. Typically, if the amount of emergency or breakdown work consumes more than 20% of the maintenance labor resource, then the preventive maintenance program is viewed as ineffective. Therefore, this indicator becomes a key to PM program evaluation.

Weaknesses

This indicator, like almost all others, is dependent on accurate data collection. Without accuracy, a problem with the preventive maintenance may go undetected. Additionally, what is classified as an emergency or breakdown may need clarification.

3. Cost of Breakdown Repairs

This indicator examines breakdowns in yet another way: the direct cost of breakdowns and emergency repairs. This figure includes the cost of the labor, materials, rental equipment, contractors, and any other direct maintenance cost. However, the cost of lost production (or throughput) should not be included in this calculation. The figure is then divided by the total maintenance cost and a percentage is derived. This indicator can again be calculated at different levels: the maintenance department level, a trade or craft level, a production department or area level, or even the equipment level.

$$\frac{\text{Direct Cost of Breakdown Repairs*}}{\text{Total Direct Cost of Maintenance}}$$

This indicator is calculated by taking the direct cost of maintenance for all of the breakdown or emergency repairs and then dividing that cost by the total direct maintenance cost. The result is expressed as a percentage. Because the cost of performing maintenance in a reactive mode is considerably higher than the cost in a planned mode (by as much as two-to-four times), this indicator will not match the percentage in the previous indicator.

Strengths

This indicator highlights the impact that breakdown or emergency work is having on the maintenance budget. It can be used to cost justify improvements

Indicators marked with an (*) are expressed as a percentage

in the preventive maintenance program, when the percentage of maintenance dollars on breakdown or emergency activities is clearly shown.

Weaknesses

This indicator requires that all breakdown or emergency repairs be clearly identified. Even small activities, in the 5-to-10-minute range, must be clearly identified; otherwise, many costs will not be correctly identified. When the small activities are included, preventive maintenance problems are often exposed and then can easily be corrected.

4. Preventive Maintenance Compliance

This indicator examines the number of preventive maintenance tasks that are scheduled compared to the number of preventive maintenance tasks completed. Typically compiled on a weekly basis, it is useful for highlighting a preventive maintenance program that may be developed, but not effective. In this case, the effectiveness is hampered by failure to complete the tasks that are scheduled. The reason for this failure may be that production is overcommitted and will not release the equipment for maintenance, or the maintenance resources are overcommitted on breakdowns and emergency work and, therefore, do not have the capacity to complete the scheduled preventive maintenance tasks.

$$\frac{\text{Preventive Maintenance Tasks Completed*}}{\text{Preventive Maintenance Tasks Scheduled}}$$

This indicator takes the total number of preventive maintenance tasks completed (usually weekly) and divides them by the total number of preventive maintenance tasks scheduled. The result is then expressed as a percentage. Of course, the goal is to have 100% completion of the scheduled tasks. Although this number is not easily achieved, it should be the goal of all organizations. All preventive maintenance tasks, including tasks performed by maintenance, operations, or even contractors, should be factored in by this indicator.

Strengths

This indicator effectively measures the compliance an organization has with its preventive maintenance program. It is one of the key indicators for any preventive maintenance program. If the indicator is graphed weekly over a window of six months, it can be correlated with the percentage of maintenance activities that are breakdown or emergency. The graph will show that as completion rate goes up, the breakdowns and emergencies go down. Conversely, as the completion rate drops, the breakdowns and emergencies increase. If accurately tracked, the correlation is undeniable, and can be used to gain support for the preventive maintenance program.

Weaknesses

The weakness highlighted is not for the indicator, but for a type of preventive maintenance schedule that obscures or hides the fact that preventive maintenance tasks are not completed. This is the dynamic or sliding preventive maintenance schedule. The weakness is that the preventive maintenance task is based on last completion date, not on a fixed schedule or a usage counter. Therefore, if the task is not completed this month, it is not rescheduled until it is completed. There are actually cases where monthly tasks have not been completed for three to six months and they do not show up as late or overdue. No organization that is truly serious about its preventive maintenance program should ever use sliding or dynamic schedules.

5. Preventive Maintenance Estimates Compliance

This indicator compares the estimates of labor and materials costs for preventive maintenance tasks with the actual costs to perform the tasks. This measure points to the accuracy of the estimates. If the estimates are inaccurate, then adjustments can be made so that accuracy can be insured. Accuracy is particularly vital when the maintenance organization is using a scheduling system that is integrated with the production scheduling system. Inaccuracies in such a system will have dramatic negative consequences over time.

$$\frac{\text{Estimated PM Task Costs*}}{\text{Actual PM Task Costs}}$$

The indicator is calculated by dividing the estimated cost by the actual cost, with the result expressed as a percentage. A caution must be highlighted: this indicator should not be measured over a small window of time. On occasion, it is possible for a task to exceed the estimated cost due to exposed problems. However, if this analysis is performed on a semi-annual or annual basis, the results should provide a good indication of the accuracy of the estimates.

Strengths

The strengths of this indicator include the ability to effectively monitor the accuracy of the preventive maintenance task estimates. If the accuracy of the individual estimates are not constantly monitored, then the overall accuracy of the estimated labor and materials required to perform the preventive maintenance tasks will be inaccurate, leading to budgetary problems.

Weaknesses

The biggest weakness of this indicator is the problem of charging non-preventive maintenance tasks to the preventive maintenance activities. For example, if a problem uncovered during the performance of the task is corrected while performing the task, how is the additional labor and material charge billed? If the actual charges, which are repairs, are charged to the preventive maintenance work order, then the estimate is exceeded and the integrity of the estimate is in question. It is a good practice to complete the repair and then charge the costs to a new work order written to identify the work that was actually performed.

6. Breakdowns Caused by Poor PMs

This indicator examines the root causes of breakdowns and then investigates whether those causes should have been detected as part of the preventive maintenance program. This indicator evaluates both the effectiveness of the PM task and the thoroughness of the individual carrying out the task. For example, lubrication-related failures should not occur on equipment that is inspected and lubricated as part of the PM program. The breakdown indicates a failure of the program. Modifications to the task listing, the retraining of an individual, or the addition of some visual control technique may be required to insure that the failure is not repeated.

$$\frac{\text{Number of Breakdowns that Should Have Been Prevented*}}{\text{Total Number of Breakdowns}}$$

The measure compares the total number of breakdowns that could have been prevented or detected by the preventive maintenance program with the total number of breakdowns. The resulting percentage indicates the opportunity for improvement by upgrading or changing the preventive maintenance program. An additional driver for improvement can be uncovered if the losses incurred by the breakdowns (maintenance costs, equipment damage, downtime costs) are also included.

Strengths

This indicator, which is beneficial to any organization desiring to improve its PM program, provides an accurate insight into the effect that preventive maintenance is having on the equipment breakdowns. Monitoring this indicator helps to insure that the preventive maintenance policy is cost effective.

Weaknesses

This indicator's largest weakness is procedural. In other words, the organization must be committed to completing accurate and detailed root-cause analysis of equipment breakdowns. If the root cause is merely assumed or guessed, then the true effectiveness of the preventive maintenance program is obscured.

7. Preventive Maintenance Efficiency

This indicator examines the amount of work that is generated from the PM program. When carrying out the preventive maintenance inspection, the inspector will uncover components or systems showing signs of wear, or even an impending failure. The inspector will then write work orders to correct the problem before a breakdown occurs. These orders may involve adjustments, changing components, or even a major overhaul. Some work should be generated from the inspections and service; otherwise, the preventive maintenance tasks are probably being carried out too frequently.

$$\frac{\text{Total number of Work Orders generated from PM Inspections}}{\text{Total Number of Work Orders Generated}}$$

The formula shows that efficiency is measured by dividing the total number of work orders generated from the preventive maintenance program by the total number of work orders submitted. This measure is generally examined on a monthly basis, although other frequencies can be acceptable, depending on the inspection frequency. The resulting percentage will highlight whether the preventive maintenance program is effective in proactively finding developing equipment problems.

Strengths

This indicator is effective for preventive maintenance program evaluations. It is viewed as effective if the majority of the work orders submitted are found through the PM program. Although this may appear to be performing too much preventive maintenance, this fact will not be established until further factors are applied in the reliability-centered maintenance approach.

Weaknesses

This indicator can be misleading if excessive work is performed by the inspector while actually carrying out the preventive maintenance task. If, rather than writing a work order, the repairs are hidden in the preventive maintenance charges, the effectiveness of the inspections will be called into question. A second problem may be motivating individuals to fill out the necessary documentation to establish the data. If the inspectors would rather do the task than write up a work order, the amount of work discovered by the PM program is hidden. Another factor may be the lack of good inspection skills. Do the inspectors really know how to inspect, what to look for, and how to find true root causes? These questions can be resolved by good testing and training of the inspectors.

8. Equipment Uptime

This indicator highlights the amount of uptime that is required for the equipment to meet the production forecasts. In a sold-out market condition, the required uptime may be 100%. However, if the equipment is required 100% of the time because the plant has to continually make up production losses caused by unreliable equipment, then the desired uptime may change as the PM program becomes more effective. Requiring 100% uptime makes it difficult to perform the right level of maintenance on the equipment which, in turn, contributes to future problems. This indicator may help determine if the organization has a realistic expectation of the equipment output. If 100% is expected all of the time, then the organization's technical understanding and commitment to the longevity of its assets must be questioned.

$$\frac{\text{Desired Equipment Uptime} - \text{Downtime*}}{\text{Desired Equipment Uptime}}$$

The indicator is measured by first finding the desired uptime minus the downtime, then dividing by the desired uptime, and expressing the result as a percentage. Some organizations refer to this as availability. The percentage should be evaluated on a weekly or monthly basis and trended. A decrease in uptime indicates a problem with the PM program, possibly indicating a change in the life cycle phase of the equipment. It can also indicate a possible change in operational schedules, which severely impact calendar-based PM programs.

Strengths

This is a good indicator because ultimately the preventive maintenance program is designed to maximize uptime. Most of the information to calculate the uptime comes from the production or facilities groups. Using this calculation helps to insure their understanding and support of the PM program. This indicator may be superior to the one used previously because all downtime is included. This aspect will foster more departmental support for the indicator because any downtime related to causes within their control is also exposed, not just maintenance.

Weaknesses

The weakness to this indicator is that all causes of downtime are tracked and used in the calculation, whereas the previous indicator tracked just the maintenance-related downtime. This differentiation requires very accurate data so that the PM program does not get blamed for downtime it can not prevent.

9. Overdue PM Tasks

This indicator examines the number of preventive maintenance tasks that are not being completed on schedule. It is valuable for spotting trends where schedule compliance is beginning to slip. This indicator will forecast problems because once the schedule begins to slip, the breakdown or emergency requests will begin to rise in the near future. Paying attention to this indicator allows a proactive approach to managing the PM program. This indicator is most effective when monitored on a weekly basis and then trended over a rolling six-month time period.

$$\frac{\text{Number of PM's Overdue*}}{\text{Total number of PMs Outstanding}}$$

This indicator represents the number of preventive maintenance tasks that are past due divided by the number of preventive maintenance tasks currently in the active backlog. This measure gives an accurate representation of the level of effort required to keep the PM program in compliance. The goal, of course, is to keep this percentage as low as possible.

Strengths

This indicator is required for any company monitoring the progress of its preventive maintenance program. Without this indicator, there would be virtually no way to track the compliance status of the PM program.

Weaknesses

The only weakness of this indicator is the challenge of keeping the data accurate. Some organizations cancel preventive maintenance tasks so that they do not clutter the work order backlog. This practice is not recommended because it can alter the accuracy of the PM program compliance data. It is better to allow the problems to be exposed so that they can be corrected than it is to hide the problems by manipulating the work order data.

10. Percentage of Overtime

Although this indicator is not always a direct indicator of the PM program's effectiveness, it can still be helpful. In many organizations overtime is worked in response to equipment breakdowns or emergency work. High overtime rates can indicate the ineffectiveness of the PM program.

$$\frac{\text{Hours Worked as Overtime*}}{\text{Total Hours Worked}}$$

This indicator is derived by dividing the hours worked as overtime by the total hours worked. This percentage then shows the premium (overhead) time that is being used to perform work. Proactive maintenance organizations work 5% or less of their total time as premium time.

Strengths

This indicator will help managers monitor the amount of emergency or breakdown work that requires overtime to complete. This measure is important because the overtime requires a premium cost.

Weaknesses

Some organizations have developed a poor practice of working overtime rather than increasing personnel. This may obscure the amount of overtime worked that is due to a poor PM program.

Preventive Maintenance Program Problems

Figure 3-1 summarizes the most common disablers for preventive maintenance programs. If these conditions exist in an organization, it will be difficult, if not impossible for a sustainable preventive maintenance program to be implemented.

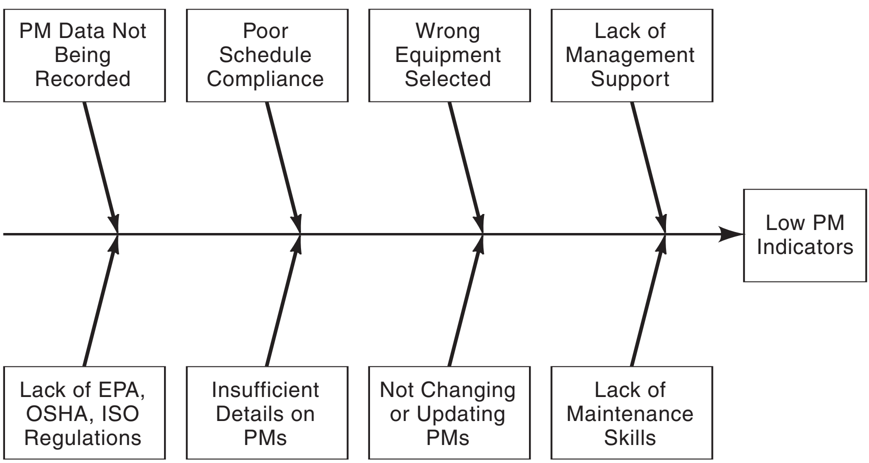


Figure 3-1 Preventive Maintenance Indicator Tree.

1. Lack of Management Support

Management support is the single most critical factor to the success or failure of a preventive maintenance program. If management is not committed to the PM program, it will fail. In turn, all other maintenance initiatives within an organization will be suboptimized.

While there is no magic answer to solving this problem, companies that have management support, obtain it with financial justification. Preventive maintenance can address many issues that affect a company's ability to remain profitable. Some of these include:

ISO,OSHA, EPA, and PSM

Most of the regulatory programs require equipment that is safe to operate and maintain, not hazardous to the environment, and able to hold specifications to produce a quality product.

Total Quality Management (TQM).

The support for this program is clearly seen in the ISO-9000 and QS-9000 program requirements for good preventive maintenance.

Just-In-Time (JIT).

Simply, it is impossible to produce products on an exacting schedule without reliable and maintainable equipment. It is also impossible to have reliable and maintainable equipment without an effective preventive maintenance program.

Customer Service Orientation.

A company cannot satisfy its customers by producing the lowest cost product, with perfect quality and timely delivery, unless it has a PM program to insure equipment reliability.

Capacity Constraints.

Preventive maintenance insures, not only uptime of the equipment, but also performance efficiency. Thus, when the equipment is operating, it produces at design capacity with the desired uptime; the company does not develop equipment-related capacity constraints.

Redundant Equipment.

Equipment that operates as designed and when it is required to oper ate reduces the need for redundant equipment that backs up unreliable equipment or that supplements the existing equipment capacity. In turn, the return on net assets indicator is kept at a best-practice level.

Energy Consumption.

Well-maintained equipment requires 6% to as much as 11% less energy to operate than poorly-maintained equipment. When a company considers the cost of heat exchangers, coolers, HVAC systems, steam leaks, and air leaks, it can quickly see the potential for considerable savings.

Usable Asset Life.

Well-maintained equipment lasts 30-to-40% longer than poorly-maintained equipment. Developing a "don't maintain, just replace" attitude with equipment can lead to unnecessary capital expenditures. Examine how often equipment is replaced in kind – no major upgrade in engineering or technology – just because it wore out. Is it possible that the purchase could have been deferred if proper preventive maintenance had been performed?

By examining these eight areas, it may be possible to convince the appropriate managers to provide the support necessary for a successful preventive maintenance program.

2. Lack of Maintenance Skills

This area is developing into one of the major problems facing preventive maintenance programs today. The skills necessary to inspect and perform basic maintenance tasks on equipment today seem to be deteriorating. These routine tasks include proper lubrication of bearings, using the right lubricant, the right quantity, and the right frequency, and selecting the right application method.

In many companies, basics such as these are virtually ignored. The problem compounds when proper installation and maintenance of basic components such as belts, chains, gears, pneumatic and hydraulic systems are considered. It does little, if any, good to schedule preventive maintenance activities, if they can not be carried out correctly.

The key to correcting this problem is training (see Chapter 7) and enforcement of the learned behavior. This means that the training will have to be made available to anyone required to operate or maintain the equipment. Once the training reaches critical mass, then peer pressure and the sense of equipment ownership will be required to assure that good practices are continued.

3. Wrong Equipment Selected

Selecting the wrong equipment can be a start-up problem for many preventive maintenance programs. When starting a preventive maintenance program, the mission-critical equipment should be selected. It is imperative that results be shown early in the PM program. The equipment selected should be constraint equipment (equipment causing a bottleneck) or equipment that has no backup and will severely impact production or availability of the facility if it incurs downtime.

This problem can be overcome by prioritizing the equipment when beginning the PM program. The equipment selected should meet the previously mentioned criteria. It may be best to poll different departments, managers, and shop floor personnel to insure support for the equipment selected is developed, thereby fostering organizational support for the preventive maintenance program.

4. Not Changing or Updating the PM Program

This problem develops after the preventive maintenance program has been in place for a time period. The program was probably once effective, but then the level of breakdowns and reactive maintenance started to increase. Even though the PM program is in compliance, results are diminishing.

This change may be due to the fact that the equipment is entering a different phase of its life cycle. Whatever may have been the right level of service and activities in the past, the equipment maintenance needs change as equipment ages. The preventive maintenance tasks should be re-evaluated in light of the current equipment problems. It may be that when the preventive maintenance tasks were developed, the daily, weekly, and monthly tasks were defined, but the service required at semiannual, annual, and biannual frequencies was never developed. Thus, components on the equipment may develop undetected problems and fail.

The preventive maintenance tasks must be evaluated in context with the long-term equipment needs, insuring that preventive maintenance occurs for the entire life cycle of the equipment.

5. Poor Schedule Compliance

Compliance problems occur for several reasons, but always impact the effectiveness of the PM program. When tasks are scheduled and not completed within the assigned time frame, the equipment begins to deteriorate. Although the equipment may not begin to fail immediately, it begins to develop multiple deteriorated components. The interaction of the worn component conditions begins to mask problems. Operating the equipment becomes more complicated, as it no longer stays in adjustment or holds specifications. The equipment no longer runs at design speed; the deterioration requires it to be slowed 10% or more, reducing its capacity. Troubleshooting the equipment also becomes more difficult as one problem leads to another. The equipment will require a rebuild to reach an acceptable baseline, where the preventive maintenance tasks will once again be effective.

The only cure is to fully dedicate the resources and provide the release time needed to keep the PM program in compliance. This cure may require management support because production schedules may have to be altered or, over time, may have to be authorized.

6. Insufficient Detail on PM Sheets

Insufficient detail is typically a start-up problem with the preventive maintenance program. Because the proper level of detail is not developed, items are missed on the preventive maintenance inspections or services. Some samples of poor detail include checking the motor to see if it is hot, checking the belt drive, and checking the chain drive.

These are examples of vague preventive maintenance inspections. For example, when checking the motor, how hot is hot? The task description should contain temperatures, pressure setting, flow values, and so forth.

Some may argue that that level of detail is expensive and time consuming. By itself, that statement is true. However, what does a missed inspection point cost when the equipment fails? The lack of PM inspection details allows for items to be overlooked or viewed incorrectly, this contributing to breakdowns and overall loss of preventive maintenance efficiency.

One of the greatest causes contributing to the lack of detail is the lack of resources during the initial development of the PM program. For example, how can the resources be calculated? The following information illustrates one approach:

Number of equipment items	1,000
Average number of PMs per item	X3
Total PMs required	3,000
Average 1 hour per PM	
For development	X 1
Total man hours required	3,000 or 1.5 man years of effort

Because most companies do not allocate this level of resource, the preventive maintenance tasks are only partially developed, with the hope of going back someday and finishing the development. But in most organizations, this never happens and the preventive maintenance program is ineffective.

The only solution is to dedicate the resources necessary to develop the task details initially. Then the company will realize the full benefits of preventive maintenance.

7. PM Data Not Being Recorded

Sometimes after the preventive maintenance program is implemented and the completed inspections are turned in for processing, the inspections are never reviewed and the notations are not permanently documented. This problem usually occurs because there are no resources to transfer the inspection results to a database so they can be analyzed. Therefore, the comments made by the inspectors are lost and any subsequent work that was to be requested and performed is also lost. This problem prevents evaluation of the PM program's results and effectiveness. In turn, the PM program will deteriorate as the equipment ages, unable to meet the equipment's changing needs.

The lack of data gather is also commonly caused by the lack of an easy-to-use computerized maintenance management system. Give scarce resources, any CMMS used to manage data must make it easy to input and analyze that data.

This problem has a two-part solution. First, the correct staffing level must be determined, based on the amount of data collection and analysis the organization is performing. When the department is understaffed, data accuracy ultimately suffers and what is collected is of no value. Once the correct staffing level is provided, the organization should plan to utilize the most effective CMMS it can afford. This step reduces the amount of frustration that employees would otherwise have if they had to record and analyze data on antiquated software.

8. Lack of Understanding of EPA, OSHA, and ISO Regulations

This problem stems from a lack of education and the discipline to carry out data recording based on that education. The regulatory requirements for maintenance organizations are complex and require extensive training to accurately understand. However, most maintenance management positions are high-turnover positions, with newer and younger replacements regularly being hired.

This problem places the company under tremendous pressure. If the preventive maintenance is not carried out on the equipment, the company may be in violation of a regulatory standard. However, the maintenance manager may not even have a good understanding of which preventive maintenance activities require priority. This leads to compliance issues and ultimately a failure of the preventive maintenance program.

The only solution to this problem is effective education for the maintenance supervisors about regulatory requirements and then the ability to enforce the requirements for collecting the data and keeping the company equipment in compliance.

CHAPTER 4

Stores and Procurement

Maintenance materials is the largest maintenance support function contributing to low maintenance efficiency and effectiveness; it subsequently becomes one of the largest root causes of equipment downtime and capacity losses. MRO (Maintenance, Repair and Overhaul) spare parts account for an average of 50% of the maintenance budget It is the second most important function in maintenance (first being preventive maintenance) management. Therefore, it is essential to examine performance indicators that will insure proper management of the stores and procurement functions for maintenance

1. Inactive Stock Showing No Movement in the Last 12 Months

This indicator is used to find spare parts that are no longer needed. These items may have been purchased as spare parts for equipment that is no longer in the plant. Occasionally items were purchased in large quantities on a one-time basis, possibly for construction or a project, but were not used and have no further use at the plant or facility. Eliminating these items reduces the inventory value and the subsequent holding cost the company must pay.

$$\frac{\text{Inactive Stock Line Items*}}{\text{Total Stock Line Items}}$$

As seen by the formula, this indicator measures the number of line items that are inactive divided by the total number of line items carried in the inventory. The percentage shows the opportunity for improvement by eliminating line items from the store inventory.

A second way the indicator can be used is to divide the dollar value of the inactive stock items by the total inventory valuation. This percentage would give the percentage of value that it would be possible to achieve through inventory reduction.

Strengths

This indicator is useful for highlighting opportunities to reduce the overall inventory valuation. In companies where equipment and processes are rapidly outdated by technology changes, this indicator is critical to monitor.

Weaknesses

The weakness of this indicator is that it doesn't differentiate between a disposable spare and one that is kept on hand due to lead time and delivery issues. Some equipment spares are kept in stock because the equipment is produced in another country and the lead time to obtain a spare may be months or even a year. In these instances, keeping the spare is wise, even if it doesn't move for several years

Any time this indicator is used to highlight items for possible removal from inventory, careful research should be made to insure that the part does not have a long lead time nor that it is difficult to obtain the spare part. Parts should never be arbitrarily removed from inventory.

2. Stores Annual Turns (Dollar Amount)

This indicator is used to determine the number of times in a year the dollar value of the stores inventory is actually used. While there are some spare parts that will not be used in a year, many will show numerous turns in a year. This indicator compares the dollar value of the issued items to the total inventory valuation

This indicator is a widely-accepted benchmark for maintenance stores. The average for companies in the United States is from 1 to 1.2 turns per year. Organizations that practice advanced strategic supplier techniques, are working to raise the number much higher. However, many organizations are still below 1 turn per year.

$$\frac{\text{Total Annual Dollar Amount of Stores Usage}}{\text{Total Inventory Valuation}} \qquad \text{Expressed as a decimal number}$$

The measure clearly shows the total annual dollar amount of stores usage is divided by the total dollar value of the inventory. The result is not expressed as a percentage, but rather as a decimal number. It provides the commonly-used number of turns indicator.

Strengths

This indicator is almost an industry standard as a benchmark. It clearly shows whether a company has too large an inventory (in dollars). The indicator can be used to compare different organizations because the inventory goal is similar for almost all organizations.

Weaknesses

This indicator's greatest weakness is that companies owning a lot of foreign-made equipment will tend to have lower numbers. If the items are arbitrarily removed from inventory to meet some benchmark number, the company may experience a large increase in downtime and a subsequent large decrease in capacity. This indicator must be used carefully

3. Percentage of Spare Parts Controlled

This indicator highlights the uncontrolled spare parts within a company. In most cases, reactive maintenance organizations tend to develop personal or pirated stores. These spares are never tracked, yet the company paid for them In many cases, the stores personnel may be re-ordering items when they already are in the plant in several untracked locations. The goal is to have all spare part in a controlled stores to insure cost effective inventory policies.

$$\frac{\text{Total Dollar Value of Maintenance Spare Parts in a Controlled Stores Location*}}{\text{Total Inventory on Hand (Estimated Controlled + Uncontrolled)}}$$

As the formula shows, this indicator is the dollar value of all controlled stores items divided by the estimated dollar value of all spare parts. The total value must almost always be estimated, since the actual cost is rarely available. The result is expressed as a percentage. The closer this measure is to 100%, the better are the inventory policies a company is utilizing. In addition, the indicator tends to be lower when the maintenance organization is reactive, driving many expedited orders

Strengths

The strength of this indicator is that it accurately represents the level of financial control the inventory and procurement departments have over the maintenance spare part value.

Weaknesses

The indicator's greatest weakness is that it is hard to calculate. In most companies, it is difficult (if not impossible) to calculate the value of all of the open storage locations and personal storage locations

4. Service Level of the Stores

This indicator shows the percentage of time that the stores department was able to fill maintenance requests for spare parts. This indicator is becoming a standard benchmark to compare stores performance. Higher percentages reflect better performances of the stores and purchasing groups in meeting their customers' needs

$$\frac{\text{Total Number of Orders Filled on Demand}}{\text{Total Number of Orders Requested}}$$

The indicator represents the total number of orders filled on demand divided by the total number of orders requested. The result is expressed as a percentage. The benchmark value for this indicator is between 95% and 97%. Any performance lower than 95% will contribute to delays in work execution and lead to individuals developing their own storage areas. Values higher than 97% suggest that the store is carrying too many spare parts

Strengths

This indicator is an accepted measure of stores performance and allows for a fair comparison of stores functions between companies. It has the benefit of being accepted internationally. It has little opportunity for error in its calculation, providing the input data is accurate

Weaknesses

The largest weakness for this indicator is the opportunity to make an error on the timing of a stock out The questions that must be asked are: When is the stock out registered? Does it have an impact on the service level? Is it a stock out when the job is being planned that the part is not in stock or is it when an individual goes to the store room counter and requests the part? When the indicator is calculated at issue time, the percentage should be higher than when at the time of planning If a company counts the stock out at the time of planning and still has a 95 to 97% service level, it is likely they have too large an inventory.

5. Stock Outs

Stock outs are the inverse of service level. The stock out indicator represents the number of times the order could not be filled. It too is a widely-accepted indicator. The service level indicator seems to appeal more to customer service oriented organizations, whereas the stock out indicator seems to be used by organizations with a more technical focus. In reality, it doesn't matter which indicator an organization utilizes; they both measure basically the same thing.

$$\frac{\text{Total Number of Items Not Filled on Demand*}}{\text{Total Number of Items Requested}}$$

The formula measures the total number of items were not filled on demand divided by the total number of items requested. The result is then presented as a percentage. The goal is a 3% to 5% stock out percentage. As with the service level indicator, if the number is too small, then too much inventory is carried. If the number is too large, then delays in work will be experienced.

Strengths

This indicator is an accepted measure of stores performance and allows for a fair comparison of stores functions between companies. It has the benefit of being accepted internationally. The indicator has little opportunity for error in the calculation, providing accurate data exists.

Weaknesses

The largest weakness for this indicator is the opportunity to make an error on the timing of a stock out. The questions that must be asked are: When is the stock out registered? Is it registered when the job is being planned and the part is not in stock or when an individual goes to the store room counter and requests the part?

When the indicator is calculated at issue time, the number should be lower than if it is calculated at the time of planning. If a company counts the stock out at the time of planning and still has a 3% to 5% stock out level, it is likely they have too large an inventory.

6. Percentage of Rush Purchase Orders

This indicator highlights the amount of reactive ordering that occurs to fill customer orders. A maintenance organization that is reactive drives the ratio of rush purchase orders to a higher level. However, if the maintenance organization is more proactive and the percentage of rush purchase orders is high, then the stores and purchasing function is trying to hold too few spare parts.

$$\frac{\text{Total Number of Rush Purchase Orders*}}{\text{Total Number of Purchase Orders}}$$

As the formula indicates, the number of rush purchase orders is divided by the total numbers of purchase orders. The result is expressed as a percentage Higher percentages indicate a more reactive purchasing function, which will impact the organization with increased expediting costs and a higher rate of downtime. The lower the percentage, the more managed and proactive is the purchasing function, which will allow for planned purchases and consolidated purchase orders, further reducing the overall cost of the inventory

Strengths

This indicator is useful when examining the cost to process purchase orders The goal is to keep the percentage as low as possible. However, there are so many factors, such as customer demand, that impact this indicator, it should never be used as a single performance indicator for stores and purchasing.

Weaknesses

The weakness of using this indicator was highlighted above; that too many factors outside the control of the stores and purchasing function have an impact on the indicator. For example, if the maintenance organization doesn't plan their work in advance, then the store and purchasing department are forced to make rush orders to meet the demand. This would make the evaluation of their service unfair

7. Percentage of Single Line Item Purchase Orders

The cost of processing a purchase order ranges from below $50 for smaller companies to over $250 for larger organizations. If the purchase order has only one line item on it, then the cost is additional to the price of that one item. When multiple line items are consolidated on a single purchase order, then the cost of the purchase order (which will increase somewhat, although not in direct proportion) per line item is reduced. This indicator focuses on the percentage of single line item purchase orders. If the number is high, then it is likely that the maintenance department is reactive with many rush requests. If the maintenance department is proactive with forecasted demands, then multiple items can be consolidated on a purchase order, reducing processing costs.

$$\frac{\text{Total Number of Single Line Item Purchase Orders*}}{\text{Total Number of Purchase Orders}}$$

The formula divides the total number of single line item purchase orders by the total number of purchase orders. The higher that this percentage is, the more expedited tasks that the purchasing department is performing. The lower the number, the more proactive the purchasing function.

Strengths

This indicator highlights the opportunity to save purchasing processing costs by consolidating line items and reducing the total number of purchase orders processed. It is valuable for determining whether the purchasing function is reactive or proactive.

Weaknesses

This indicator is similar to the previous one in that by trying to meet reactive customer demands, the purchasing function may be unfairly evaluated. This indicator should also not be used as a single indicator for the stores and purchasing function because of the impact of external factors that can not be controlled.

8. Percentage of Maintenance Work Orders Waiting on Parts

This indicator highlights the impact the stores and purchasing function has on the execution of maintenance activities. The higher the percentage, the more maintenance work that is being held up by the lack of spare parts.

$$\frac{\text{Maintenance Work Orders On Hold Awaiting Parts*}}{\text{Total Number of Maintenance Work Orders}}$$

The formula highlights the amount of maintenance activities actually impacted by the lack of parts The indicator is calculated based on the number of work orders. If the planning function is fully utilized in maintenance, then the hours of work and the cost of the work can also be highlighted. This places yet another perspective on the impact the stores and purchasing function has on maintenance.

Strengths

This indicator shows the maintenance work that is on hold due to parts of the organization other than just the maintenance department. Although it is not a common indicator, it is useful when trying to decide where work execution is a problem

Weaknesses

If not used carefully, this indicator can be used to place blame. There are dynamic issues impacting this indicator and all must be considered before reaching a decision to take action based on this indicator. These dynamic issues include improper planning of maintenance work orders, excessive amounts of reactive maintenance being performed, and poor organizational disciplines within the inventory and procurement departments.

9. Percentage of Material Costs Charged to a Credit Card

This indicator tracks the usage of credit cards for small purchases in companies today. Although this practice is fairly recent, it is misused in most organizations. Many companies used the credit cards to lower their purchasing costs. Although this goal is a good one, it often compromises the integrity of the material cost data for the equipment life cycle costs. For example, when replacement parts are purchased on a credit card, how is the cost tracked to the equipment history? These may be small items, yet over time, the purchases can add up to a considerable amount. This indicator is monitored to insure there are no abuses of the credit card policy.

$$\frac{\text{Maintenance Material Costs Charged to a Credit Card*}}{\text{Total Maintenance Materials Costs}}$$

The indicator is derived by totaling the costs of all items charged to a credit card and dividing that total by the total maintenance material costs. The result is expressed as a percentage. This percentage should be trended to insure that the charges to the credit cards are not excessive or increasing to a high level

In addition, this indicator should be compared to the total maintenance material costs not charged to a work order. If the maintenance materials are going into a black hole, then it is likely that credit card usage has become excessive

Strengths

This indicator helps to insure that credit card usage is under control. If the indicator is tracked closely, it can be used to spot abuses or negative trends in the card usage.

Weaknesses

This indicator has no major weaknesses. Credit card use is a practice that needs close control This indicator is a necessity for any organization utilizing credit cards.

10. Internal Costs To Process a Purchase Order

This indicator is not really calculated by a formula, but rather by tracking the internal costs that are associated with processing a purchase order. This includes the costs involved in processing the purchase order, including the approval levels and time to process. In some organizations, this cost is virtually unknown; single line item purchase orders are routine because there appears to be no penalty for the practice. Tracking the costs creates an awareness and promotes more multi-line item purchase orders

Strengths

This indicator is useful for tracking the costs. It helps to insure that the approval policy and processing procedures are cost effective. It should be tracked by all organizations. A monthly posting and trending for a rolling year time period is typical.

Weaknesses

There are no major weaknesses with this indicator. The only time this indicator is not effective is when an organization is not accurately tracking its internal processing costs.

Stores and Procurement Problems

The following are common problems preventing the cost effective optimization of inventory and procurement practices

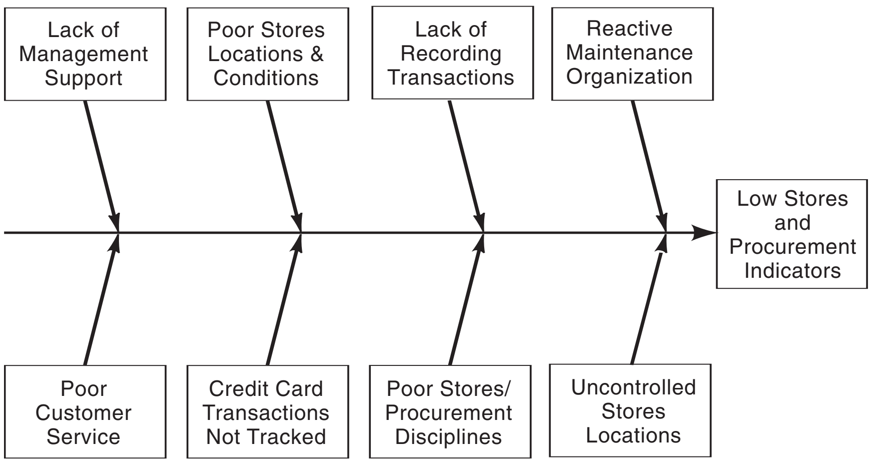


Figure 4.1 Stores and procurement indicator tree

1. Reactive Maintenance Organization

Of all of the items on this list, having a reactive maintenance organization is by far the one that causes the majority of the problems. In fact, it is the key to making the inventory and purchasing functions ineffective. The inventory and purchasing function can not have every spare part that maintenance might need on just a few minutes notice

An effective preventive maintenance program can reduce the amount of reactive or unplanned work to less than 20% of all maintenance activities. When a large percentage of the maintenance work is performed with a 2-to-4 week notification time, the inventory and purchasing organization has time to respond to the needs of maintenance. Unless the reactiveness of the maintenance department is controlled, there is no possibility of the inventory and purchasing functions performing satisfactorily

2. Uncontrolled Stores Locations

This problem occurs when the cost of inventory loss is not clearly understood Many companies today use unsecured storage locations. Although some theft occurs, it is not the major problem. The greater problem occurs when items are used, but are not recorded. The lack of discipline to record the data causes two problems:

a. The item is not reordered, creating a stock out and delay next time one is needed.
b. The cost of the item is not recorded against the piece of equipment or location where it is used. This creates inaccuracies in the equipment's cost history. It also invalidates any attempt to do life cycle costing of the affected equipment

Although there have been many attempts to try alternative methods to insure the data is recorded, the only method proven successful over time is to secure and staff the store locations. In addition, the value of the data recording process must be instilled in each employee. Otherwise, there will be constant problems with inventory levels and data analysis

3. Lack of Recording Transactions

This problem is related to the previous one, but applies even when secured and manned locations exist. The discipline to record data must be instilled in everyone who has a responsibility for issuing, receiving, or returning inventory items. When the value of what is done with the data is not clearly understood, the data collection may seem to be a non-value added function. However, the following scenario should be considered:

If the transaction is not recorded, then the data about stock levels is incorrect. If people who are planning a job and, relying on the data in the system (whether computerized or manual), make a decision based on that data, they will make the wrong decision. They may have a crew of crafts personnel scheduled, a contractor scheduled, and equipment rented. Then when they go to pick up the part, it is missing, even though the system indicates it is there Meanwhile the costs of the equipment being shut down (when it could have been running) and the resulting lost production costs continue to rise.

The cost of not recording the transactions must be clearly communicated . Once a system is put in place, all employees must discipline themselves to utilize it fully. Anything less will create inventory and purchasing problems.

4. Poor Stores and Procurement Disciplines

This problem occurs when the basics of inventory and purchasing management are not enforced. These include all aspects from initiating an order to receiving, issuing, and recording transactions. The same rule applies in inventory and purchasing management as it does in maintenance: Concentrate on the basics first

The pattern for inventory management is easy to find – your local auto parts store. The entire operation is well managed; because it has to be profitable, it is controlled. The analogies are abundant. There are self-service areas where you select items and bring them to the counter, and their usage is recorded. There is a secured area, where you cannot personally go back and get your parts. The stores catalog and parts lists are at the counter; what you need is identified and the stores attendant goes back to get the item, brings it to you, and records the transaction. All of your transactions are paid for (charges to an equipment item's account) and typically you go home and perform some work with your purchases.

Many companies today have begun contracting out their stores functions. They claim that there are major financial gains to be realized It is true that the vendor typically takes the inventory off the company's books, and provides staff to manage the stores, yet this is not the whole picture. The vendor also adds a per transaction charge to each issue. Although this cost is accrued in small increments, it adds up to significant amounts when annualized. In fact, in most cases, the charges amount to more than before, when the company managed its own stores function. This practice is never actually studied and reported in most companies, and because the taxable inventory is gone, the decision to contract out appears to be a good decision.

The decision is often based on what was good for one department or area, but not for the company's overall financials. These decisions should be carefully studied by all departments impacted before they are arbitrarily implemented by one function within the company

5. Poor Stores Locations And Conditions

This problem is an indication of the priority the inventory and purchasing function has within a company. Ideally, the company will operate stores locations that provide the type of environment that protects and preserves the spare parts while they are in storage. After all, the investment in spare parts for many companies is considerable. Allowing spare parts to deteriorate while in storage is financially wasteful

A stores location should be able to protect the spare parts from contamination, moisture, and mishandling by unqualified personnel. Yet, there are companies that store major spare parts in open, exposed outside storage areas called Boneyards, where the major components may be exposed to dramatic temperature changes, moisture, and contamination. Then when the spare parts are needed, people wonder why they don't last as long as they should. This problem reflects a lack of knowledge and appreciation for the company's financial investment in the spare parts.

In addition to the condition of the storage, the location of the storage should also be a factor. If the locations are remote, away from the center of the plant, how much time and efforts are required to move the spare parts from the stores to the job? This question should provide a basis for choosing an appropriate location for the stores. If there is considerable time and effort involved in moving the spares from storage to the work area, it will result in lower maintenance productivity, increased downtime, and ultimately reduced equipment capacity.

6. Credit Card Transactions Not Tracked

If the credit card transactions are not tracked correctly, with the charges tracked back to the equipment on which the spare parts are being used, then the cost histories of the equipment items are invalidated. When this occurs, the following results:

a. The ability to make cost-effective equipment replacement decisions is forfeited
b. The ability to choose the correct replacement based on repair cost is forfeited
c. The ability to do life-cycle costing is forfeited
d. The ability to decide how much to spend re-engineering equipment to eliminate chronic problems is forfeited

The credit cards may be a cost-effective solution for the inventory and purchasing departments. Yet the impact that credit cards have on all departments' ability to perform their functions should be considered, in depth, before any policies are changed. The ability to eliminate the cost of some clerical work in purchasing is insignificant when compared to the overall impact the decision may have on plant capacity.

If credit cards are utilized, there must be some mechanism to charge the costs accumulated on the cards to the appropriate equipment history. Otherwise, the credit card system should never be implemented for maintenance spare parts.

7. Lack of Management Support

Management must understand the inventory and purchasing functions and support any policy that enhances the overall competitive position of the company. This does not give these departments unlimited ability to set policies They are service departments, providing services to internal customers. Unless they are responsive and cost effective, the customers may go elsewhere (outsourcing).

However, when it comes to supporting the basics of good inventory and purchasing, management should support any overall cost-effective policies. The proper storage locations, proper staffing, proper procedures, and proper disciplines should always be in place and fully supported. If not, then the stores and procurement function will have no chance to contribute fully to company profitability.

8. Poor Customer Service

This is a major problem in many companies today, where the inventory and purchasing departments try to dictate to their customers policies that conflict with the customers' charter in the company. The inventory and purchasing departments must understand who their customers really are, what their needs are, and how to meet those needs in a manner that is cost effective for the entire company.

Unless customer service is the focus, untold problems develop, with adversarial relations between the customers and the inventory and purchasing groups. It is only when the customers' needs are the focus that an organization can overcome this problem.

CHAPTER 5

Work Flow Systems

The work flow system is the information system for the maintenance organization. Without the dedication to record all of the maintenance activities on a work order, the organization does not have the data to perform any meaningful analysis on its policies and practices, or more importantly on the equipment it is responsible for maintaining. In addition, without a work flow system, it is impossible to plan and schedule maintenance activities.

There have been many analogies for work flow systems over the years, but the most applicable one is the customer order for a product. This order is transferred to internal company documents, where the labor, materials and equipment resources are all planned and scheduled. Without the production planning and scheduling department, trying to fill multiple customer orders with changing priorities would be chaotic. The same process occurs when attempting to plan, schedule, and ultimately control maintenance activities. Without the control document (work order), the maintenance activities quickly devolve to chaos.

The following indicators monitor the work flow system. A second set of indicators monitors the subsequent planning and scheduling activities.

Work Flow Indicators

1. Total Maintenance Labor Reported to a Work Order

This indicator checks the accuracy of the maintenance labor reporting. It compares the maintenance department labor records to the accounting labor records for the same time period. This allows the maintenance personnel to find out if there are gaps in their recording of data. Although this information is important from the departmental standpoint, it is also critical from the equipment standpoint. If the labor costs are not being recorded on the work order, then the labor component of the equipment history is suspect.

$$\frac{\text{Maintenance Labor Costs on Work Orders*}}{\text{Total Maintenance Labor Costs}}$$

This indicator is derived by dividing the total of the maintenance labor costs charged to a work order by the total maintenance labor costs from accounting. The resulting percentage raises several issues:

If the indicator is below 100%, then some of the maintenance labor costs are not being posted to the work order.

If the indicator is above 100%, then some of the maintenance labor is being overcharged.

If the indicator is at 100%, then labor records are considered accurate. The resulting information in the equipment's history is also accurate.

This indicator can be calculated on a weekly or monthly basis. It is not likely to be effective outside these ranges. The progress can be tracked over a rolling 12-month time period for observing accuracy trends.

Strengths

This indicator is essential for any organization striving for data accuracy. Unless it is monitored, individuals may find themselves slipping into bad habits and not recording all necessary data. This indicator is recommended for all organizations.

Weaknesses

The only weakness in this indicator is its potential misuse as a "Big Brother" tool to monitor what individuals are actually doing. The indicator should be used only to monitor the accuracy of reporting. If individuals are having difficulty recording the data, then methods should be implemented to make data collection easier. Training employees how to report the data and selecting an easy-to-use system for reporting can enable better data collection.

2. Total Maintenance Material Costs Reported to a Work Order

This indicator is similar to the labor indicator. It compares the material charges tracked by maintenance to the material charges tracked by accounting. This information will highlight the accuracy of the data collection and reporting on the materials component of maintenance costs. As with the previous indicator, it allows the maintenance department to see if there are any gaps in data collection and reporting. In addition, as previously mentioned, the impact on the equipment history accuracy can also be seen.

$$\frac{\text{Maintenance Material Costs on Work Orders*}}{\text{Total Maintenance Material Costs}}$$

The indicator is derived by dividing the total material costs tracked by the maintenance department by the total material costs tracked by accounting. The result is expressed as a percentage. The following can be derived from the results:

If the percentage is below 100%, then there are some gaps in the maintenance data collection that need to be corrected

If the percentage is over 100%, then the inventory and purchasing departments may need to check their records to insure the proper materials are being charged to the correct account. Also, the maintenance department may need to check its data to insure that the materials are being charged to the correct account.

If the percentage is 100%, then the materials cost being posted to the equipment histories should be considered accurate.

Strengths

This indicator is essential for any organization striving for data accuracy. Unless it is monitored, individuals may find themselves slipping into bad habits and not recording all data. This indicator is recommended for all organizations.

Weaknesses

The only weakness in this indicator is its misuse as a “Big Brother” tool to monitor what individuals are actually doing. The indicator should be used only to highlight the accuracy of reporting. If individuals are having difficulty recording the data, then methods should be implemented to make data collection easier. Training employees how to report the data and selecting an easy-to-use system for reporting can enable better data collection.

3. Total Maintenance Contract Costs Reported to a Work Order

This indicator is used to check the accuracy of the maintenance contractor reporting. It compares the maintenance department contractor records to the accounting contractor records (probably purchase orders or line items) for the same time period. This allows the maintenance personnel to find out if there are gaps in their recording of data. Although this is important from the departmental standpoint, it is also critical from the equipment standpoint. If the contractor costs (labor and materials) are not being recorded on the work order, then this component of the equipment history is suspect.

$$\frac{\text{Maintenance Contract Costs on Work Orders*}}{\text{Total Maintenance Contract Costs}}$$

The indicator is derived by dividing the total of the maintenance-recorded contractor costs charged to a work order by the total contractor costs from accounting. The resulting percentage can raise several issues:

If the indicator is below 100% then some of the contractor costs are not being captured on a work order.

If the indicator is above 100%, then some of the contractor costs could be overcharged.

If the indicator is at 100%, then the contractor cost records are considered accurate. The resulting information in the equipment's history is also accurate

The indicator can be calculated on a weekly or monthly basis, but is likely not effective when outside these ranges. Accuracy trends can be tracked over a rolling 12-month time period.

Strengths

This indicator is essential for any organization striving for data accuracy. Unless it is monitored, individuals may find themselves slipping into bad habits and not recording all data. This indicator is recommended for all organizations. The data can be used to monitor contractor usage and effectiveness. If the contractor charges to perform work on certain jobs begin to exceed the in-house costs to perform the same work, then negotiations on pricing can occur, or the decision may be made to bring the particular job back in house.

Weaknesses

There is no weakness to this indicator. If the data utilized is accurate it is an effective management tool for contractor evaluation.

4. Total Maintenance Downtime Reported to a Work Order

This indicator is used to check the accuracy of downtime reporting. It compares the maintenance department downtime figures to the production or operations downtime records (probably from production reports) for the same time period. This allows the maintenance personnel to find out if there are gaps in their recording of downtime data. Although this information is important from the departmental standpoint, it is also critical from the equipment standpoint. If the downtime statistics are not being recorded on the work order, then this component of the equipment history is suspect. This will create conflicts when trying to use the data to influence decisions about repairing or replacing equipment.

$$\frac{\text{Maintenance Downtime on Work Orders*}}{\text{Total Maintenance Downtime Charged}}$$

The indicator is derived by dividing the total of the maintenance recorded downtime charged to a work order by the total downtime recorded by operations or production. The indicator is tracked by equipment item, with data reported in hours or fractions thereof. The resulting percentage can raise several issues:

If the indicator is below 100% then some of the downtime incidents are not being captured on a work order.

If the indicator is above 100%, then some of the downtime incidents are probably inflated.

If the indicator is at 100%, then the downtime incidents should be considered accurate and the resulting information in the equipment's history is also accurate.

This indicator, which can be calculated on a weekly or monthly basis, is not likely to be effective when outside these ranges. Accuracy trends can be tracked over a rolling 12-month time period. The calculation should be on an equipment item by equipment item basis. There is no real value in trying to perform downtime roll ups.

Strengths

This indicator is essential for any organization striving for data accuracy. Unless it is monitored, individuals may find themselves slipping into bad habits and not recording all data. This indicator is recommended for all organizations. In addition, the data can be utilized to monitor problem equipment items. Common reports look at the top ten highest-recorded downtime equipment items. This allows the maintenance department to concentrate its efforts on problem equipment.

Weaknesses

This indicator can be used to as a “smoking gun” between maintenance and operations departments trying to fix the blame for poor performance. If the indicator is used for this, accuracy of data and the teamwork required for a successful operation will suffer.

5. Maintenance Labor Costs Charged to a Standing or Blanket Order

This indicator checks the amount of maintenance labor that is charged to a standing work order. This is important because many companies, in an effort to try to improve maintenance record keeping, set up a series of blanket work orders. If these blankets are set up with a charge code or charged to a department (instead of equipment), then the costs and related information are collected in a manner that will make further analysis of the data difficult. In addition, the cost and repair information is not charged to the proper equipment item and the ability to analyze this equipment data is lost.

$$\frac{\text{Maintenance Labor Cost Charged to Standing Work Orders*}}{\text{Total Maintenance Labor Costs}}$$

This indicator is derived by dividing the total of the maintenance labor costs charged to a standing work order by the total maintenance labor costs. The result is expressed as a percentage. The indicator can be tracked by area, craft, or production department. The indicator can be calculated on a weekly or monthly basis, but is not likely to be effective when outside these ranges. Trends can be tracked over a rolling 12-month time period.

Strengths

This indicator is essential for preventing excessive charging to blanket work orders. It is recommended for all organizations. When the percentage of work charged to standing or blanket work orders is high, then much of an organization's ability to manage data is lost. This indicator is useful for highlighting when organizations start to develop the bad habit of taking short cuts on data collection.

Weaknesses

There is no real weakness to this indicator. It is useful for insuring the correct level of data collection

6. Materials Costs Charged to a Standing or Blanket Work Order

This indicator is used to check the amount of maintenance materials charged to a standing work order. This measure is important because many companies, in an effort to try to improve maintenance record keeping, set up a series of blanket work orders. If the blankets are set up with a charge code or charged to a department (instead of equipment), then the material costs and related information are collected in a manner that will make analysis of the data at the equipment level difficult. In addition, the cost and repair information is not charged to the proper equipment item and the ability to analyze this equipment data is lost.

$$\frac{\text{Materials Costs Charged to a Standing Work Order*}}{\text{Total Maintenance Materials Costs}}$$

The formula shows the indicator is derived by dividing the total of the maintenance material costs charged to a standing work order by the total maintenance material costs. The result is expressed as a percentage. The indicator can be tracked by area, craft, or production department. The indicator can be calculated on a weekly or monthly basis, but is likely not effective when outside these ranges. Trends can be tracked over a rolling 12-month time period.

Strengths

This indicator is essential to prevent excessive charging to blanket work orders. It is recommended for all organizations. When the percentage of materials charged to standing or blanket work orders is high, then much of the ability for an organization to manage data is lost. This indicator is useful in highlighting when organizations start to develop the bad habit of taking short cuts on data collection.

Weaknesses

There is no real weakness to this indicator. It is useful for insuring the correct level of data collection.

7. Percentage of Standing or Blanket Work Order Activities Charged to a Specific Equipment Item

This indicator checks the amount of maintenance data being recorded to a standing work order for a specific equipment item. This information is important because many companies, in an effort to improve maintenance record keeping, set up blanket work orders to accumulate small jobs or material charges. Trying to save time, maintenance craftsmen occasionally use the standing or blanket work order as a type of "charge card." They begin charging almost everything to the blanket to avoid writing an individual work order. This practice prevents recording specific information about the labor or material usage and makes future analysis of the data difficult.

$$\frac{\text{Total Charges for a Specific Equipment Item Written to a Standing Work Order*}}{\text{Total Charges for a Specific Equipment Item}}$$

This indicator is derived by dividing the total charges (labor, materials, and contractor) for a specific piece of equipment charged to a standing work order by the total charges (labor, materials, and contractor) recorded against a specific piece of equipment. The result is expressed as a percentage. The indicator can be calculated on a monthly basis, but is not likely to be effective using other windows of time. Trends can be tracked over a rolling 12-month time period.

Strengths

This indicator is essential to prevent the excessive charging to blanket work orders. It is recommended for all organizations. When the percentage of costs charged to standing or blanket work orders is high, then much of an organization's ability to manage data is lost. This indicator is useful in highlighting organizations developing the bad habit of taking short cuts on data collection.

Weaknesses

This indicator has no real weakness. It is useful for insuring the correct level of data collection.

8. Percentage of Work Distribution by Type of Work Order

This indicator monitors the work distribution for an organization. This shows the focus of the organization and where most of the resources are being consumed. While the terminology may differ in organizations, a typical series of categories are emergency, preventive, and corrective orders. Some organizations may choose to add one or two additional categories (e.g., predictive or overhaul), but the number should be kept small. These figures are calculated and should show a 20/40/40 distribution. The reactive should be less than 20%, the preventive should be in the 40% range, and the planned and scheduled (weekly) corrective work should be about 40%.

$$\frac{\text{Emergency Orders}}{\text{Total Work Orders}} \qquad \frac{\text{Preventive Work Orders}}{\text{Total Work Orders}} \qquad \frac{\text{Corrective Orders}}{\text{Total Work Orders}}$$

These indicators are derived by dividing the total charges (labor, materials, and contractor) for a specific type of work by the total charges for all types of work. There is tremendous versatility in utilizing the format of this indicator. The work categories can be used to examine the following:

Labor costs in the three categories
Material costs in the three categories
Contractor costs in the three categories
The three categories by department
The three categories by the area of the plant
The three categories by type of equipment
The three categories by manufacturer of equipment
(for future purchasing considerations)

The indicator is most effective when displayed graphically, first as a pie chart on a weekly basis, then as a bar chart on a rolling annual basis.

Strengths

This indicator format is essential for analyzing work distribution within the maintenance organization. Depending on the priority the manager has in controlling the organization, this format is flexible enough to closely analyze trend and spot developing problems early, and take proactive steps to prevent the organization from sliding into an unbalanced work distribution.

Weaknesses

The real weakness of this indicator is that it may not be useful if the work order system does not allow tracking work types to the necessary categories. While the indicator is useful, the data supporting the calculations must be accurate. If management cannot make decisions based on the data provided for the indicator, then the indicator is useless.

Planning and Scheduling

Once the work order system is being utilized correctly, then the work can be planned and scheduled for maximum efficiency and effectiveness. Planning and scheduling maintenance activities is as important a planning and scheduling production or operational activities. For over a decade, manufacturing resource planning systems (MRPII) have been focused on increasing production efficiencies through better planning, scheduling, and coordination of resources. However, equipment or asset reliability and availability were not closely considered. Ultimately, a company cannot plan manufacturing resources without considering availability of the equipment in the process.

With the emphasis on lean manufacturing, the need became critical for reliable equipment capable of performing at design rates when operating. Planning and scheduling of maintenance activities and integrating those activities into the operations schedule gained new emphasis. The following indicators help evaluate and control how effective an organization is in planning and scheduling maintenance.

9. Percentage of Maintenance Work Orders Planned

This indicator monitors the amount of maintenance work being planned. Planned work costs less to perform than unplanned work because there is less waste when the work is controlled. When the work is unplanned, there are logistic delays getting the equipment shut down, organizing the labor resources, finding and delivering all of the spare parts, and perhaps even coordinating the job with contractors. Less planning of all of these elements can result in more lost productivity from the workforce. Also, the downtime required to perform the work is increased, further decreasing the capacity of the plant.

On the other hand, it is not necessary to plan all maintenance work because the goal is to reduce the amount of time spent performing the work.

For example, if the planner takes an hour to plan a job and only saves an hour of labor on the job (and doesn't reduce the required downtime), then the plan was not worth the effort. However, if the planner can plan a job in an hour and save two or more hours of labor or reduce either the amount of downtime or the equipment required, then the plan is worth the effort. Setting the level of jobs to be planned is a management decision. However, all factors (labor savings, downtime savings, reduced costs, etc.) should be considered when setting the level.

$$\frac{\text{Maintenance Work Orders Planned*}}{\text{Total Work Orders Received}}$$

This indicator is derived by dividing the total number of work orders planned by the total number of work orders received. The indicator will not be 100%, but should be tracked closely to insure the proper number of jobs are being planned. Examining the indicator over several departments, craft lines and even planners can reveal some interesting trends. Some crafts may have a lower percentage of planned jobs. Some departments may also have a lower percentage. This indicator will provide a manager with opportunities for improvement in the overall planning program. The indicator should be tracked on a weekly basis, and then charted on a rolling 6-to-12-month window.

Strengths

This indicator is valuable to insure that the proper level of maintenance activities are being planned.

Weaknesses

The weakness of this indicator is misinterpreting the results. Planning 100% of all jobs is not important; on the other hand, too low a percentage shows a lack of disciplined planning and the resulting high costs that go with it. The results must be carefully understood to be useful.

10. Percentage of Maintenance Labor Costs Planned

This indicator is a subset of the previous one. However, instead of examining the number of work orders planned, it is focused on the maintenance labor costs being planned. This removes the focus from the smaller jobs because their costs will be proportionately the smaller part of the overall costs. Instead, this indicator focuses on planning and controlling the largest percentage of maintenance labor costs. One additional note for this indicator: preventive and predictive maintenance costs are considered planned and should be included in the calculation.

$$\frac{\text{Maintenance Labor Costs Planned*}}{\text{Total Maintenance Labor Costs}}$$

This indicator is derived by dividing the maintenance labor costs charged to work orders that are planned by the total maintenance labor costs. As before, the indicator will not be 100%, but should be tracked closely to insure the proper number of labor hours are being planned. Examining the indicator over several departments, craft lines, and even planners can reveal some interesting trends. Some crafts may have a lower percentage of planned jobs. Some departments may also have a lower percentage. This indicator will provide a manager with the opportunities for improvement in the planning for maintenance labor resources. The indicator should be tracked on a weekly basis, and then charted on a rolling 6-to-12-month window.

Strengths

This indicator is valuable for insuring that the proper level of maintenance labor resources are being planned.

Weaknesses

The weakness of this indicator is misinterpreting the results. Planning 100% of all jobs is not important; on the other hand, too low a percentage shows a lack of disciplined planning and the resulting high costs that go with it. The results must be carefully understood to be useful.

11. Percentage of Maintenance Material Costs Planned

This indicator parallels the last one. However, instead of focusing on maintenance labor costs, it focuses on the maintenance material costs being planned. This removes the focus from the smaller jobs because their costs will be proportionately the smaller part of the overall costs. The goal with this indicator is to focus on planning and controlling the largest percentage of maintenance material costs. One additional note for this indicator: preventive and predictive maintenance material costs are considered planned and should be included in the calculation.

$$\frac{\text{Maintenance Material Costs Planned*}}{\text{Total Maintenance Materials Costs}}$$

This indicator is derived by dividing the maintenance material costs charged to planned work orders by the total maintenance material costs. The indicator will not be 100%, but should be tracked closely to insure the proper number of material costs are being planned. Examining the indicator over several departments, craft lines, and even planners can reveal some interesting trends. Some crafts may have a lower percentage of planned maintenance materials costs. Some departments may also have a lower percentage. This indicator will provide a manager with the opportunities for improvement in the planning for maintenance materials and the subsequent impact on stores performance. The indicator should be tracked on a weekly basis, and then charted on a rolling 6-to-12-month window.

Strengths

This indicator is valuable for insuring that the proper level of maintenance materials are being planned.

Weaknesses

The weakness of this indicator is misinterpreting the results. Planning 100% of all materials is not important; on the other hand, too low a percentage shows a lack of disciplined planning as well as the resulting high costs and impact on the stores that go with it. The results must be carefully understood to be useful.

12. Schedule Compliance

This indicator begins the transition away from the planning aspect to the scheduling aspect of work control. The focus is not on the hours planned compared to the actual hours, but rather the hours that were scheduled versus those actually worked. This indicates whether the schedule and the scheduling process was effective. Where the goal of the previous indicator was just to indicate what percentage of the resources were planned, the goal for this indicator is to reach 100%. If work is scheduled, it should be completed. The first scheduling indicator examines the labor component. If labor hours are scheduled, then how close to the scheduled numbers are the actual numbers? Again, the goal is 100%.

$$\frac{\text{Maintenance Hours Scheduled*}}{\text{Total Maintenance Hours Worked}}$$

This indicator is derived by dividing the maintenance hours scheduled by the total maintenance hours worked. This gives the total maintenance hours scheduled as a percentage of total maintenance hours worked. Examining this indicator by departments, craft lines, supervisor, and even planner can reveal some interesting trends. Some crafts may have a lower percentage of schedule compliance. Some departments may also have a lower percentage. This indicator will provide a manager with opportunities for improving schedule compliance and its impact on the organization. The indicator should be tracked on a weekly basis, and then charted in a rolling 6-to-12-month window.

Strengths

This indicator is valuable for insuring that the proper level of maintenance is being worked as scheduled.

Weaknesses

There is no major weakness to this indicator. It is recommended for all organizations as a measure of scheduling effectiveness.

13. Overtime Percentage

This indicator is not always a direct indicator of the planning and scheduling program. Because planning and scheduling effectiveness impact it, however, this indicator is considered in this section. In many organizations, overtime is worked in response to poor planning and scheduling disciplines. Furthermore, many companies work a high level of overtime to compensate for a shortage of labor resources. This practice is not recommended and should be closely monitored. Excessive overtime can have an impact on workforce efficiency. High overtime rates can indicate a problem with the planning and scheduling disciplines.

$$\frac{\text{Hours Worked as Overtime*}}{\text{Total Hours Worked}}$$

This indicator is derived by dividing the hours worked as overtime by the total hours worked. This percentage then shows the premium time that is being used to perform work. Proactive maintenance organizations work 5% or less of their total time as premium time.

Strengths

This indicator is valuable for insuring that no excessive maintenance overtime is being utilized.

Weaknesses

There is no major weakness to this indicator. It is recommended to all organizations as an indicator.

14. Planning Compliance

This indicator checks the accuracy of the estimates for the work that is on the weekly schedule. The indicator is important for organizations moving toward an integrated scheduling program, where the maintenance and operations schedules are combined. Any inaccuracies in the maintenance schedule would have a direct impact on the production or operations schedule. In organizations where schedule integration is not an issue, this indicator is still beneficial because the maintenance schedule will still have some impact on the production or operations schedule.

$$\frac{\text{Total Hours Estimated on Scheduled Work Orders*}}{\text{Total Hours Charged to Scheduled Work Orders}}$$

This indicator is derived by dividing the hours estimated for all of the work orders on the week's schedule by the actual time it took to perform the work orders on that schedule. The tracking system should give a manager the ability to drill down into the data to see which work orders cause any discrepancies.

Strengths

This indicator is valuable for insuring the accuracy of the maintenance schedule.

Weaknesses

There is no major weakness to this indicator. It is recommended to all organizations using an integrated schedule. It is also advisable for any organization to use as a performance check on scheduling accuracy.

15. Work Orders Completed Within ± 20% of Planned Labor

This indicator checks the accuracy of the labor estimates for the work that was completed. This indicator is useful for monitoring performance on at least the following three levels.

The planner performance: Were any discrepancies due to the planner's lack of knowledge or skills?
The supervisor (or coach) performance: Were any discrepancies due to the supervisor's lack of skills of knowledge?
The craft technician's performance: Were any discrepancies due to the craft technician's lack of skills or performance?

This indicator tracks problems that impact the labor estimate of the planned job. Most companies start with a goal of plus or minus 20%, and then narrow the margin to 10% as the organization becomes more efficient.

$$\frac{\text{Number of Work Orders Completed Greater than 20\% of Estimated Labor*}}{\text{Total Number of Maintenance Work Orders}}$$

This indicator is derived by dividing the work orders over (or under) the estimated labor by more than 20% by the total number of work orders. The tracking system should then help a manager to identify and resolve those individual problem work orders that exceeded the labor estimate by more than 20%.

Strengths

This indicator is valuable for insuring the accuracy of the maintenance schedule.

Weaknesses

There is no major weakness to this indicator. It is recommended to all organizations trying to improve the accuracy of their estimating techniques.

16. Work. Orders Completed within ± 20% of Planned Material Costs

This indicator is used to check the accuracy of the material estimates for the work that was completed. This indicator is useful for monitoring performance on at least the following three levels.

The planner performance: Were any discrepancies due to the planner's lack of knowledge or skills?

The supervisor (or coach) performance: Were any discrepancies due to the supervisor's lack of skills of knowledge?

The craft technician's performance: Were any discrepancies due to the craft technician's lack of skills or performance?

This indicator tracks problems that impact the material estimate of the planned job. Most companies start with a goal of plus or minus 20% and then narrow the margin to 10% as the organization becomes more efficient.

$$\frac{\text{Number of Work Orders Completed Greater than 20\% of EstimatedMaterial*}}{\text{Total Number of Maintenance Work Orders}}$$

This indicator is derived by dividing the work orders that are over the estimated materials by more than 20% by the total number of work orders. The tracking system should then help a manager to identify and resolve individual work orders that exceeded the materials estimate by more than 20%.

Strengths

This indicator is valuable for insuring the accuracy of the maintenance schedule.

Weaknesses

There is no major weakness to this indicator. It is recommended to all organizations trying to improve the accuracy of their estimating techniques.

17. Work Orders Overdue

This indicator checks the timeliness of the work order completion. When a work order is initiated, the goal is to finish the work in 2-to-4 weeks. This level keeps the backlog current and prevents a perceived lack of responsiveness on the part of the maintenance organization. The goal is zero work orders overdue. Although this is difficult to achieve, the lower the percentage, the better the performance of the maintenance organization.

$$\frac{\text{Work orders Overdue*}}{\text{Total Work Orders}}$$

This indicator is derived by dividing the number of work orders overdue (exceeding the 2-to-4-week backlog) by the total number of work orders. The percentage highlights the amount of work not being performed in a timely fashion. The manager should then have the ability to examine the individual work orders to see what can be done to expedite completion.

Strengths

This indicator is valuable for insuring the timely service of the maintenance department.

Weaknesses

There is no major weakness to this indicator. It is recommended to all organizations trying to improve their responsiveness.

Typical Work Order and Planning and Scheduling Problems

In the United States, less than one-third of the maintenance organizations are satisfied with their work order performance. Why is the satisfaction rate so low? Below are the common reasons for poor work order and planning, and scheduling satisfaction.

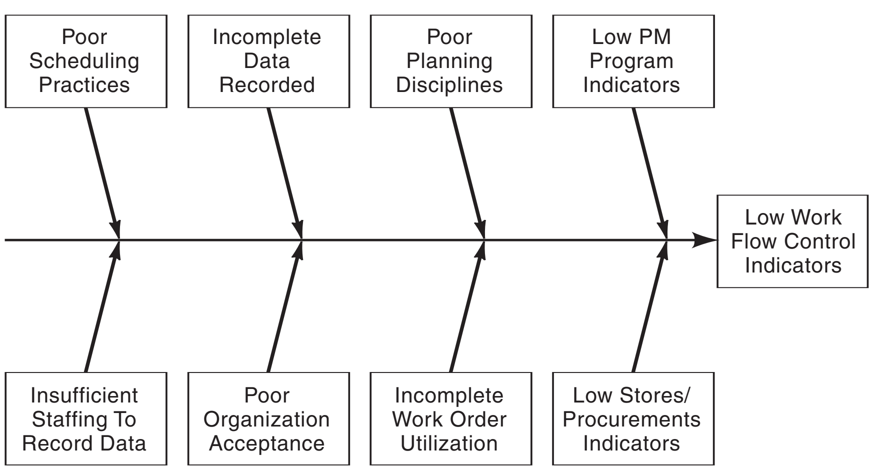


Figure 5.1 Work flow indicator tree

1. Low PM Program Indicators

Although it may seem unlikely, the poor performance of the preventive maintenance program is the leading cause of poor work order systems. Strong preventive maintenance program reduce the amount of reactive maintenance activities to a level that allows the work order system to function. Unless the majority of the maintenance work can be requested in a proactive mode, the work order system will be ineffective. The proactive organization can take the time to properly utilize the work order, filling in the detail necessary to make the work order usable for later analysis. A work order that says "It's broke, fix it" and comes back with the information "I did and it took two hours" has little if any usable data in it for root cause failure analysis. The preventive maintenance program must reduce the amount of reactive maintenance to less than 20% of all activities before any work order or planning and scheduling system can be truly effective.

2. Low Inventory / Procurement Indicators

This cause of work order problems is closely related to the first one. Unless the stores and procurement system is functioning correctly (95%+ service level), the maintenance plan will not be successful. The reason is that it does little good to plan and schedule a job and then, when it comes time to perform, the materials are not available, out of stock, or not even ordered. Unless the inventory and procurement functions are working at a satisfactory level, the work order and the planning and scheduling functions will be perceived to be ineffective.

3. Poor Planning Disciplines

If the planning disciplines are not effective, the work order system will not be effective. For example if the planner constantly underestimates the labor resources to perform work, then the schedule is inaccurate and the overall organizational perception is that the maintenance work order system is not working. If the planner underestimates the materials required to perform work, then the work will always experience delays and the craft technicians will become frustrated. This leads to a lack of trust in the planner and, ultimately, failure of the planning and scheduling system. Planners should always receive adequate training and have refresher training as needed to remain effective.

4. Incomplete Work Order Utilization

The issue that contributes to this problem is the lack of organization acceptance and, in turn, the discipline to fully utilize the work order system. All parts of an organization must be disciplined to use the work order system to request, plan, schedule, and complete maintenance work. Unless full commitment is achieved, the work order is only partially utilized by the organization, and instead viewed as something the maintenance department uses. Ultimately the system will then be used as a work log book and little else.

5. Incomplete Data Recorded

This problem is typically created by a failure to understand the value of the maintenance data. If the data is not valued, then the time and resources required for collecting it will not be sufficiently allocated. Therefore, the data necessary to calculate Mean Time Between Failure, Mean Time To Repair, and Life Cycle Costing may not be available. This data collection failure will sub-optimize the effectiveness of the work order system and lead to the ultimate failure of the program. Education related to the value of maintenance and equipment history data is required at all levels of the organization.

6. Poor Organizational Acceptance

Even if the data is collected and the work order system is fully utilized, the data must be used to make technical and financial decision about the equipment and facility. If not, support for the work order and the planning and scheduling systems ultimately dwindles and falls into partial or incomplete usage, leading to failure of the entire system. The organization must value the technical data and blend it with financial information to make value-based decisions.

7. Poor Scheduling Practices

This failure, which is related to the lack of organizational discipline to adhere to the schedule, is based on several factors. First the schedule may not be accurate due to poor estimating, poor stores, or an overall reactive organization. As a result, individuals may take matters into their own hands and having the work performed that they feel is important. This practice leads to confusion and, ultimately, a failure of the scheduling discipline. A second factor is the autonomy that many supervisors (both maintenance and operations) believe they have when it comes to work control. If they arbitrarily change work schedules that have previously been accepted, the organization develops a reactive mentality. In turn, overall productivity falls and the scheduling practice fails. Commitment to the schedule at all levels in the organization is necessary for it to be successful.

8. Insufficient Staff To Record Data

This problem has developed due to the current trend of downsizing (dumbsizing?) organizations. Because staff reductions are typically made by those who have little or no technical skills (or even an appreciation for or an understanding of the technical requirements of their organization), many of the reductions happen in the maintenance and engineering groups. The technical staff is reduced to the point that it doesn't have the resources to collect the data, much less analyze it. As a result, many of the cost benefits of a competent technical component of an organization go unrealized and the overall competitiveness of the company is reduced. In the long term, the company may not be a viable business. Proper appreciation of the cost benefits delivered by the maintenance and engineering groups must be developed in all organizations. That appreciation begins with education.

CHAPTER 6

Computerized Maintenance Management Systems (CMMS) and Enterprise Asset Management Systems (EAM)

The Computerized Maintenance Management System (CMMS) and Enterprise Asset Management System (EAM) are, in reality, nothing more than computerized versions of a maintenance information system. In fact, anything that can be done with a CMMS/EAM system can be done in a manual system. Using the computer, however, should make it faster and easier to collect data and then manipulate that data into a meaningful report format.

Recall from Figure 2-1 that the work order is the key feature of the system. It collects all of the labor data, the materials data, the contractor data, and the preventive maintenance data and that is written against a piece of equipment (or a facility, building, floor, or room). The information collected is then stored in a database called the equipment history. It is from here that all of the data is drawn to produce all of the reports needed by the organization to manage its equipment or assets.

However, a study conducted by Engineer's Digest in 1992 highlighted a problem. The majority of organizations owning and using a CMMS used only 50% to 60% of it. The question now is: What parts of the CMMS can you not use, without compromising the integrity of the data in the equipment history database? For example,

If you don't record labor data, is the cost history accurate?
If you don't record material data, is the cost history accurate?
Could you perform life cycle costing?
Could you calculate the MTBF?
Could you calculate the MTTR?

The answer is, of course, no. Therefore, full use of the CMMS is necessary if any usable data is to be collected. The following indicators should be utilized to insure full and accurate data collection.

1. Percentage of Maintenance Labor Costs Recorded in CMMS/ EAM System

This indicator compares the maintenance labor costs captured in the CMMS /EAM to the maintenance labor costs captured in the accounting system. If the CMMS/EAM is part of or integrated to an Enterprise Resource Planning system (ERP), then the reconciliation is not optional; the costs must match. This indicator insures that all labor costs are being recorded correctly.

$$\frac{\text{Total Maintenance Labor Costs in CMMS /EAM*}}{\text{Total Maintenance Labor Costs from Accounting}}$$

This indicator is derived by dividing the maintenance costs recorded in the CMMS /EAM by the maintenance labor costs in the accounting system. The resulting percentage is the degree of accuracy the labor data has in the CMMS/EAM. If the percentage is above 100%, then somehow the maintenance department is overbilling for its services. If the percentage is below 100%, then the maintenance department is not recording all of its labor activities.

Strengths

This indicator is mandatory for any company striving to insure complete accuracy of its maintenance labor charges.

Weaknesses

The weakness of this indicator is that sometimes it forces a maintenance organization to try to balance the numbers. At times, the organization may open a standing or blanket work order as a quick fix to try to cover the differences in the systems. This action should not be done. The real issue is that somewhere the labor data is not being recorded accurately against the appropriate equipment item. The errors should be traced and corrected.

2. Percentage of Maintenance Material Costs Recorded in CMMS/ EAM System

This indicator is similar to the previous one except that it compares the maintenance material costs captured in the CMMS /EAM to the maintenance material costs captured in the accounting system. If the CMMS/EAM is part of or integrated to an Enterprise Resource Planning system (ERP), or even a general ledger system, then the reconciliation is not optional; the costs must match. This indicator insures that all material costs are being recorded correctly.

$$\frac{\text{Total Maintenance Material Costs in CMMS /EAM*}}{\text{Total Maintenance Material Costs from Accounting}}$$

This indicator is derived by dividing the maintenance material costs recorded in the CMMS/EAM by the maintenance material costs in the accounting system. The resulting percentage is the degree of accuracy the material cost data has in the CMMS/EAM. If the percentage is above 100%, then somehow the maintenance department is overbilling for spare parts. If the percentage is below 100%, then the maintenance department is not recording all of its spare part transactions and costs.

Strengths

This indicator is mandatory for any company striving to insure complete accuracy of its maintenance material charges.

Weaknesses

The weakness of this indicator is that sometimes it forces a maintenance organization to try to balance the numbers. At times, the organization may open standing or blanket work orders as a quick fix to try to cover the differences in the systems. This action should not be taken. The real issue is that somewhere the spare parts data is not being recorded against the appropriate equipment item. The errors should be traced, and corrected.

3. Percentage of Maintenance Contracting Costs Recorded in CMMS/EAM System

This indicator is similar to the previous two; it compares the maintenance contractor costs captured in the CMMS/EAM to the maintenance contractor costs captured in the accounting system. If the CMMS/EAM is part of or integrated to an Enterprise Resource Planning system (ERP), or even a general ledger system, then the reconciliation is not optional; the costs must match. This indicator insures that all contractor costs are recorded correctly. Many organizations are not effective in recording contractor costs to specific equipment items. This area is one of concern, especially if a company uses a high proportion of outside contractors. In some companies, contractors are paid from a different account, and the maintenance department never sees the actual costs. This issue may need attention in many companies.

$$\frac{\text{Total Maintenance Contracting Costs in CMMS/EAM*}}{\text{Total Maintenance Contracting Costs from Accounting}}$$

This indicator is derived by dividing the maintenance contractor costs recorded in the CMMS (and EAM) by the maintenance contractor costs in the accounting system. The resulting percentage is the degree of accuracy the contractor cost data has in the CMMS/EAM. If the percentage is above 100%, then somehow the contractor costs are excessive. If the percentage is below 100%, then the maintenance department is not recording all of the contractor costs.

Strengths

This indicator is mandatory for any company striving to insure complete accuracy of its maintenance contractor charges.

Weaknesses

The weakness of this indicator is that sometimes it forces a maintenance organization to try to balance the numbers. At times, the organization may open standing or blanket work orders as a quick fix to try to cover the differences in the systems. This action should not be taken. The real issue is that somewhere the contractor data is not being recorded against the appropriate equipment item. The errors should be traced and corrected.

A second major weakness is that not all CMMS/EAM systems accurately track contractor costs. In some systems it is a manual entry and must be manually posted. If a company utilizes many outside contract services, a CMMS/EAM that supports this function should be selected and implemented to insure accurate data collection.

4. Percentage of Equipment Coverage by CMMS/EAM System

This indicator examines how many of the equipment items in the plant are covered by the CMMS/EAM equipment history. During implementation of a CMMS/EAM, many companies take a short cut and enter only the critical equipment. This shortcut leaves second- and third-tier equipment without coverage in the CMMS/EAM. The costs against these levels of equipment are instead charged to a standing or blanket work order, but the information is virtually unusable for data analysis, equipment troubleshooting, or life cycle costing. Eventually all equipment, even if it is at a system level, must be entered into the CMMS/EAM.

$$\frac{\text{Total Number of Equipment Items in CMMS /EAM*}}{\text{Total Number of Equipment Items in the Plant}}$$

This indicator is derived by dividing the total number of equipment items entered into the CMMS/EAM by the total number of identified equipment items in the plant or facility. Although some equipment systems are broken down to the component level, others (especially non-critical units) can be left at the system level. This choice allows for data collection against the equipment item, without making the process too detailed. The alternative of not collecting any data is unacceptable.

Strengths

This indicator is mandatory for any company striving to insure complete accuracy of the maintenance data and being able to charge all costs and repair information to the appropriate equipment history. It is a valuable tool for insuring complete equipment coverage.

Weaknesses

The weakness of this indicator is that sometimes it forces a maintenance organization to try to balance the numbers. At times, the organization may open standing or blanket work orders as a quick fix to try to cover the differences in the systems. This action should not be taken. The real issue is that the proper time and resources must be taken during the CMMS /EAM implementation. If the data in the CMMS/EAM is to be accurate, then all equipment items must be in the CMMS/EAM, even if non-critical items are at the system level.

5. Percentage of Stores Coverage by CMMS/ EAM System

This indicator examines the extent to which inventory and spare parts in the plant are covered by the CMMS/EAM. During implementation of a CMMS, many companies take a shortcut and enter only critical or major spare parts into the CMMS/EAM. This leaves the majority of stores items (usually over 50%) without CMMS/EAM coverage. The costs for these spare parts are difficult to reconcile, so these items are charged to standing or blanket purchase orders. The information is virtually unavailable for data analysis, equipment troubleshooting, or life cycle costing at the equipment level. Eventually all spare parts must be entered into the CMMS/EAM.

$$\frac{\text{Total Number of Part Items in CMMS /EAM*}}{\text{Total Number of Part Items in the Plant}}$$

This indicator is derived by dividing the total number of spare parts (also called stores line items) entered into the CMMS/EAM by the total number of identified spare parts in the plant or facility. Although this information may be difficult to derive, it is usually available from the procurement department.

Strengths

This indicator is mandatory for any company striving to insure complete accuracy of the inventory and procurement data, and being able to charge the parts cost to the appropriate equipment history. It is a valuable tool for insuring complete cost accuracy.

Weaknesses

The weakness of this indicator is that sometimes it forces a maintenance organization to try to fabricate information. In many cases, the organization doesn't know a part number or buys directly from vendors. All too often, the information about the part, its cost and the vendor is never recorded. These cases make accurate data tracking impossible. They also lengthen procurement times, because the next time the part is required, someone will have to look up all of the ordering information. Tracking all of the spare parts through the CMMS/EAM can help shorten the lead times for procurement.

6. Percentage of PM Coverage by CMMS/EAM System

This indicator examines the level of preventive maintenance coverage in the CMMS /EAM. By examining the total number of equipment items and comparing it to the average number of preventive maintenance tasks for an equipment item, a theoretical goal can be derived. By comparing the current number of preventive maintenance tasks to this number, one can get an approximation of the level of coverage. A piece of equipment may have the following tasks interval:

Daily
Weekly
Monthly
Quarterly
Semi-annual
Annual
Other

Few, if any, equipment items will have all of these intervals. But what if they each had on average three? Then the number of equipment items multiplied times three should be the theoretical number of preventive maintenance tasks for the plant or facility. In reality, most companies don't put this level of detail into their preventive maintenance programs.

$$\frac{\text{Total Number of Preventive Maintenance Tasks*}}{\text{Total Number of Equipment Items in the Plant X 3}}$$

This indicator is derived by dividing the total number of preventive maintenance tasks identified in the CMMS /EAM by the total number of equipment items in the CMMS/EAM multiplied by three. The goal is 100%. This indicator provides a theoretical check, but over 15 years of usage has shown it to provide an accurate check on preventive maintenance coverage in a CMMS/EAM.

Strengths

This indicator is essential for any company striving to insure that the preventive maintenance program completely covers the equipment entered into the CMMS /EAM.

Weaknesses

The weakness of this indicator is that it is just an average guideline. Even though time has proven it to be accurate, some companies will average less preventive maintenance tasks than 3 per equipment item. Others will average more. This indicator should never be used as a performance indicator, only as a suggested guideline.

7. Percentage of Maintenance Information Recorded at the Equipment Level

This indicator examines the amount of cost information that is recorded at the equipment level compared to untracked or unspecified cost information. This indicator is useful for discovering how much of the maintenance cost cannot be traced to a specific equipment item for data analysis, equipment troubleshooting, or life cycle costing.

$$\frac{\text{Total Maintenance Costs Charged to Individual Equipment Items*}}{\text{Total Maintenance Costs from Accounting}}$$

This indicator is derived by dividing the total maintenance costs charged against an individual equipment item by the total maintenance costs from accounting. The resulting percentage is the cost that is traceable to an equipment item. The other costs are most likely charged to a standing or blanket work order or else go unrecorded.

Strengths

This indicator is mandatory for any company striving to insure complete accuracy of the maintenance cost tracking. It is a valuable tool for insuring complete cost accuracy.

Weaknesses

The weakness of this indicator is that sometimes it forces a maintenance organization to try to fabricate information. The organization may charge costs to equipment that were not actually incurred on the equipment, trying to account for all the costs and make the indicator look good.

8. Supervisory or Coaching Staffing Ratios

This indicator monitors the span of control for a front-line maintenance supervisor. In a traditional organization, the proper ratio is 1 supervisor for every 8-to-12 maintenance technicians. Some organizations have tried to extend the ratio, but such efforts usually result in wasted labor productivity that incurs greater cost than the savings from eliminating a supervisory position.

$$\frac{\text{Number of Maintenance Employees or Full Time Equivalents}}{\text{Number of Supervisors or Coaches}}$$

This indicator is derived by dividing the total number of maintenance employees or full-time equivalents by the number of maintenance supervisors. The ratio should range from 8:1 to 12:1. Any ratio over 12 results in ineffective supervision. If the number is less than 8, there is not sufficient work to justify the supervisor. The exception to this occurs when the total number of maintenance employees is less than 8. Then, the maintenance supervisor may still be required.

Strengths

This indicator is mandatory for any company striving to insure proper supervisory levels for the maintenance organization.

Weaknesses

The weakness of this indicator is that organizations try to de-emphasize the span of control of the supervisors or coaches by hiding under the concept of empowerment. The typical organization using this excuse has little understanding of what the legal requirements under the National Labor Relations Act and OSHA regulations actually involve. If these requirements are clearly understood, many companies could save themselves OSHA fines and civil lawsuits.

9. Planner Ratios

This indicator is used to monitor the span of control for a maintenance planner. In a traditional organization, the proper ratio is 1 planner for every 15-to-20 maintenance technicians. Some organizations have tried to extend the ratio, but such efforts usually result in wasted labor productivity that incurs greater cost than the savings from eliminating a planner's position.

$$\frac{\text{Number of Maintenance Employees or Full Time Equivalents}}{\text{Number of Planners}}$$

This indicator is derived by dividing the total number of maintenance employees or full time equivalents (in the case of operations involvement or team-based maintenance) by the number of maintenance planners. The ratio should range from 15:1 to 20:1. Any ratio over 20 results in ineffective planning. If the number is less than 15, there is not sufficient work to justify the planner full time. The exception to this is when the total number of maintenance employees range from 8 to 15. Then the maintenance planner may still be required.

Strengths

This indicator is mandatory for any company striving to insure proper levels of planning and scheduling for the maintenance organization.

Weaknesses

The weakness of this indicator is that organizations try to de-emphasize the span of control of the planners by hiding under the concept of empowerment. The typical organization using this excuse has little understanding of what impact planning has on labor productivity. In organizations without planners, the hands-on or wrench time is low. When the work is planned, the wrench time is higher. Imagine a NASCAR pit crew working effectively without planning. The pit stop would be in minutes, not seconds. Planners have the same impact on maintenance labor productivity and equipment uptime.

10. Percentage of Maintenance Support to Direct Maintenance Costs

This indicator is used to monitor the support personnel required for the maintenance hourly technicians. In a traditional organization, the proper ratio is 1 support person for every 3-to-5 hourly maintenance technicians. Some organizations have been able to extend the ratio by applying easy-to-use CMMS /EAM for data collection and analysis. However, a CMMS/EAM that is not easy to use and is keystroke intensive may actually lower the ratio.

$$\frac{\text{Total Number of Maintenance Overhead Personnel}}{\text{Total Hourly Maintenance Personnel}}$$

This indicator is derived by dividing the total number of maintenance overhead personnel by the number of hourly maintenance personnel. The ratio should range from 3:1 to 5:1. Any ratio over 5 results in ineffective staffing. For example, it is more economical to pay a maintenance clerk to enter information than it is to pay a maintenance technician $20 or more an hour to enter data. A company does not want to staff the overhead roles too heavily, but it is just as costly to staff the roles too lightly.

Strengths

This indicator is mandatory for any company striving to insure proper levels of support for the maintenance organization.

Weaknesses

The weakness of this indicator is that organizations try to de-emphasize the support for the organization by hiding under the concept of empowerment. The typical organization using this excuse has little understanding of what impact the overhead functions have on the accuracy of the equipment maintenance data. If an organization desires to be competitive by utilizing maintenance data, it will provide the correct level of maintenance overhead personnel.

CMMS/EAM Problems

As highlighted earlier, the overall usage of the CMMS /EAM as a tool is poor by the majority of organizations. Couple this with the fact that about 50% of all CMMS/EAMs are deemed to have failed after less than two years of operation, and there are clearly issues that must be addressed for the CMMS/EAM to be an effective tool for most organizations. The eight most common reasons are explained next.

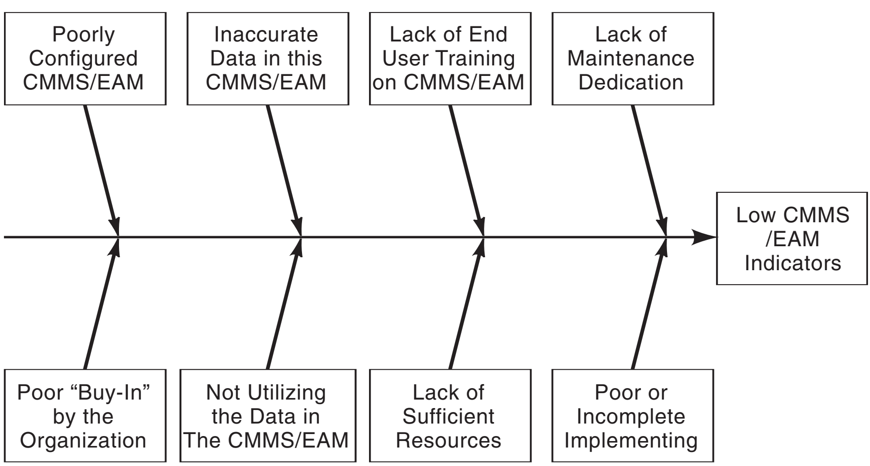


Figure 6.1 CMMS/EAM indicator tree

1. Lack of Maintenance Dedication

This problem develops when the maintenance organization lacks clear definition of their roles and responsibilities. The organization may actually believe that maintenance is a necessary evil, insurance, or just an overhead expense. Instead of focusing on value-added functions, it focuses on reactive maintenance. This type of maintenance organization needs education on what equipment management really entails. Unless it develops a proactive attitude by understanding the impact it can make on the company's profitability, it will never be dedicated to Best Practice maintenance concepts (including full usage of its CMMS /EAM) and will never improve.

2. Poor or Incomplete Implementation

This is a typical problem for organizations that never fully understood the implementation costs for a CMMS /EAM. The rule of thumb is that the software is somewhere between 1/3 and 1/5 of the total cost of the implementation. If the budget for the implementation is insufficient, then the data collection and training of the end users is often eliminated. The organization may believe the employees can figure out how to use the software: after all, the salesmen said it was easy to use. The organization also figures that the hourly technicians can gather the data as they work. This never happens. As a result, the CMMS/EAM is underutilized and the implementation fails; the return on investment in the CMMS/EAM is never realized.

3. Lack of End User Training on CMMS /EAM

Although this problem was partially covered previously, it deserves special mention. No matter how easy a CMMS /EAM appears to be, never shortcut the end-user training. Microsoft Windows is supposed to be very easy to use, but how many casual users ever realize the power of the operating system? The same is true for any CMMS/EAM. Unless the end users are trained, the full power of the system is never realized. Lack of training is the single biggest factor in the overall failure of the CMMS/EAM as a maintenance tool.

4. Lack of Sufficient Resources

If a company is to utilize a CMMS /EAM successfully, it must remember that "Someone must feed the monster". The system requires certain amounts of data to be entered every day if it is to be effective. Unless the support resources are in place to insure data entry, the data is not input. Without the data being entered in a timely fashion, the CMMS/EAM has nothing of value with which to manage maintenance. The labor resources to operate the CMMS/EAM properly must be clearly defined during implementation and then be provided on an ongoing basis to insure there is value added in the data being provided by using the CMMS/EAM. Otherwise, another failure results.

5. Inaccurate Data in the CMMS /EAM

This problem is typically caused by partial or casual use of the CMMS /EAM. If there is no dedication to entering accurate data, the expression garbage in means garbage out finds fulfillment. The expression No data is better than bad data is also applicable. If any decisions are made based on the data in the CMMS/EAM, they are wrong, and the maintenance department loses credibility. In most cases, the rest of the organization knows the information in the maintenance system is inaccurate. Therefore, it is never allowed to be used to influence decisions and the CMMS/EAM is ruled a failure. Unless the resources and disciplines are in place to insure accurate data collection and usage, the CMMS/EAM will fail.

6. Not Utilizing the Data in the CMMS /EAM

This problem is a trap organizations fall into when they lose focus of the real value of the CMMS /EAM: to manage maintenance and the organization's equipment. The maintenance organization may have collected accurate data, but never have the time or the resources to analyze it. Therefore, it is collected, but never used. Eventually, the CMMS/EAM falls into a lack of use because no one ever saw any value from collecting the data. The only way to eliminate this problem is to plan from the beginning to use a maintenance or reliability engineer to analyze the data that will be collected. Without this focus the CMMS/EAM will eventually fail.

7. Poorly Configured CMMS /EAM

This problem is a software issue. The vendor did not design the CMMS /EAM correctly and the system is difficult to configure. The modules may not cleanly integrate data between the work order and the stores or labor module. As a result, additional clerical support will be required. Because this increase wasn't planned, it is not in the budget and is usually not provided. In turn, the

CMMS/EAM will fail. Before any CMMS/EAM is purchased (or built in-house, although no competitive organization really does this any more because they don't have the time, money or resources), the end users should be consulted on what they want the CMMS/EAM to do for them and how it should do it. Therefore, functionality should be approved before it is ever purchased. If not, another failure will result.

8. Poor "Buy-In" by the Organization

This is similar to the first problem, except the rejection is organizational, not just by the maintenance department. In some cases. the CMMS /EAM is viewed as something that only the maintenance department uses, not as an organizational tool for managing the company's equipment. In other cultures, the CMMS/EAM is viewed as an Equipment Management Information System (EMIS). This reinforces the idea that it is not just a maintenance tool, but also an organizational tool. Unless the organization can see the value of the CMMS/EAM, it will not receive the acceptance it requires to be useful. This problem is overcome by the organization being educated to the value of good maintenance and data collection.

Chapter 7 – Technical and Interpersonal Training

The training and education of today's workforce, whether salaried or hourly, is a major issue. Many organizations have aging workforces and the skills of those entering the workforce are below the standard that will be necessary to replace those who are exiting the workforce. Training, and in some cases retraining, is essential if the skills required to operate and maintain the high-tech equipment now being installed in plants and facilities are to be developed.

Consider the new technicians. It is hard to classify them. Are they white collar workers? Are they blue collar workers? They may actually become known as gold collar workers because they will be able to name the company they want to work for, what area of the country they want to work in, and what wage they want to work for. If this seems unrealistic, consider what it takes to hire a skilled electronics technician today. They are rare, and they will receive almost any wage they request because their skills are in high demand and there are relatively few available. The same is true of the mechanical technicians who understand the operating dynamics of their equipment.

The present rate of technology change is leaving some workforces falling behind in technical skills. It is estimated that the technical skills of those working in the plants today will be outdated within the next three-to-five years without retraining. Although this may seem too quick for some industries, there are others where the process technologies change so quickly that they are replacing equipment every year with newer models that have increased technology.

Consider your automobile. Would you want auto technicians who had not been trained in the last three-to-five years working on your latest model? Probably not. First, they would not understand all the new design features, let alone be able to do anything with them. Second, unless they had the latest diagnostic equipment and knew how to use it, they would be limited in evaluating many problems.

A recent study of the job market noted that ”the fastest growth job market for the next decade will be the plant technicians; people who can operate and maintain high tech equipment.”

How is training justified? There are examples of companies that have initiated specialized training for employees and tracked the results from a financial perspective. One company saved over $4.5 million by training its maintenance technicians in the proper installation and maintenance of bearings. Another company saw its maintenance costs for forklifts drop 20% after training the workforce in how to properly operate the forklifts. Each manager should carefully reflect on how much damage is done to plant equipment because the operational and maintenance technicians are not properly trained.

With these points in mind, it is beneficial for each manager to ask “How is my workforce doing in keeping pace with the changing equipment technologies?“ An honest evaluation will be beneficial for all managers. What are some of the indicators to examine? The following indicators will help in the evaluation.

1. Dollars per Employee

This indicator examines the actual average training dollars being spent per employee per year. Many companies will train a select group of employees, such as upper managers, but how much is actually spent on the workforce, where a large return on investment is waiting for most companies? It is not that the importance of management training is being minimized, but rather the focus is shifting to the operating and maintenance technicians and their training. Averages for this indicator range from $1,200 to $1,500 per employee per year.

$$\frac{\text{Total Training Dollars}}{\text{Total Number of Employees}}$$

This indicator is derived by dividing the total training expenditures by the total number of employees. This ratio gives in dollars the revenue per employee spent on training. The indicator can be calculated on a monthly basis and trended over time to insure that proper attention is being given to the training needs of the organization.

Strengths

The indicator is useful for trending the training expenditures and insuring that the proper overall level of training is being funded.

Weaknesses

The indicator fails to address the issue of training needs. In other words, is the training that is being funded the right training for the needs of the workforce at the current time? If this indicator is utilized exclusively, then a false sense of achievement may be realized by some organizations.

2. Hours per Employee

This indicator examines the actual average training hours being allocated per employee per year. Many companies will train a group of employees with "soft" skills, such as diversity and team building training, but how much time is allocated for their technical training? It is not that the importance of soft skills training is being minimized because these skills are essential to improving organizational effectiveness. However, how much is being expended in pure technical training for the operating and maintenance technicians? The technical training is also essential if the workforce is to be effective in operating and maintaining the company's high tech equipment. In fact, studies have shown that the technical training and the interpersonal training should be almost an even 50–50 split.

$$\frac{\text{Total Technical Training Hours}}{\text{Total Number of Employees}}$$

$$\frac{\text{Total Interpersonal Training Hours}}{\text{Total Number of Employees}}$$

These indicators can be derived by dividing the total training hours in each category by the total number of employees. This gives in hours the time per employee spent on each type of training. The indicator can be calculated on a monthly basis and trended over time to insure that proper attention is being given to the training needs of the organization.

Strengths

This indicator is useful for trending the training expenditures by type of training and insuring that the proper overall level of training is being funded.

Weaknesses

While these two indicators are more effective than the first one, they still fail to address the issue of training needs. Again, is the training being funded the right training for the needs of the workforce at the current time? Also, if these indicators are utilized exclusively, then a false sense of satisfaction may be achieved by some organizations.

3. Grade Reading Level

This indicator is more confidential that the previous two. It examines the overall grade reading level for the plant and expresses it as an average. This information is disturbing to some plants the first time they conduct a reading level assessment. In informal surveys conducted with seminar attendees over several years, the average reading level in most plants today averages about eighth grade. The ranges are from a low of a third-grade average to a high of second-year college. Another disturbing statistic is the illiteracy level in some plants. It has been found that in some plants, one-third of the maintenance workforce is functionally illiterate. It does little good to print out a work order, if the maintenance technician can't read it. At the other extreme, one computer chip manufacturer requires its maintenance technicians to have a four-year college degree. This observation is not given to suggest that all maintenance departments must set that requirement, but the chip manufacturer does set a different standard.

There is no formula for this standard. It is derived through standard testing and then averaging the plant totals.

Strengths

This indicator is useful for highlighting the company's standard when it comes to basic skills. If the results are low, then some remedial training in basic skills is required.

Weaknesses

If the testing and results are not kept confidential, the technicians may view it as a way to humiliate individuals or to highlight those who the organization may want to replace. The goal should never be to do anything like this. It is to identify if the plant has an overall problem in the area of reading skills. Furthermore, the goal is to identify what basic skills are needed in the organization and what steps must be taken to insure those needs are filled through workforce additional training.

4. National Test Averages

This indicator examines the actual skill levels of individuals in the workforce through nationally recognized testing. The company can then evaluate how their employees match up with the averages in their own area or even in the areas where their competitors are located. A highly skilled and trained workforce allows a company to do many things that a company with marginally trained workers can not. For example, if a company's competitors have a workforce with a higher level of skills, those companies may be able to move its workers into multi-skilling, operator involvement, or other high performance initiatives.

This indicator has no formula. It is derived from national testing results.

Strengths

The indicator is useful for comparing work force skills from plant to plant within a company, or for geographical comparisons with a competitor's workforce.

Weaknesses

This indicator is simply averages, which may vary. A highly-trained workforce may exist in one area raising what would otherwise be a lower average score. This can skew results when trying to compare areas. The averages are good to consider, but no comparison should be viewed as absolute.

5. Correspondence Training and Testing

This indicator examines the actual training scores of the plant employees in various technical courses. Managers can then identify and utilize the skills and talents of the various employees. If the training and testing are part of a pay-for-knowledge or a pay-for-skills program tied to a needs/task analysis, then the scores can be used to promote individual technicians or to increase their pay based on applied skills.

There is no formula for this indicator. It is derived from the testing results.

As shown, this indicator will be the test scores themselves. The scores can be used to identify those individuals with high skill levels who can then be deployed in tasks that require the higher level skills and abilities. If the training and testing are tied to a job needs/task analysis, the results can be used to move individuals into a pay-for-applied skills and knowledge program, encouraging the technicians to constantly improve their skills.

Strengths

This indicator is useful for tracking the skills of individual employees.

Weaknesses

This indicator can be used to compare employees and rate them with their peers in an open forum. However, it should never be used that way. The testing and training progress of the employees should be kept at the highest confidence level. Any failure to provide security for this information can result in a complete lack of workforce support for any training or improvement program

6. Number of Training Employees Compared to Maintenance Employees

This indicator examines the actual number of training employees per maintenance employee. This ratio will help an organization insure that the training programs for maintenance are staffed for success. Otherwise, the right amount of training will not be administered because the staff will not be available to deliver or coordinate the training.

$$\frac{\text{Total Number of Training Employees}}{\text{Total Number of Maintenance Employees}}$$

This indicator is derived by dividing the total number of training employees by the total number of maintenance employees. This ratio highlights the staff support for the maintenance training effort. Depending on how much of the training is delivered by in-house instructors and how much is performed by contractor instructors, this indicator can vary dramatically. For example, the ratio can average from one training person for every 150 employees to as high as 1 training person for every 400 employees. In establishing a ratio goal for a plant, the training staff person's workload should be closely monitored to insure effectiveness of the training.

Strengths

The indicator is useful for monitoring the level of staffing of the training department.

Weaknesses

This indicator has such a broad range that a company may feel that as long as its numbers are within that range, they are staffed satisfactorily. Without careful monitoring of the training workload, the training staff may find themselves overloaded. This overload condition will impact the overall effectiveness of the training and the company will fail to see the results from the training that should have been achieved.

7. OSHA Recordable Injuries per 200,000 Labor Hours

This indicator measures the number of OSHA recordable accidents per 200,000 labor hours worked. This indicator is a common one in the United States, but has little meaning in other countries because their monitoring organizations will utilize a slightly different calculation. The formula itself is straightforward:

$$\frac{\text{Number of OSHA Recordable Accidents}}{\text{200,000 Labor Hours}}$$

The result is expressed as a ratio.

Strengths

This indicator is standard in the United States. All companies are required by law to track this information in the same format, allowing for an accurate comparison with other companies or industries.

Weakness

This indicator has no weakness.

Indicators Specific to Technical Training

The following indicators should be valuable to organizations attempting to cost justify training programs or trying to establish the value that training programs can provide to the overall profitability of the company. One might use the saying:

"If you think training is expensive, try to calculate the cost of naivete"

The following indicators will help a company calculate what the cost is of not training their employees actually, and further strengthen the business case for increased technical training.

8. Downtime Related to Operator Training

This indicator examines the actual equipment downtime that is caused by the operators' skill deficiencies. In many cases, extensive training programs do not exist for operators. Although regulatory programs such as Process Safety Management (PSM), OSHA regulations, and ISO-9000 certification require extensive operator training, few companies actually have documented standard operating procedures. If the maintenance and engineering department personnel were surveyed, what is the equipment downtime caused by a lack of knowledge or skills on the part of the operations personnel? What if the cause could be recorded in the CMMS and added across a department or even the entire plant for a month? For a year? What amount of downtime would be identified?

$$\frac{\text{Total Downtime Attributed to Operational Errors*}}{\text{Total Downtime}}$$

This indicator can be derived by dividing the total downtime attributed to operational errors by the total downtime. This indicator has flexibility and can be derived for an area, a department, or an entire plant.

One of the most valuable alternatives to using the raw indicator is to calculate the cost of an hour of downtime to the company. It varies from type of equipment and type of process. The cost of downtime includes the cost of the lost product or throughput for the hour; not just the cost of idle labor or overhead for the hour. The argument that "there is no cost to downtime, we can make up the production" is analogous to the arguments companies use when they make rejects and rework items, but do not calculate the costs. Improvements in quality tend to come only after someone calculates what nonconformance or non-quality actually costs a company.

Estimates for per hour downtime costs range from $1,000 per hour for simple machining operations to over $40,000 per hour for line costs in a brewery and over $100,000 per hour for downtime in a computer chip manufacturing plant. If the hours of downtime attributed to operational errors are multiplied by these figures, then the training programs become easier to cost justify.

Strengths

This indicator is useful for tracking the hours of downtime caused by operational errors. However, it is even better utilized by tracking the reduction in downtime hours once a training program has been implemented. It is then easy to calculate the return on investment for the training.

Weaknesses

It is easy to use this indicator as a tool to identify operations personnel making mistakes, then punish them rather than using the training programs to improve their performance. If the indicator is used as a tool for punishment, then the operations personnel will find ways to cover over the root cause of the problem and the losses will never be identified and eliminated. If this indicator is to be utilized, it must be with the proper goals.

9. Downtime Related To Maintenance Training

This indicator is similar to the previous one with the exception that it focuses on maintenance skill deficiencies. In many companies, apprentice programs for maintenance do not exist. Some companies have no structured training programs in place to progressively improve the current level of technical maintenance skills. Although regulatory programs such as Process Safety Management (PSM), OSHA regulations, EPA requirements, and ISO-9000 certification require extensive maintenance training and documentation, few companies actually have documented standard maintenance training and procedures. Therefore, if the maintenance and engineering department records are surveyed, what is the equipment downtime caused by a lack of knowledge or skills on the part of the maintenance technicians? What if the cause could be recorded in the CMMS and added up across a department or even the entire plant for a month? For a year? What amount of downtime would be identified?

$$\frac{\text{Total Downtime Attributed to Maintenance Errors*}}{\text{Total Downtime}}$$

This indicator can be derived by dividing the total downtime attributed to maintenance errors by the total downtime. This indicator has flexibility and can be derived for an area, a department, or an entire plant.

Factoring the cost of downtime into the indicator can also provide the same benefits that it did in the operations example.

Strengths

This indicator is useful for tracking the hours of downtime caused by maintenance errors. However, it is even better utilized by tracking the reduction in downtime hours once a training program has been implemented. It is then easy to calculate the return on investment for the training.

Weaknesses

It is easy to use this indicator as a tool for identifying maintenance personnel making mistakes and punishing them rather than using the training programs to improve their performance. If the indicator is used as a tool for punishment, then the maintenance personnel will find ways to cover over the root cause of the problem; the losses will never be identified and eliminated. If this indicator is to be utilized, it must be with the proper goals.

10. Lost Productivity Related To Maintenance Training

This indicator examines the productivity losses in maintenance activities caused by a lack of skills and knowledge in the maintenance work force. This indicator is more difficult to calculate than the previous two because the measure typically involves a subjective assessment by a supervisor or manager of a maintenance technician's actual work activities. The items highlighted here would be any time that is lost because an individual does not have the skills or knowledge to perform the work in the most effective and efficient manner.

$$\frac{\text{Estimated Lost Time Due to Lack of Knowledge or Skills*}}{\text{Total Time Worked}}$$

This indicator can be derived by dividing the estimated time lost due to a lack of knowledge or skills by the total time worked. This indicator can be tracked by type of work, specific job, specific skill, or any parameter that might be useful in identifying a potential training need. These needs can then be prioritized based on the amount of time lost. The wage rate and impact on the time to perform the task (including the downtime of the equipment) can all be calculated in dollars and the required training can be cost justified.

As the training is conducted, the increased productivity can be tracked and the results expressed in dollars saved. This measure is effective in calculating return on investment for the training program.

Strengths

This indicator is useful for identifying training needs, cost justifying the training, and calculating the return on investment once the training is conducted.

Weaknesses

This indicator requires a subjective opinion on the amount of lost productivity attributed to a lack of knowledge or skills. This opinion may be disputed by some in the organization. However, if similar work can be found in other departments and plants, and comparisons drawn from these examples, then some of the disputes can be eliminated.

The indicator can also be used to compare individuals. In itself, this is not wrong, but if one uses this data to reprimand or even criticize an employee, the use of the indicator will eventually be discontinued. Proper focus and understanding of the indicator's use is critical to its success.

11. Percentage of Maintenance Rework Related To Maintenance Training

This indicator examines the amount of rework that is performed by the maintenance workers. Rework is defined as work that, because it was not done completely and correctly the first time, must be adjusted, changed, or perhaps done completely over again. What amount of this type of work occurs because there was a lack of knowledge or skills on the part of the technician who performed the work the first time? This type of rework needs to be identified because it can be eliminated through a focused training program.

$$\frac{\text{Maintenance Rework Due to Lack of Knowledge or Skills*}}{\text{Total Maintenance Work}}$$

This indicator can be derived by dividing the total hours of maintenance rework by the total hours of maintenance work. The resulting percentage highlights the opportunity for improvement by training the technicians so they can do the job right the first time. The losses in labor costs and material costs can be calculated for the rework and used as justification for the training program. In addition, the cost of the downtime incurred during the rework should also be factored in the savings potential. The return on the investment for the training can be calculated by trending the decrease in maintenance rework. The return on investment is calculated by the cost of the training program compared to the savings in reduced maintenance labor, materials, and plant equipment downtime.

Strengths

This indicator is useful for calculating the potential benefits of eliminating or reducing maintenance rework by increased maintenance training.

Weaknesses

This indicator's weakness is the slight chance that some of the maintenance rework will not be properly identified. In addition, the information may be misused as a way to punish technicians, instead of using it to focus the training effort.

12. Average Training Versus Payroll

This indicator examines the actual average training dollars being spent compared to actual payroll. It is similar to the training dollars per employee calculation. However, this indicator compares the actual training cost as a percentage of plant payroll. Typically about 3% of the plant payroll should be spent on training. Again, the question must be asked: What type of training and for whom? Is it management training, interpersonal training, or technical training? The indicator is calculated as follows:

$$\frac{\text{Total Training Dollars*}}{\text{Total Plant Payroll}}$$

This indicator can be derived by dividing the total training expenditures by the total plant payroll. The resulting percentage shows the amount of the plant payroll allocated to training.

Strengths

The indicator is useful for trending the training budget as the plant payroll increases or decreases. It insures that the proper level of training is budgeted.

Weaknesses

The indicator has no major weaknesses. It is essential to have plant management commit to the proper percentage. Then as the plant increases or decreases the number of employees, the proper level of training is assured.

Problems with Technical Training Programs

With the challenges mentioned at the start of this chapter, it is apparent that most training programs are experiencing problems, if not outright failure. The most common reasons for training program failures are discussed in the following material.

1. Only Using On-The-Job Training (OJT)

This problem is common in organizations without the resources to develop a structured and documented training program. The managers rely on the other technicians to show an operator how to run equipment or, for a maintenance person, how to maintain, troubleshoot, and repair the equipment. Because the employees giving the on-the-job instruction also have other jobs, they are hurried to convey the minimum of what the trainees need to perform the basics of the job.

The detailed instruction that makes a technician efficient and effective is never provided. The trainees then may make great personal efforts to perform

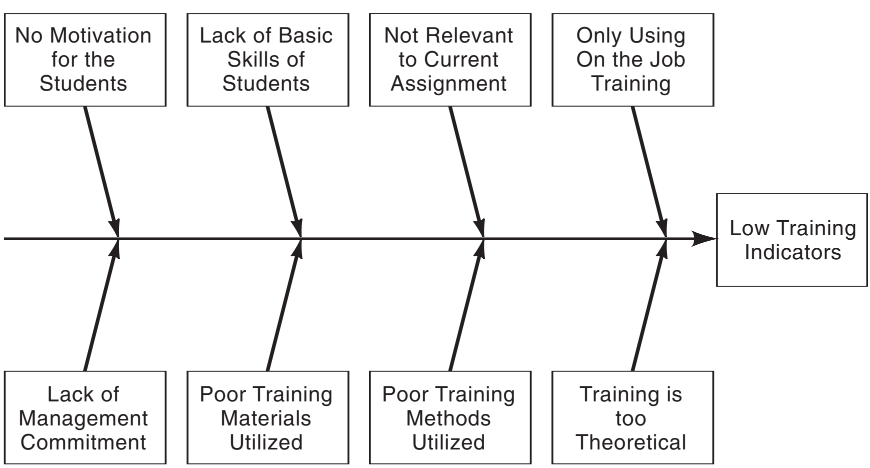


Figure 7.1 Training program indicator tree

the job, but are never efficient and effective. In addition to wasted labor resources, the equipment operation is affected and plant capacity suffers.

If companies are using only on-the-job training, they should remember that the method also teaches trainees someone else's bad habits. On-the-job training is never successful unless it is supplemented by additional training.

2. Training Is Too Theoretical

In some training programs, the information is taught directly out of textbooks and never supplemented with any actual application of the material to the technician's work assignment. Instead, the technician must make the application. Some will be able, but most will not. This limitation impacts the effectiveness of the training; the return on investment in the form of improved technician performance will not be realized.

The solution is to make the training job relevant. This may involve a duty or task analysis of the job, and blending theory, hands-on lab activities, and on-the-job training to assure that the trainees will be able to master the new skills being taught. Without being able to make the training job relevant, there is little chance for retention on the part of the trainees.

3. Training Not Relevant to Current Assignment

Once training has taken place, it is important that the trainees can put the new skill and knowledge to use. If they must go weeks or even months before they can use the training on the job, their retention rate falls to a very low level. In fact, if months have elapsed, they may need retraining.

The message here is short and concise: provide the right training at the right time and at the right level. Unless these criteria are met, the organization will waste its training expenditures.

4. Poor Training Methods Utilized

The issue underlying this problem is a lack of flexibility in the training delivery. A good training program uses a blend of materials and presentation styles. These include:

Traditional classroom settings
Computer-based training modules
Video-based training modules
Self-paced correspondence materials
Satellite training broadcasts

If one style of presentation is used exclusively, then trainees become bored and uninterested. By using a blend of techniques, the instructors can insure the training program always holds the attention of the trainees.

5. Lack of Basic Skills of Students

Unfortunately, lack of preparation is becoming a large problem in many companies today. As individuals leave high school, they lack the basic skills in reading, writing, and mathematics. In turn, companies have no choice but to develop internal basic training programs designed to insure a minimum competency in the workforce. Although some companies do not have a problem in this area, due to acceptance testing, other companies do not have favorable geographic locations, compensation systems, or work environments to assure a pool of highly-qualified candidates from which to select employees.

6. Poor Training Materials Utilized

Poor training materials may indicate insufficient funding for the training program. Some training programs using photocopies of copyrighted materials. In other cases, materials are many years old are used and even recirculated among trainees. If a training program is to be effective, appropriate training materials must be provided. Many quality sources provide excellent training materials.

7. No Motivation for the Students

This area is sensitive in many companies. What is the incentive for an employee to want to learn new skills? Some issues include:

Will there be a pay increase?
Do the new skills lead to a new job?
Is training required to perform the current job due to a technology upgrade of the equipment?
Is training just to insure the employability of the technician?

The motivation may be all, some, or even none of these reasons. Keep in mind: no matter what is used, something will have to motivate the employees to take the training and apply it. It is up to the management of each organization to find the right motivation for its workforce.

8. Lack of Management Commitment

One fact is clear: training is expensive, but ignorance is even more costly. In many cases, however, when cost reductions are made, cuts begin in training and maintenance. These cuts are really a problem in maintenance training. Management needs to be committed to training its employees if the company is to be competitive in the next decade.

Training needs to focus on the return on investment the company will receive. Therefore, training must focus on resolving identified issues. These issues will have to be rated by the financial impact they have on the company. They will have to have a training needs analysis performed to identify the training requirements. The training will have to be developed or purchased. The results of the training will have to be tracked. The improvements will have to be expressed in a dollar amount so that the return of the training investment can be calculated and the effectiveness of the training evaluated.

Unless these activities are undertaken in a detailed and structured format, management will never commit to a sustainable training program.

CHAPTER 8

Operational Involvement

Most organizations today face a shortage of maintenance technicians to perform much of the technical work that needs to be performed on the equipment. In addition, many times the equipment doesn't operate correctly because it doesn't get the level of attention and service it needs from the maintenance department.

Faced with these problems, many organizations are looking for activities in which they can involve equipment operators or other operational and facilities personnel. In this way, they can then free up their maintenance resources to concentrate on other activities where their technical skills can be better utilized, such as the predictive and reliability activities detailed in subsequent chapters.

First, though, what are some of the activities in which operators or operations personnel can be involved, and that can free up maintenance resources? The activities vary from company to company, but include the following:

Start up inspections
Cleaning
Routine lubrication
Mechanical fastening
Minor maintenance
Data collection

Start up inspections require nothing more than a visual check of all of the start-up conditions of the equipment. This step would include checking for:

Proper lubrication levels
Proper, tight connections on all air, water, and hydraulic hoses
Proper connections on lubrication lines, particularly grease lines
Proper torque or tightness of all mechanical fasteners
Proper pressure, flow and temperature of process equipment

Although these may seem like little things, how much of the maintenance resources would be required to make these checks before equipment was allowed to start at the beginning of an operational shift? The resources would be considerable. But now, with the operators performing these checks, the maintenance resources can be re-deployed to other activities.

Equipment cleaning is a second activity in which many companies have operators involved. In fact, it is the primary activity in most companies, unfortunately for the wrong reasons. Certainly clean equipment is easier to inspect, it decreases contaminate related wear, and it raises morale. Yet there is also a technical reason that clean equipment is required. Operators, helping to insure removal of contamination from their equipment, can do much to relieve extra work from the maintenance department. As an example, gearcases, motors, and hydraulic systems are required to be kept clean to prevent heat buildup. If contamination is allowed to build up, the thermal transfer process (allowing heat dissipation) is interfered with, and heat build up begins. As the temperature increases, the life of the component decreases. While equipment breakdowns do not occur immediately, they happen in a fraction of the design life of the component. Many of these types of breakdowns can be minimized or prevented altogether through operational involvement in the cleaning and inspecting.

A third activity that operators can be involved in is the routine lubrication of the their equipment. This does not mean the operators have to walk to the storeroom and find the right oil or grease for their equipment. In many companies, it is the responsibility of the maintenance department to insure the proper lubricant is close to the equipment. Therefore, it takes little time and effort for the operators to get the lubricant they need for their equipment. Dispensers and filling equipment should also be conveniently provided. Instructions on quantity and application method of the lubricant should be provided. If the operator lubrication program is properly structured, it can relieve a large portion of the maintenance labor to be re-deployed.

A fourth activity for the operators involves proper fastening or tightening procedures. When examining the root cause for many mechanical breakdowns, it is apparent that the majority begin due to poor fastening procedures. Lack of proper torquing techniques is a major factor. Operators can be taught to look for loose fasteners, then to report or repair them before they start to loosen and create wear. This step reduces the need for maintenance technicians to be involved in this level of activity, again freeing up more of their time to concentrate on other activities.

In some companies, the operators are trained to perform minor maintenance on their equipment. The tasks that they perform must be carefully selected because training will be required for each task. Generally, the companies select the top 5-to-10 nuisance tasks. These are tasks that generally take less time to perform than is needed to get a maintenance technician to the equipment.

These tasks are typically small items, such as realigning a photocell, adjusting a mechanical stop, or resetting a stop switch. Each of the tasks are carefully outlined, detailing each step, identifying all of the possible safety issues, the small tools that may be required, and a visual diagram of the task. The operator is then trained how to do the task by the maintenance technician responsible for the equipment. When the training is complete, the task sheet is kept in a notebook at the operator's station for further reference each time the job needs to be performed. This process insures the operator is trained to work safely and the task is performed correctly.

One additional task in which some companies are involving the operators is using the CMMS/EAM system for data collection. In these companies, rather than forwarding a hand-written request (or even a telephone request), the operators actually enter work requests into the CMMS/EAM system. This request is then processed by someone in the maintenance department (usually a planner) and is converted into a work order. Some companies will even have the operators enter the minor maintenance they perform on their equipment directly into the CMMS/EAM system. In other companies, the operators record downtime amounts and causes. Again, the focus is on activities that free maintenance resources.

How does one monitor the effectiveness of operational involvement in maintenance activities? The following are some suggested indicators and performance measurements.

1. Percent of PMs Performed by Operators

This indicator examines the preventive maintenance program and what percentage of the work is being performed by the operations group. This indicator is valuable for insuring that some of the preventive maintenance is being performed by the operators. In most companies, the range is from 10% to 40% of the preventive maintenance workload.

$$\frac{\text{Hours of Preventive Maintenance Performed by Operators*}}{\text{Total Preventive Maintenance Hours}}$$

This indicator can be derived by dividing the total hours of preventive maintenance performed by operators by the total hours in the preventive maintenance program. The resulting percentage shows the amount of the PM program being performed by the operators. In calculating this indicator, it is best to use a weekly total and then trend the indicator over a 6-to-12 month window.

Strengths

This indicator is useful for insuring there is operational involvement in the preventive maintenance program. It helps everyone in the organization to focus their efforts on performing the most maintenance on the equipment that they can with the best results.

Weaknesses

The weakness of this indicator is that sometimes someone has in mind a preconceived target level of the percent involvement that operators should have in the preventive maintenance program. To meet this level, they either encourage the operators to do too much or too little. When determining the correct level of operator involvement at a plant, the focus should be on the high time/lower skill activities that can easily be transferred to the operators. This insures the correct level of operations involvement.

2. Savings Due to Operator Involvement

This multi-part indicator focuses on the value derived from the operator's involvement in maintenance activities. The areas are:

A. Increased Uptime

This indicator examines the increased uptime that equipment is experiencing due to the operators' activities. The indicator looks at the maintenance downtime for the current year and divides it by the maintenance downtime for last year for the same time period. The result is the percentage increase (or decrease) in uptime. This information helps the operations and maintenance technicians clearly see the benefits of operational involvement.

$$\frac{\text{Maintenance-Related Equipment Downtime (current period)*}}{\text{Maintenance-Related Equipment Downtime (previous year same period)}}$$

This indicator can be derived by dividing the total hours of maintenance-related equipment downtime for the current period this year by the maintenance-related equipment downtime for the same period for the previous year. The resulting percentage shows the increase in uptime for the operator involvement. In calculating this indicator, it is best to use a monthly total and then trend the indicator over a 12-month window.

Strengths

This indicator is useful for highlighting the benefits of the operator involvement in the maintenance activities

Weaknesses

The weakness of this indicator is that, in all probability, not all of the increase in uptime will be directly attributed to the operator involvement. However, even if the increased uptime is due to some predictive maintenance or reliability activity, the operator involvement still contributed by freeing up the resources to engage in these activities.

B. Increased Capacity

This indicator examines the increased capacity for the equipment due to the operator's activities. The indicator looks at the equipment throughput for the current year and divides it by the equipment throughput for the same time period last year. The result is the percentage increase (or decrease) in throughput (capacity). This indicator is different from the previous one in that the last one focused on equipment uptime. This indicator focuses on capacity, which is the uptime, performance efficiency of the equipment and the quality of the product. This indicator helps the operations and maintenance technicians clearly see the benefits of operations involvement.

$$\frac{\text{Actual Equipment Throughput (current period)}}{\text{Actual Equipment Throughput (previous year same period)}}$$

This indicator can be derived by dividing the total output for the equipment for the current period this year by the total output for the equipment for the same period for the previous year. The resulting percentage shows the increase (or decrease) in uptime for the operator involvement. In calculating this indicator, it is best to use a monthly total and then trend the indicator over a 12-month window.

Strengths

This indicator is useful for highlighting the direct production benefits of the operator involvement in the maintenance activities

Weaknesses

The weakness in this indicator is that, in all probability, not all of the increase in capacity will be directly attributed to the operator involvement. However, even if the increased capacity is due to some predictive maintenance or reliability activity, the operator involvement still contributed by freeing up the resources to engage in these activities.

A second weakness is the possible variance in market demand for the product between the two years. Fluctuating demand can have an impact on the throughput, thus impacting the indicator. If this is the case, the calculation may need to be adjusted to a combination of target and actual design capacity to insure a realistic indicator.

NOTE: The indicators above help show the maintenance and operations technicians the value of their involvement. However, before using the indicators to show upper management the benefits, it will be necessary to convert them to a financial indicator that shows the impact on profitability that the increase in uptime or capacity has had across the year
.

C. Maintenance Resources Made Available

This indicator examines the increased maintenance resource available due to the operator's activities. The indicator compares the percentage of maintenance activities the operators are performing this year with the same time period last year. The result is the percentage increase (or decrease) in maintenance resources available. This information shows the operations and maintenance technicians the benefits of operational involvement.

$$\frac{\text{Hours of Maintenance Activities Performed by Operators (current period)}}{\text{Hours of Maintenance Activities Performed by Operators (previous year same period)}}$$

As the formula shows, the indicator can be derived by taking the total hours of maintenance activities performed by the operators for the current period and dividing it by the total hours of maintenance activities performed by operators for the same period for the previous year. The resulting percentage shows the increase (or decrease) in operator-performed maintenance activities. In calculating this indicator, it is best to use a monthly total and then trend the indicator over a 12-month window.

Strengths

This indicator is useful for highlighting the change in the operator involvement in the maintenance activities

Weaknesses

The weakness in this indicator is that, in all probability, over time, the percent increase will level out and decrease as the operators assume all of the maintenance duties that they can fit into their schedule. Therefore, as the indicator decreases in size, the reason must be clearly communicated. Any increase after saturation will be incremental, but shows a continuous improvement attitude.

3. Percent of Operator Time Spent on Equipment Improvement Activities

This indicator examines the percent of time the operators spend on equipment improvement activities and compares it to the operator's total time.

$$\frac{\text{Hours of Equipment Improvement Performed by Operators*}}{\text{Total Hours Worked by Operators}}$$

This indicator can be derived by dividing the total hours of equipment improvement activities that the operators perform by the total hours worked by operators. The resulting percentage can be trended over time to show the level of involvement of the operators in equipment improvement activities. In calculating this indicator, it is best to use a monthly total and then trend the indicator over a 12-month window.

Strengths

The indicator is useful for highlighting the level of involvement in equipment improvement activities. It helps to insure that the improvement activities are consistent. It prevents the program from losing focus. If any negative trends are noted, they can be corrected before serious damage is done to the equipment improvement program.

Weaknesses

There is no major weakness in to this indicator. It should be used by any organization utilizing continuous improvement tools.

Problems With Operational Involvement

Although the majority of companies today see the benefits of involving their operations groups, few are able to accomplish this involvement successfully. In fact, surveys have shown that, on average, only about 30% of the companies achieve the results they intended. Why is the success rate so low? The following problems are common to operations involvement.

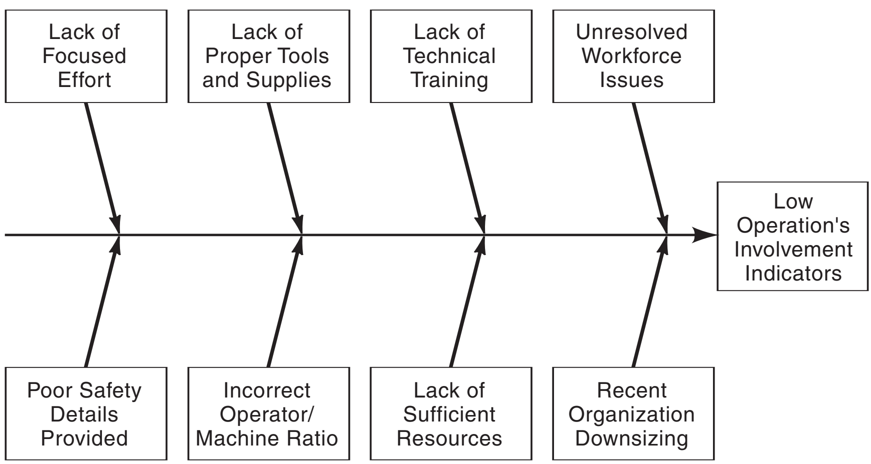


Figure 8.1 Operation's involvement indicator tree

1. Unresolved Workforce Issues

This problem can also be referred to as unresolved labor-management issues. In most cases, successful operational involvement programs have cooperative union and management relations. But when management and the workforce have a high level of grievances and unresolved issues, it is difficult to initiate operational involvement in maintenance or equipment improvement activities.

Typically, the involvement of operations personnel in maintenance activities requires crossing boundaries (either imaginary or real) between what has been two separate organizational functions. Even when management and workforce relations are good, the start up can be somewhat rocky. If the relations are already strained, then initiating discussion about operators being involved in maintenance activities may further worsen the situation.

If the negative issues are not resolved, then discussions typically reach an impasse, preventing any positive progress toward operational involvement. If the involvement of operations personnel in maintenance and equipment improvement activities is the goal of an organization, then positive management–workforce relations must be developed and nurtured. Without a mutual trust and a focus on being competitive in the world market, a company will not initiate any sustainable operations involvement program. Always remember that the real competitors are outside the company – not inside.

2. Recent Organizational Downsizing

A negative trend in most companies today has been the downsizing of the workforce. While it is true that some organizations have grown heavy with excess employees, many have cut too deeply into their employee base. An honest evaluation should be made as to whether the reductions are truly part of a focused reengineering effort, or just a way to convince Wall Street to raise the stock price.

The reason that this issue is critical is that if the workforce is concerned about what downsizing has recently occurred and whether there is going to be more in the future, it is difficult to start any operational involvement activity. Some employees may feel that if they take on any tasks that maintenance personnel currently perform, then the maintenance department might lose more people. In addition, the maintenance personnel will feel the same, and only partially train the operations personnel to perform the transferred tasks. The result is that equipment suffers and more problems occur, insuring the maintenance personnel will have enough work to keep the current staff busy.

If the workforce is concerned about losing more personnel through operational involvement in maintenance activities, then there is little chance of success. If operational involvement is to be successful, company management must address job security issues for the workforce. Unless company management is willing to do this, it would be in the best interests of all concerned to wait until another time to begin operator involvement in maintenance activities.

3. Lack of Technical Training

Many companies lack an appreciation for the skills required to be proficient in performing maintenance activities. In some cases, companies have provided operators with grease guns to lubricate their equipment, but have never provided any training on lubrication techniques. As a result, bearings were found with no grease, others had their seals blown out from excessive grease, and some had the wrong grease. The number of bearing failures and the resulting equipment downtime increased dramatically, affecting the equipment capacity and the morale of the workforce.

If a company is going to involve operators in any maintenance or equipment improvement activities, then technical training must be provided. Unless it is clearly understood that maintaining and improving a technology (which is what a piece of equipment is) requires technical skills, little if any benefits will result from operator involvement in maintenance activities.

4. Lack of Sufficient Resources

This issue focuses on the resources required to perform any activities assigned to the operators. Suppose the equipment to be maintained is on a manufacturing line, and the line requires four operators to run it. If only four operators are scheduled, how will they find the time to perform any maintenance activities? If their assignment on the line does not include some free time to perform the maintenance activities, then they must shut the equipment down to perform the maintenance activities. Is this cost effective? Do the downtime losses outweigh the benefits derived from the operator-based activities? Without proper resources, the maintenance activities are likely not to be performed because they are viewed as lower priority than the production throughput.

Many companies actually overstaff their lines or processes with an extra person (or more, depending on workload) to perform maintenance activities and other functions assigned to the operators. This overstaffing alleviates the strain on the resources and insures the equipment receives the correct level of attention. For continuous run processes, the activities are divided into run and down maintenance. The run maintenance activities can actually be performed when the equipment is operating, further reducing the amount of downtime required to perform maintenance. These activities further reduce the resource strain when the equipment is down. The company must examine methods that will eliminate the strain on resources and still keep the equipment properly maintained.

5. Lack of Proper Tools and Supplies

Many companies don't realize that it requires tools and supplies to perform maintenance on the equipment. The maintenance department is typically autonomous in obtaining its supplies. The operators are not as adept at it. So someone needs to insure that the operators have the tools and supplies they need to perform their assigned tasks.

The solution is not complicated. Either maintenance can supply the operators' needs or a means can be provided for them to easily procure their own supplies and tools.

6. Incorrect Operator/Machine Ratio

In many companies, the operators are required to work in manufacturing cells, meaning that one operator may run multiple pieces of equipment to produce a product. This involves considerable time and effort on the part of the operators. The question is: Do these operators have additional time to properly perform maintenance activities on the equipment? As before, it may be assumed that they can take a few minutes here and there to get the maintenance tasks done. However, if they are pushed to meet their production goals, will they take the time?

In companies where operators are required to operate multiple equipment items, the level of maintenance activities assigned to them may have to be reduced. This may be a resource issue, but it is better to insure that maintenance is being performed.

7. Lack of Focused Effort

The lack of focused effort can also be tied to a lack of training. The operators will lose focus if they do not understand they are being asked to undertake maintenance activities in an attempt to make more maintenance resources available for other activities, while at the same time insuring that the correct level of maintenance is till being performed on the equipment.

Furthermore, if management does not also stay focused and clearly communicate to the operators the value of the activities that they are performing, the operators will lose focus.

The problem is overcome when the organization itself assumes the proper focus and then instills the organizational discipline that insure the operators stay focused on results.

8. Poor Safety Details Provided

This problem focuses on regulatory safety and health issues. If operators are going to perform even small amounts of maintenance on their equipment, they need training to be safe. This training goes beyond the basic operational lock-out tag-out training they may have already received. They need maintenance-level training in these issues. They need to be aware of the second- and third-level energy systems that they may need to lock out before they do maintenance work. They need to be aware of the OSHA regulations impacting any work they are doing.

The solution to this problem is just a good training program, coupled with supervised practice, to insure they are aware of all of the safety issues.

CHAPTER 9

Predictive Maintenance

Predictive maintenance is the monitoring of equipment operating conditions to detect any signs of wear that is leading to a failure of a component. The goal of the predictive maintenance program is to track the component wear with a methodology that insures that any impending failure is detected. Once detected, the component wear is tracked more closely. The component will then be scheduled for replacement before it fails during a scheduled run.

Monitoring the operating condition of the equipment can be accomplished by examining its operating dynamics. The most common techniques for measuring operating dynamics include:

Vibration analysis
Thermography
Ultrasonics
Oil analysis
Lubricant condition
Wear particles

Vibration analysis measures the physical operating vibrations of rotating equipment. Based on the type of equipment, the analysis can indicate problems with bearings, belts, chains, gears, shaft misalignment, and out-of-balance conditions. The major impact that vibration monitoring has in most plants is its use in detecting bearing problems. By knowing days, weeks, or even months in advance that a component is wearing and will fail, the maintenance department can change the part with minimal impact on the operations department.

Thermography measures the temperature of a component. This trending of temperature indicates wear because increased wear is generally accompanied by a temperature rise. The thermographic equipment can be anything from a small temperature strip to an infrared imaging system. The level of detail, coupled with the ability to measure the parameter safely, quickly, and accurately, determines the cost of the tool required. Thermography is typically utilized for finding potential problems (usually poor connections) with electrical and electronic systems. However, it is also used in high temperature applications like furnaces and heat exchangers. In addition, it is used to indicate misalignment in drive couplings.

Ultrasonic inspections are used to check for high frequency noise that is typically created by leaks. Ultrasonic detectors can thus be used to find air leaks, steam leaks, and other fluid leaks. Using stationary detectors, ultrasonic detectors can also be used to inspect pressure vessels and other containers. Although ultrasonics tend to be used as an instantaneous check, the data, especially for pressure vessels, can be trended to show rate of wear.

Oil analysis can be used to refer to at least two different techniques. The first examines the lubricant itself for condition. The analysis reveals whether the oil has become contaminated, is losing its lubrication qualities (corrosion resistance, wear resistance, load rating, etc.), or has been damaged from overheating. The second examines wear particles in the lubricant. This is an indication of the type of wear occurring in the unit being lubricated. If the wear particles show an accelerated wear rate, then the unit can be more closely inspected to find the cause of the wear and correct it. This leads to extended life of the component by detecting a problem before any damage is done to the component.

Because each of the predictive techniques are used to check for a particular type of wear, a mix of the techniques is typically used in a predictive maintenance program. The predictive maintenance program focuses on the following steps:

Track equipment conditions not easily inspected in the preventive maintenance program

Reduce the amount of effort in the preventive maintenance program by using technology instead of disassembly

Reduce the spare parts required to be on hand for unexpected equipment breakdowns or component failures

Allow for a high level of planned and scheduled maintenance work, lowering the amount of conflict with the production schedule

Increase the equipment capacity by insuring it is technically capable of performing at design specifications

Some of the indicators that can be used to determine if the predictive maintenance program is successful follow.

1. Predictive Maintenance Activities as a Percent of Total Maintenance Activities

This indicator examines the percent of maintenance activities that are predictive compared to the other categories of maintenance work. There are two ways to view the indicator. The first is by total hours of predictive maintenance (PDM) time compared to all other hours of maintenance work. The second is by total expense for the PDM program compared to the total dollars spent on maintenance. Most of the PDM work is labor-intensive inspections. Few spare parts are used. However, if the work tracking system can be used to highlight corrective work resulting from predictive inspections, then the ability to compare additional cost benefits will be available.

For Hours:

$$\frac{\text{Hours of Predictive Maintenance Activities*}}{\text{Total Maintenance}}$$

For Costs:

$$\frac{\text{Predictive Maintenance Costs*}}{\text{Total Maintenance Costs}}$$

These indicators can be derived by dividing the total hours (or costs) of the predictive maintenance activities by the total hours (or costs) worked by the maintenance department. The resulting percentages can be trended over time to show the level of hours or costs invested in the predictive maintenance program. In calculating these indicators, it is best to use a weekly total and then trend the indicator over a 12-month window.

Strengths

This indicator is useful for highlighting the level of predictive maintenance activities and insuring that the PDM activities are consistent. They prevent the predictive maintenance efforts from losing focus. If any negative trends are noted, they can be corrected before serious problems develop with the predictive maintenance program.

Weaknesses

There are no major weaknesses with this indicator. They should be used by any organization serious about the predictive maintenance program.

2. Savings Attributed to Predictive Maintenance Activities

This indicator highlights the savings attributed to the predictive maintenance program. It should include equipment breakdowns that were eliminated or prevented due to a predictive inspection. Although this may be difficult to calculate, a real attempt should be made to quantify the savings, thereby insuring the ongoing organizational support for the predictive program. The three major areas of saving are:

a. Increased Equipment Uptime or Downtime Avoidance Cost
b. Increased Equipment Capacity or Increased Performance of the Equipment (not uptime, but performance efficiency)
c. Decreased Maintenance Expense (it is less expensive to make a repair in a planned mode)

These indicators should be tracked on a monthly basis and trended over a year. They should include an annual summary of the yearly savings since the program's inception.

Strengths

These indicators are useful for obtaining and maintaining organizational support for the predictive effort. They can also be used as an educational tool, helping the organization understand the impact equipment reliability has on the profits of the company.

Weaknesses

The major weakness is the difficulty in calculating the cost avoidance. It may be easier if cost data for a previous breakdown were accurately recorded in the CMMS. The downtime should have been a part of the record and the loss can be calculated from that figure. Capacity increases can compare current production rates to the rates before the predictive program was started

3. Decreased Maintenance Expenses Attributed to PDM Activities

This indicator examines the maintenance expense reduction for operating in a predictive mode compared to a reactive or preventive mode. The reduction, which occurs because of the longer planning cycle, lowers the inventory on hand because the order can be placed and the materials received just before they are required for the repair. Because the jobs can be scheduled so far in advance, production disruptions are minimized and less maintenance overtime is required. The two major areas of savings are labor (improved and more reliable scheduling) and spare parts (forecasted demand, not store and use as needed).

$$\frac{\text{Current Maintenance Costs*}}{\text{Maintenance Costs Prior to Predictive Program}}$$

This indicator can be derived by dividing the current maintenance labor and materials costs by the benchmarked maintenance costs prior to starting the predictive program. These costs should be the monthly maintenance expenditures. The result, which is expressed as a percentage, can be trended over a rolling 12 months, with the lowest and highest months displayed as the range.

Strengths

This indicator is useful for developing and maintaining support for the predictive maintenance program. It helps educate the organization about the financial benefits of PDM to the company's profitability. It is also useful for insuring that there is an ongoing return on investment for the predictive maintenance activities.

Weaknesses

The only major weakness of this indicator is collecting the cost data so that it is accurate enough to be accepted by the organization. The cost data should be able to be correlated to the accounting data.

4. Decreased Breakdown Frequency

This indicator examines the Mean Time Between Failure (MTBF) calculation for selected critical equipment items. The effectiveness of the PDM program is determined by having fewer equipment breakdowns. On an equipment-by-equipment basis, the number of breakdowns is divided by the time period, producing a mean time between failure (MTBF).

$$\frac{\text{Number of Equipment Breakdowns}}{\text{Total Hours in Time Period}}$$

This indicator can be derived by dividing the total number of breakdowns by the total time in the examined period. The resulting ratio (MTBF) can be trended over time to show the level of improvement. If the predictive program is working, the MTBF will increase. If it does not increase, then the predictive program needs adjusting. The time frame to use for the calculation is equipment specific. It should depend on the frequency of the failures upon starting the program.

Strengths

This indicator is useful for highlighting the impact that PDM activities have on the equipment failures. It is beneficial to use this indicator to keep the predictive program effective. As long as the MTBF is increasing, the predictive program is effective. If the MTBF decreases, then some adjustments are required.

Weaknesses

There is no major weakness in this indicator. It should be used by any organization utilizing a predictive maintenance program. By the time the organization reaches this level of maturity, the data collection system should be accurate enough to develop the MTBF calculation.

Problems with Predictive Maintenance Programs

Predictive maintenance programs have the potential to produce results for many companies, although few ever achieve the full range of PDM benefits. Why is it difficult to achieve sustainable results? The following problems are often encountered with PDM programs.

1. Insufficient Equipment Failure Data

This problem occurs when an organization has started the predictive maintenance program without building a foundation of the maintenance basics.

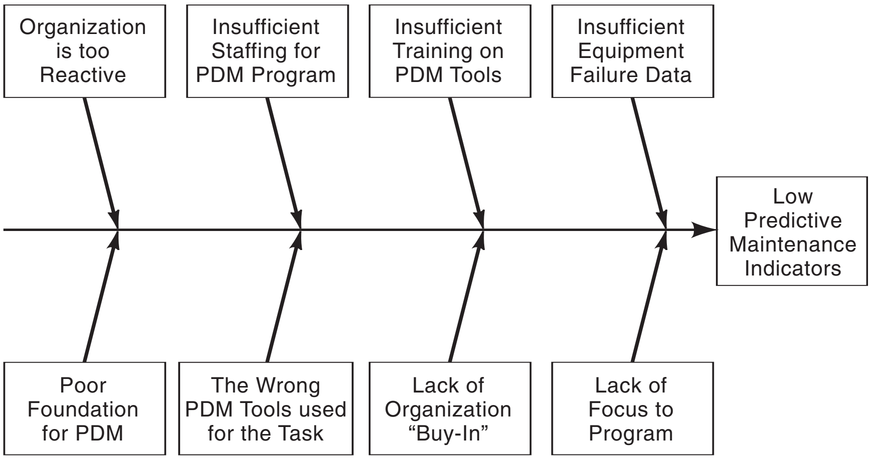


Figure 9.1 Predictive maintenance indicator tree

Because the organization is not fully using the work order system and/or the CMMS, it does not have the data to produce the predictive program indicators.

The solution is to go back to the basics and insure they are in place if the predictive program is to be effective and sustainable.

2. Lack of Focus to the Program

This problem occurs when an organization becomes involved in predictive maintenance because of interest in the "toys of technology." The predictive instruments were purchased, and they were used when new on specific problems, but a structured and disciplined program was never implemented. Therefore, the maintenance department has the tools, but was never trained to be proficient.

This problem is remedied only when a predictive effort is properly scoped for the organization. This means that a study of the equipment, its operating dynamics, and its failure modes must all be performed. Based on the data gathered during the study, the appropriate predictive tools are purchased to detect the equipment problems. The scope of the program, the equipment to be included, the schedule of the inspections, and how to record the data must all be defined. Once the predictive tools are purchased, extended training must be planned and implemented for the maintenance technicians. As the predictive program continues, then adjustments are made to insure its effectiveness, based on the indicators.

3. Insufficient Training on the PDM Tools

In many companies, the permission to purchase maintenance tools is given to several people. In some companies, if an employee needs something, he or she buys it; and a lot of justification is not required. However, sending someone to training or bringing training to the plant is another matter. The request must go through several layers of approvals, with each one asking more questions and cutting a small amount out of the appropriation. Then when the process is finished, there is not sufficient funding to get the best training, so compromises are made and less-than-optimal training is provided, which leads to less-than-optimal results. The effectiveness of the predictive program is impaired and the benefits are never realized. Management then moves on to another program with more promise.

The only way to prevent this problem is to create the proper understanding of the requirements of a successful predictive program when developing the plan. In this way, when the request for training is generated, it is already preapproved.

4. Lack of Organization "Buy-In"

This problem occurs when the maintenance department never really sold the predictive program to the rest of the company. The maintenance department personnel know what to do and what the benefits will be, but this information is never clearly understood by the rest of the organization. When the maintenance department then says the equipment needs to be taken off line for an imminent failure, no one believes them. The equipment fails and the maintenance department is driven into a reactive mode.

The only way to insure that this does not happen is to clearly communicate the benefits and scope of the predictive program prior to starting it. Sufficient examples from other companies (usually available from the predictive maintenance vendors) with success stories must be communicated to the organization. Sample scenarios of what will happen in a predictive program in the company, based on others' experiences, must be developed. Then when issues are raised, they will be easier to resolve.

5. Insufficient Staffing for the PDM Program

This problem is related to several of the previous issues, but begins with a lack of a complete plan to implement the predictive maintenance program.

Without the plan, requirements are never understood; proper staffing is one of the requirements. Maintenance departments should never be asked to do predictive maintenance instead of some other aspect of the maintenance program. A predictive maintenance program should not have the motto "In your spare time, do this."

When starting the predictive maintenance program, a business plan must be put together with resource requirements and a return-on-investment study. Otherwise, proper staffing will always be a problem.

6. The Wrong PDM Tools Being Used for the Task

There could be several reasons for the wrong tools being used. One could be that the manager is knowledgeable about only one predictive maintenance technique; therefore, the sole focus of the program is on that technique. Another reason could be cost. With a limited budget, maybe only one predictive tool could be purchased and trained. Whatever the reason, the predictive program will have limited success if it has a single focus. What complicates matters even further is if the wrong technique is applied to solve an equipment problem. Meanwhile, the rest of the organization is observing what is taking place. If the predictive program doesn't work (because of using the wrong tool), then the organization develops the attitude that all of the tools don't work.

This problem has a simple solution: use the right tool for the right job. Although this seems easy to say, it is not always easy to do. Someone in the organization must have a good knowledge of the various predictive techniques available. He or she will also have to know the strengths, weaknesses, and application of the predictive tools. Only in this way will the right technique be used for the right problem.

7. Organization is Too Reactive

The predictive maintenance program should not be introduced before the maintenance organization is mature enough to effectively use the tools. Suppose the maintenance organization is still performing over 20% of its work in a reactive mode. If this is the case, then the work order data is inaccurate. The cost data will be inaccurate. Therefore, no true cost justification or return on investment study can be conducted. The predictive tools may be purchased, but no real structure and discipline to the program is developed. The results will be fragmented and not sustainable.

The solution is to insure the basics are in place and that the maintenance organization is ready to implement predictive maintenance. If the maintenance organization is not ready, then it is highly unlikely that the rest of the organization will be ready. Build the foundation first and then mature the maintenance program.

8. Poor Foundation for PDM

Although related to some of the previous problems, this problem is somewhat more encompassing. As shown previously, in the pyramid of performance indicators (see Chapter 1), the foundation must be in place before the predictive program will be effective. It is mandatory for the improvement process to be followed if the entire maintenance improvement effort is to be successful. A flawed foundation will ultimately result in sub-optimization of the entire effort and a lack of a competitive maintenance program.

Predictive maintenance is one of the most valuable tools enabling maintenance to make long-term plans and increase the equipment mean time between failures. But it must always be built on a solid foundation.

CHAPTER 10

Reliability Centered Maintenance

Note: This chapter does not presume to define in detail Reliability Centered Maintenance. For a detailed approach to RCM, see the book RCM II by John Moubray, published by Industrial Press, 1992.

Reliability Centered Maintenance (RCM) is an evolutionary approach to equipment reliability. It focuses on the optimization of the preventive and predictive maintenance programs to increase equipment efficiency (uptime, performance, and quality) while minimizing the related maintenance costs. The RCM approach can be highlighted by the decision tree in Figure 10-1

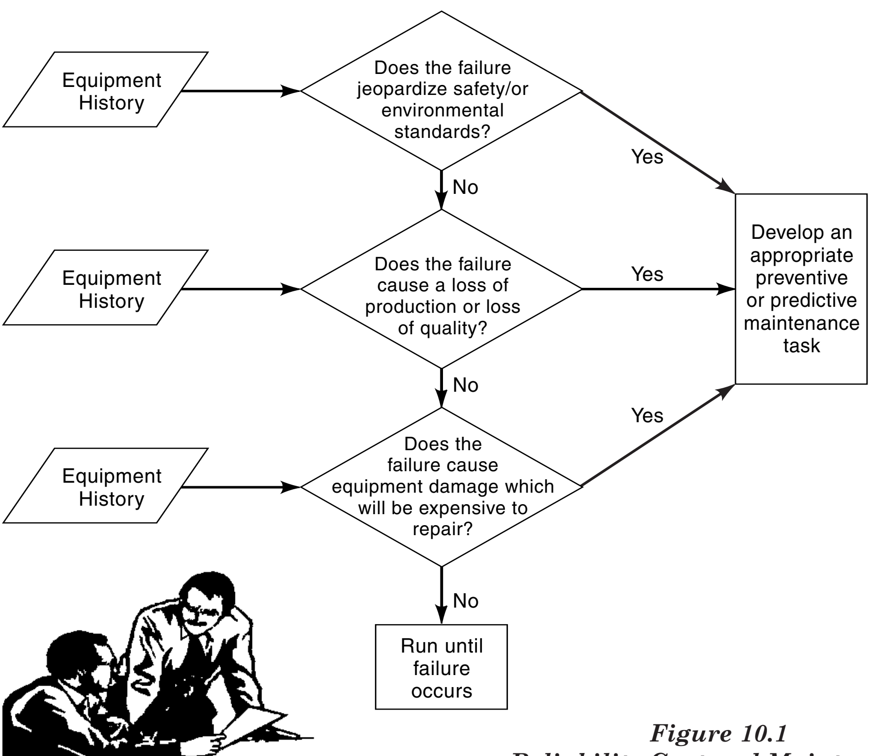


Figure 10.1
Reliability Centered Maintenance

In the decision tree, the consequences of failure are taken into consideration when evaluating the preventive and predictive maintenance tasks. For example, if a regulatory issue, such as the safety of an employee or the environment, would be endangered by the failure, the preventive and predictive programs would be modified in such a way that the consequence could:

- be prevented by proper preventive maintenance
- be monitored by predictive techniques, so the time of the failure could
- be identified and the defective component could be changed before the failure occurred
- be designed out by changing the equipment design to eliminate the component that would have failed

If the failure would cause a major production stoppage or process loss, then the same process would be applied to eliminate the problem.

If the answers to the first two decision tree questions are no, then the last question is: Would the failure cause considerable damage to the equipment and be expensive to repair? If yes, then the preventive and predictive process would be applied.

If no, then run to failure is an acceptable alternative.

In reality, while appearing simple, significant analysis goes into each step of the process. Consider the understanding of the operating dynamics of the equipment that is necessary to identify the possible component failures and all of the consequences of each of the failures. Also consider the degree of understanding of both preventive and predictive techniques that is necessary to decide which technique would prevent or detect a failure.

These complexities highlight the reason that most RCM projects are undertaken as a team. No one individual has all of the knowledge to make all the decisions in the RCM process.

Because RCM is an advanced technique that should be utilized by organizations, how is its performance monitored? The following indicators help monitor RCM.

1. Percentage of Repetitive Equipment Failures

This indicator compares the repetitive failures on critical equipment to the total failures. The resulting percentage highlights the opportunity to focus on failure elimination through the RCM process. The focus should be on critical equipment items first, but could be expanded to second- and third-tier equipment as resources are available.

$$\frac{\text{Number of Repetitive Equipment Failures*}}{\text{Total Number of Equipment Failures}}$$

This indicator can be derived by dividing the number of repetitive equipment failures by the total number of equipment failures. The resulting percentage represents the opportunity to reduce equipment failures through the RCM process. The indicator should be tracked by individual equipment item but can be rolled up to a line, process, department, or area level. This information can be tracked monthly or (for more proactive organizations) quarterly. It can then be trended over a rolling 12 months, and should indicate a declining percentage, based on the improvements RCM is making in the repetitive failure rate.

Strengths

The indicator is useful for highlighting potential opportunities for RCM analysis in the areas of repetitive equipment failures.

Weaknesses

There are two major considerations when using this indicator. First, accurate data on the equipment failures is a prerequisite before starting the process. Second, major this indicator should not be the sole focus of the RCM effort. This is only one area in which RCM may be useful in the plant. Other indicators will highlight other opportunities.

Percentage of Equipment Failures Where Root Cause Analysis is Performed

This indicator compares the number of equipment failures on which root cause analysis is performed with the total number of equipment failures. The resulting percentage highlights the opportunity to focus on failure elimination through the RCM process. The focus should be on critical equipment items first, but could be expanded to second- and third-tier equipment as resources become available.

$$\frac{\text{Number of Failures Where Root Cause Analysis Was Performed*}}{\text{Total Number of Equipment Failures}}$$

This indicator can be derived by dividing the number of equipment failures where root cause analysis was performed by the total number of equipment failures. The resulting percentage represents the opportunity where preliminary data exists to start the RCM process. Through further comparison, common root causes can be identified, highlighting opportunities for major improvement by addressing causes of multiple failures. The indicator should be tracked by individual equipment item, but can be rolled up to a line, process, department, or area level. This information can be tracked monthly or (for more proactive organizations) quarterly. This can be trended over a rolling 12 months, and should indicate an increasing percentage as failure analysis becomes more common.

Strengths

This indicator is useful for highlighting potential opportunities for RCM analysis in the areas of repetitive equipment failures with common root causes.

Weaknesses

There is only one major consideration when using this indicator. Accurate data on the causes of equipment failure is a prerequisite before starting the process. There can be no guess work in root cause analysis; otherwise, costly mistakes will be made.

3. Percentage of PM Program Activities Audited Annually for Effectiveness

This indicator examines the number of preventive maintenance tasks that are audited for effectiveness each year. It compares that number to the total number of preventive maintenance tasks. This indicates the level of PM tasks that are actually being compared to the equipment history and the root causes of breakdowns, insuring that the correct procedures are on the PM tasks, and that they are being performed at the correct frequency.

$$\frac{\text{Number of Maintenance Tasks Audited*}}{\text{Total Number of Maintenance Tasks}}$$

This indicator can be derived by dividing the total number of preventive maintenance tasks audited by the total number of preventive maintenance tasks. The result, which is expressed as a percentage, can be calculated annually and over a multi-year period. To be meaningful, the effort would have to be ongoing for years.

Strengths

The indicator is useful for insuring the preventive maintenance program is closely monitored. The indicator can be reviewed by craft, equipment, area, or even department, allowing for focused efforts in the PM program.

Weaknesses

The only major weakness to this indicator is that it is a lagging indicator. Although it could be used by dividing the total number of preventive maintenance activities by 12 and calculated on a monthly basis, this amount of calculation is usually more effort than it is worth.

4. Percentage of PDM Program Activities Audited Annually for Effectiveness

This indicator compares the number of predictive maintenance tasks that are audited for effectiveness each year to the total number of predictive maintenance tasks. This indicates the level of tasks that are actually being compared to the equipment history and the root causes of breakdowns, insuring the correct inspections are on the predictive maintenance tasks.

$$\frac{\text{Number of Predictive Maintenance Tasks Audited*}}{\text{Total Number of Predictive Maintenance Tasks}}$$

This indicator can be derived by dividing the total number of predictive maintenance tasks audited by the total number of predictive maintenance tasks. The result should be expressed as a percentage. This can be calculated annually and over a multi-year period. To be meaningful, the effort would have to be ongoing for years.

Strengths

This indicator is useful for insuring the predictive maintenance program is closely monitored. It can be reviewed by craft, equipment, area, or even department, allowing for focused efforts in the PDM program.

Weaknesses

The only major weakness to this indicator is that it is a lagging indicator. Although it could be used by dividing the total number of predictive maintenance activities by 12 and calculated on a monthly basis, this amount of calculation is usually more effort than it is worth.

5. Savings Attributed to the RCM Program

Several indicators examine the savings that are realized by the RCM program. This series of indicators is vital to companies wanting to maintain the resources necessary to sustain an ongoing RCM program. As with other parts of the maintenance program, a financial return on the investment in the program is necessary before management will allow it to continue. The RCM program produces a financial return in at least three major areas.

Equipment Uptime

Because the equipment is closely monitored by the preventive and predictive maintenance programs, there are few if any breakdowns, leading to maximum uptime for the plant equipment. Because the equipment is online consistently, the production throughput is increased. When the cost of the increased production is calculated, it should show a significant return on the investment in RCM.

Equipment Capacity

In addition to increasing uptime, the RCM program also improves performance efficiency. In other words, the equipment now operates at design speeds and capacities. In some cases, plant equipment is operated at 70% or 80% of what the equipment was designed to produce. This leaves 20% to 30% of the return on the asset as lost production. If this amount can be realized, the savings will be significant. The RCM process can help to recover this lost capacity.

Maintenance Labor Resources

By this stage of maturity, the maintenance organization is not fire fighting. Therefore, the savings does not come from increased labor productivity. Instead it comes from eliminating maintenance work in the form of ineffective preventive maintenance tasks, PM tasks that are done too often, or predictive inspections that are either done too often or are unnecessary.

There are no direct formulas for calculating these indicators. Each is tracked by individual equipment item, the same as is performed for RCM analysis. The financial performance can be tracked for each part of the indicator separately, then totaled for the combined savings. There is no standard way to perform these calculations, due to the differences in production processes and accounting procedures within companies.

Strengths

This indicator is mandatory for developing and maintaining organizational support for the RCM program. It can be useful for educating the organization to the financial benefits of RCM and how it contributes to the profitability of the company. It is also useful for insuring that there is an ongoing return on investment for the RCM activities.

Weaknesses

The only major weakness of this indicator is collecting the cost data so that it is accurate enough to keep the organization from debating the data. It should be able to be correlated to the accounting data. In addition, a lot of effort is needed to collect the data. This effort should not be underestimated when starting the data collection and tracking.

6. Percentage Reduction in Regulatory Violations and Non-Conformance

This indicator examines the reduction in regulatory violations and non-conformance penalties for implementing the RCM program. Because reducing unplanned failures and their impact on the operations is the goal for RCM, regulatory issues related to consistent and safe operation of the equipment will be dramatically reduced. The three major areas to monitor are:

OSHA

$$\frac{\text{Citations/Notices per Inspection (Current Year)}}{\text{Citations/Notices per Inspection (Previous Year)}}$$

EPA

$$\frac{\text{Citations/Notices per Inspection (Current Year)}}{\text{Citations/Notices per Inspection (Previous Year)}}$$

ISO-9000

$$\frac{\text{Notices of Non-conformance per Inspection (Current Year)}}{\text{Notices of Non-conformance per Inspection (Previous Year)}}$$

These indicators can be derived by comparing inspections results from the last year to the inspection results for the current year. These inspections may be made by either the regulatory inspectors or internal inspectors. The indicators can be trended over several inspections as the RCM program remains in place over time.

Strengths

The indicator is useful for developing and maintaining support for the RCM program. It can be useful for educating the organization to the regulatory benefits of RCM and the impact it has on the business. It is also beneficial for insuring continuing management support for the RCM program.

Weaknesses

The only major weakness to this indicator is the effort required to track and collect the data

7. Extension of Equipment Life and Increased MTBF

This indicator examines the Mean Time Between Failure (MTBF) and the lengthening of the overall service life of the equipment. The first is easy to track; the second more difficult. The MTBF calculation for selected critical equipment items is identical to the calculation in the section on predictive maintenance. On an equipment-by-equipment basis, the number of breakdowns is divided by the time period and a mean time between failure (MTBF) result is produced.

$$\frac{\text{Number or Equipment Breakdowns}}{\text{Total Hours in Time Period}}$$

This indicator can be derived by dividing the total number of breakdowns by the total time in the examined period. The resulting ratio (MTBF) can be trended over time to show the level of improvement. If the RCM program is working, the MTBF will increase. If it does not increase, then the RCM program needs adjusting. The time frame to use for the calculation is equipment specific. It should depend on the frequency of the failures upon starting the program.

Strengths

The indicator is useful for highlighting the impact that RCM activities have on the equipment failures. It is beneficial to use this indicator to keep the RCM program effective. As long as the MTBF is increasing, the RCM program is effective. If the MTBF decreases, then some adjustments are required.

Weaknesses

The major weakness here is the ability to separate the impact that the RCM program has on the MTBF calculation from that of the predictive program. The two are so closely linked, it may be difficult to determine which program is having the impact.

The extension of equipment life is more difficult to determine. The cost of performing maintenance must be compared to the benefit gained by avoiding failure; this measure is easier to calculate for the preventive and predictive programs. However, what is the value of lengthening equipment life by five years worth? The value of deferring the capital investment is worth the price of the equipment for the time period. That money can be invested in other priority purchases or added to the profits for the year. Again, this area is one where the company financial advisors need to be closely consulted in order to see what savings the company can achieve by increasing equipment life.

Typical Reliability Centered Maintenance Problems

Most organizations today, outside the airline or nuclear industry, have no real RCM efforts in place. They may try a small project in one place or anoth-

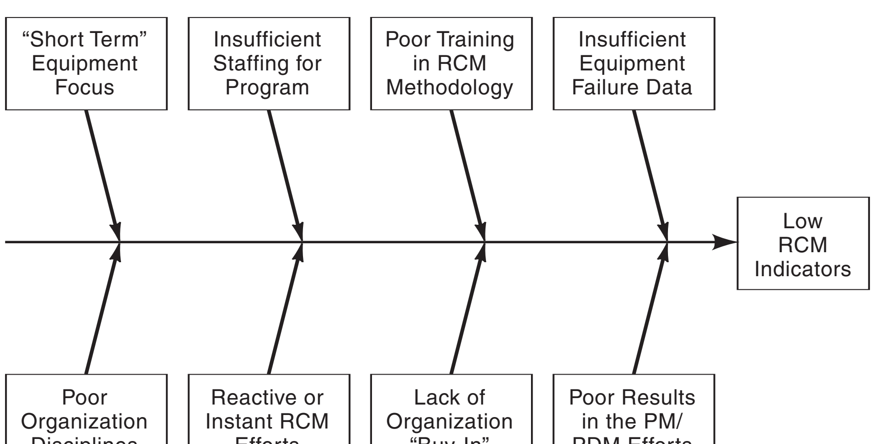


Figure 10.2 Reliability centered maintenance indicator tree

er, but have no fully organized or structured approach to RCM, which is why most companies are not successful with RCM. The following eight common problems lead to the lack of success with RCM.

1. Insufficient Equipment Failure Data

In order for the RCM program to be effective, it needs to have historical data about equipment failure including: types of failures, the frequency of failures and the root cause of failures. Without this information, the RCM program is guesswork. Some say the data isn't necessary, that instead you can estimate. RCM is an applied engineering function. You do not estimate engineering information successfully in other engineering disciplines; you don't guess in RCM either.

The reason most people want to try RCM with the equipment failure data is that they are trying to do RCM too early in the improvement process. RCM is an advanced technique that is used only when effective preventive and predictive programs are in place. This means that a work order system or CMMS is also in place where equipment failure and repair data are being collected. Without these tools in place, the RCM program has virtually no probability of success.

2. Poor Results in the PM/PDM Efforts

The preventive maintenance program has the goal of reducing the reactive maintenance activities to less than 20% of all the maintenance work. The predictive maintenance program has the goal of eliminating all unplanned breakdowns. If these programs are not producing results, why would someone want to move on to RCM? It would probably be because they are trying the "flavor of the month,"or playing the "alphabet soup game". As has previously been shown, preventive and predictive maintenance programs are successful when they are implemented with a disciplined approach, not haphazardly.

If the discipline is not in place to make the preventive and predictive maintenance programs successful, how could people begin to think they could be successful with an engineering approach to maintenance that requires a starting point of structure and discipline? This view shows a lack of understanding of the evolution of maintenance. However, it may also reflect the lack of organizational disciplines to make any improvement initiative requiring any level of effort successful. Concentrating on the basics and evolving the improvement program in a focused manner are necessary to making the RCM program successful.

3. Poor Training in the RCM Methodology

RCM has a structured and logical approach. It does not allow an individual to jump around trying one thing after another. Focus is required. Along with the focus is also a methodology. This methodology must be learned if a company is to be successful. This requires training. There are several approaches to the RCM methodology. Some have more flexibility, where others are more rigid. Some require a lot of data, others less. Some approaches are more successful in one industry than they are in another. The company must select the RCM approach that fits its needs. However, once the approach has been decided upon, then all of the employees involved in the RCM effort should be trained to a high degree of proficiency in the appropriate RCM techniques.

One of the major factors contributing to a lack of training is a failure to understand the complexity of RCM. If it is thought of as "just another maintenance thing," then the complexity may be misunderstood. RCM may be viewed like "one more thing" that maintenance does and they can figure it out. With RCM, this is not the case. The investment in training will be paid for many times over by the RCM effort. Without the training, however, the RCM effort will never achieve the maximum benefits for the organization.

4. Lack of Organizational "Buy-In"

This problem is related to the previous one. The lack of organizational 'buy in" or support is created by a lack of understanding of what RCM really is and the benefits that can be achieved from a successful RCM program.

There are two major issues: training and salesmanship. The training focuses not on the technical aspect, but rather on the business case for RCM which must be developed. What are the opportunities? What are the current losses? How much could they be reduced? How much will RCM cost? These are all questions that must be answered to achieve long-term management support.

Second, salesmanship involves putting the business case together in a manner that upper management can understand it clearly enough to support it. When selling management on the concept of RCM, remember that few plant managers or controllers really understand what MTBF and MTTR mean. However, if you show a cost-benefit analysis or a return on investment case study, then you have their attention. Using terms and tools they understand sells the program.

5. Insufficient Staffing for the Program

One of the first rules is "You don't do RCM in your spare time." RCM does not take the place of other maintenance initiatives. It is an additional task that requires additional funding for tools and personnel. After all, it will produce additional savings. Despite current trends of not adding headcount, if the RCM program is to be successful, a company will have to staff the program. If not, the individuals doing RCM will take shortcuts and produce less-than-optimal results. The return on investment that was possible will never be realized.

Most companies would pay $200,000 to receive $1,0000,000 within a year. They would line up at an investment bank to get that deal. The same deal exists in their plants and it isn't even advertised. All they have to do to is change their paradigms about staffing levels.

6. Reactive or Instant RCM Efforts

This problem arises when a company experiences a failure on a piece of equipment and someone reads an article about how RCM solved a company's problem with breakdowns. That person and the company then get hooked on the term reliability, but never understand it. All they know is that it might be the "silver bullet" that will solve their problem. RCM is not a silver bullet, however. It is a valuable tool, especially when coupled with a disciplined maintenance improvement program.

Anyone who thinks that RCM is a quick fix or a short term effort should remember that a full maintenance improvement program takes an organization from reactive to "World Class" maintenance. This journey takes three to five years, with no successful shortcuts. It takes this long to learn the disciplines and change organizational paradigms.

7. "Short-Term" Equipment Focus

This problem occurs when individuals in the organization lack technical insight and do not understand the true life cycle of their equipment and related components. As a result, you hear quotes like "This one lasted longer than the last one," "so our V-belts wear out every six months; we think that's pretty good," or "those bearings lasted two months this time." What is the design life of these basic components? Are companies really getting the full life out of them, or are they just glad they lasted as long as they did?

Companies successful with RCM must understand and value that their equipment can last longer than it currently does before it either breaks or wears so much that it is changed out. They need to develop the attitude of "How can I make it last longer, perform better, or improve quality?" If companies have the short-term focus of using up, wearing out prematurely, or accepting sub standard performance from their equipment, then they will not survive in the competitive environment they find themselves in today.

8. Poor Organizational Disciplines

This problem is related to lack of focus. The organization needs to be so focused on its vision, as well as the improvement plan and implementation methodology that it takes to get them there, that they can not be distracted. Today a lot of management changes as people come and go from an organization. This level of change can cause a lack of focus or vision. In some companies, there are so many management changes that the term "bungee manager" was developed. When there is this type of turnover, the organization develops the attitude "We don't like these changes, let's wait a while and a new manager will replace this one. Maybe we will like his ideas better."

The organization never develops the discipline to stick to any methodology for improvement. Any improvement effort is not in place long enough to become ingrained as the company's culture. Thus, no commitment develops. Even worse, with no commitment, there is no disciplined approach to improvement. The organization becomes like a rowboat adrift, without any oars, subject to the whims of the current and the winds. Strong, committed leadership is critical to developing a disciplined and focused organization.

CHAPTER 11

Total Productive Maintenance

This chapter examines one of the most misunderstood and misapplied concepts in modern organizations. Total productive maintenance is not as much a maintenance initiative or improvement program as it is a strategic operational philosophy.

Total productive maintenance (TPM) involves everyone in the organization, from operators to top management, in equipment improvement.

Equipment improvement does not just mean incremental improvements, but also optimum utilization of the equipment. The goal is to eliminate all equipment losses. There are many theories on exact number of equipment losses, but the basic six to eliminate are:

Breakdowns
Set up and adjustment losses
Idling and minor stoppage losses
Start up and shutdown losses
Reduced speed or capacity losses
Quality defects or rework

The goal is to eliminate all of these losses from the equipment operation, thus insuring maximum overall equipment efficiency. Eliminating these losses is beyond the ability of any one department. Therefore, TPM is an operational philosophy. All departments that impact the utilization of the equipment in some manner are involved; all must be part of the TPM program. Figure 11.1 illustrates the TPM philosophy.

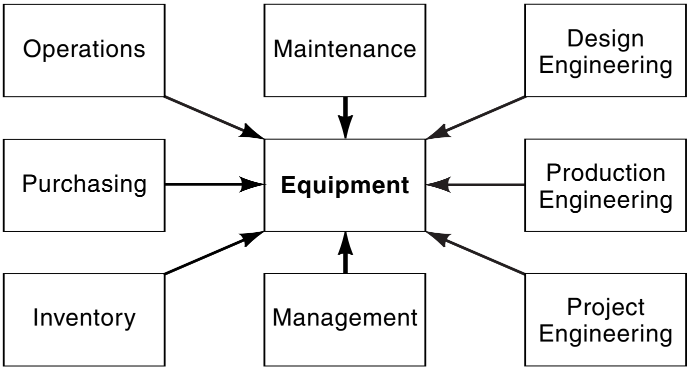


Figure 11.1 Total productive maintenance

As shown by the graphic, all departments must focus on how they impact the equipment. The diagram is the same as the one used to illustrate the Total Quality Management (TQM) process, except that instead of focusing on the product, TPM focuses on the equipment. In fact, companies that were successful with TQM are usually successful with the TPM process. However, those companies who typically had difficulties with TQM also have difficulty with TPM.

Currently, one of the biggest problems facing TPM is one that created problems for Total Quality Management as well: downsizing. Downsizing undermines employee motivation, which is a critical success factor for TPM implementation and continuance. If there are not sufficient, highly-motivated, and highly-skilled employees involved, TPM has little chance of succeeding.

If TPM is an operational philosophy, then what are the goals and objectives for the process? There is really one goal (some call them pillars) and four supporting initiatives. The goal is to continuously improve equipment effectiveness. The company wants to insure that nowhere in the world does any other company have the same equipment or processes that it has or is able to get more throughput out of the equipment or processes than it can. Otherwise, that competitor will be the low-cost producer, leaving the company in second place.

A common illustration compares your equipment and process with a NASCAR racing team. In a NASCAR event, all of the cars are basically the same, just as your company and your competitors have basically the same equipment. The winner is determined by how the team, (pit crew, design engineers, driver, fabrication technicians, etc.) works together and focuses on winning the race. The low-cost producer in competitive markets today is determined by how the organization works together and focuses on getting more out of the same assets as its competitors. This focus is the philosophy of TPM.

The philosophy is supported by four other improvement activities.

1. Improve maintenance efficiency and effectiveness.
2. Focus on early equipment management and maintenance prevention.
3. Train to improve the skills of all personnel involved.
4. Involve the operators in some daily maintenance on their equipment.

Improving maintenance efficiency and effectiveness insures that the maintenance department is as effective and efficient as a NASCAR pit crew. The performance of a pit crew is measured in tenths of a second. Any wasted time during a pit stop, as little as one tenth of a second, can mean the difference between winning and losing. One tenth of a second crossing the finish line is two car lengths. Races are won and lost every season by two car lengths. How much time do the maintenance crews for your company waste each day? Enough to make a difference in profit or loss to your bottom line?

Focusing on early equipment management and maintenance prevention means examining equipment for ways to make it more maintainable or eliminate the maintenance activity completely. New automobiles are the best example of this activity. Compared to the models in the 1970s, the cars need less maintenance (tune ups), yet performance is not sacrificed. Design changes were made based on engineering studies. The same can apply with production equipment in plants today. Engineering studies can be made to find better materials, methods, and even ways to make maintenance faster to perform.

Training has been mentioned in an earlier chapter. It is critical to train employees for the new tasks that they will be performing. Without training, the tasks will be performed partially or incorrectly. This leads to poor results, and may actually create equipment problems. Any time operators are asked to perform new tasks, they must be trained.

Involving the operators in some daily maintenance on their equipment, as mentioned previously, is designed to relieve some of the maintenance technician's time to concentrate on higher-level activities. However, the focus here is also to involve the operators in tasks that make the equipment perform better. Again, the focus on continuously improving equipment effectiveness must never be lost when defining the task for operators.

Because TPM really is an operating philosophy, what are some of the performance measures for TPM? The following are some suggested indicators.

OEE Tracked on Percentage of Critical Equipment

The OEE (Overall Equipment Effectiveness) is the main benchmark for any TPM process. If the real goal of TPM is to continuously improve equipment effectiveness, it only makes sense that the main indicator measures equipment effectiveness. The OEE compares the equipment availability, performance efficiency, and quality rate. The formula is as follows:

$$\text{Availability} = \frac{\text{Scheduled Time} - \text{All Downtime}}{\text{Scheduled Time}}$$ (should be at least 90%)

$$\text{Performance Efficiency} = \frac{\text{Actual Output for Scheduled Time}}{\text{Design Output for Scheduled Time}}$$ (should be at

$$\text{Quality Rate} = \frac{\text{Total Production} - \text{Defects or Rework}}{\text{Total production}}$$ (should be at least 99%)

Goal for Overall Equipment Effectiveness: 90% X 95% X 99% = 85%

These are the goals for the overall equipment effectiveness indicator. There are many factors that go beyond the scope of this material to explain. This indicator is so flexible it can be used for daily, weekly, and even monthly time periods for the calculation.

Strengths

This indicator is necessary for any company beginning a TPM initiative.

Weakness

The indicator has no weaknesses, except for misuse. It is the overall equipment effectiveness – not the effectiveness of the overall plant, department, area, or company. The calculation was originally intended for the operators and maintenance personnel to track their progress toward improving the equipment. They can hardly do this at a plant level. To be effective, this indicator must be equipment-oriented. Other uses are drawn up by consultants wanting to make a market for themselves.

2. Early Equipment Management and Maintenance Prevention Tracked on Percentage of Critical Equipment

This indicator examines the percentage of critical equipment that has been or is currently being studied for opportunities to make design improvements. These improvements would reduce the maintenance requirements or the time to perform maintenance on the equipment. The calculation is:

$$\frac{\text{Critical Equipment Items Covered by Design Studies*}}{\text{Total Number of Critical Equipment Items}}$$

This indicator is derived by dividing the number of critical equipment items covered by the design improvement studies by the total number of critical equipment items. The goal is 100%. When all other activities have been optimized on the equipment, the design studies can highlight opportunities for even further improvement.

Strengths

This indicator is essential for any company striving to insure maximum equipment effectiveness. This is essential because if all things are equal, changing the design to increase throughput may make the final competitive difference.

Weaknesses

There is no major weakness to this indicator.

3. 5 S's Practiced on Percent of Critical Equipment

This indicator examines the percentage of critical equipment that has been or is currently included in the 5 S program. These activities focus on cleaning and organizing the workplace. They uncover ways to make the workplace more efficient or uncover problems with equipment, because clean equipment is easier to inspect. The calculation is:

$$\frac{\text{Critical Equipment Items Covered by 5 S Activities*}}{\text{Total Number of Critical Equipment Items}}$$

This indicator is derived by dividing the critical equipment items covered by the 5 S activities by the total number of critical equipment items. The goal is 100%. These activities can highlight basic opportunities for improvement. They should never be overlooked because they are usually low cost and can produce some good cost benefits.

Strengths

This indicator is essential for any company striving to insure good employee involvement. The activities are basic in nature, but give all a chance to be involved. The indicator insures that no equipment is missed and no operators are left out of the activities.

Weaknesses

The major weakness to this indicator is it may cause some to focus too much on just cleaning and organizing. Such a focus is a trap that some companies have been led into by those who think cleaning is all the improvement their equipment requires. It certainly is a good place to start, but not to stop.

4. Savings Attributed to TPM Efforts

This indicator is calculated by quantifying the increase in overall equipment effectiveness. For example, if the OEE increases by 10 points from 45% to 55%, how much additional product is made or processed? Maybe it is 5,000 more plastic cases at a value of $10 each. This would represent $50,000 worth of additional product. Does the market exist to sell the items or are sales tied to a fixed contract? These issues impact the true value to the company of the increased production. Perhaps the only benefit is that the product is produced at a lower cost due to the increased efficiency. However, maybe the market demand for the product exists and every additional part that is made can be sold. In either case, the study needs to be made and the savings needs to be calculated. The two major areas to examine are:

Increased Capacity
Increased Quality

While the OEE is the real indicator, the results need to be converted to dollars. Then on a weekly or, at most, a monthly basis the improvement results need to be trended in dollars and posted by the equipment where the employees can see the results of their efforts. This form of recognition motivates and stimulates individuals to look for even more improvement opportunities.

5. Decreasing Cost of Production (Manufacturing) per Unit

This indicator is closely tied to the previous one. Instead of being able to sell the additional capacity that is generated from the TPM effort, some companies focus on lowering the cost to produce. This approach is generally used by companies with fixed markets. If this is the case, the profit margin is still impacted positively because the cost to produce is an expense. The expense avoidance, or cost reduction, is converted to profit on a dollar-for-dollar basis.

Tracking the cost to produce on a weekly basis and trending it over a rolling 12-month window can provide some interesting stimulation for managers interested in improving the company's profits.

6. Absenteeism

Absenteeism is a good indicator of employee morale. If a work force is highly motivated, they are more participative and productive. If they are not motivated but almost adversarial, they tend not to be as productive. Absenteeism is an indicator of employee morale. The indicator is:

Total Hours Absent
Total Hours Scheduled

This indicator is derived by dividing the total hours absent by the total hours scheduled. A low percentage of absenteeism tends to indicate high morale. A high percentage of absenteeism indicates a low morale.

Strengths

This indicator is good for any company to monitor, not just for morale but also for organizational efficiency.

Weaknesses

There are other factors that lead to absenteeism other than low morale. These other factors could impact the indicator and lead to false conclusions.

Typical Problems with TPM

Many organizations currently have partial or unfocused TPM efforts. They may have operational involvement, but lack the OEE focus. Conversely, they may track OEE, but don't perform root cause analysis to solve equipment problems permanently. The lack of success with TPM can be traced to the following eight problems.

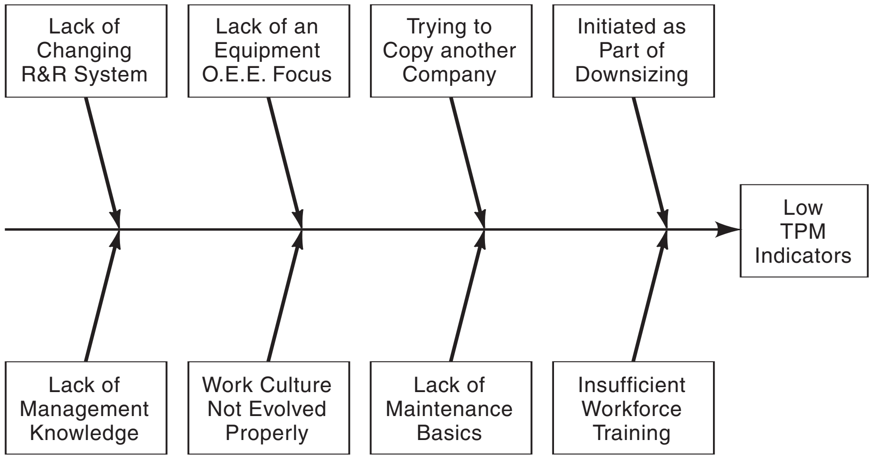


Figure 11.2 Total productive maintenance indicator tree

1. Initiated as Part of a Downsizing Effort

This problem occurs when the concepts of TPM are not clear. Some organizations still view TPM as a way to get operators involved in maintenance so that some of the maintenance personnel can be furloughed. This approach creates distrust among the workforce. As a result, the motivation that is required to make TPM successful is never generated. After all, how many people ever suggest themselves out of a job?

This problem is overcome only when the organization has the correct understanding of TPM, that it is not a "downsizing" initiative. The focus of TPM is continual improvement of the equipment. If workforce reduction is the goal of the company, do not try to start TPM; it will fail.

2. Insufficient Workforce Training

TPM requires the maintenance and operations personnel to come up with ideas of how to improve their equipment. In many cases, the equipment is increasingly technical. Because the equipment technology is increasing in complexity, the knowledge and skills of the individuals involved in TPM have to increase as well. Unless the training is required for those involved, few, if any, benefits will result.

3. Trying to Copy Another Company

TPM is not a "copycat" program. It is not implemented the same way in each company because there are variables that make each company unique.

These variables include:

Skill levels of the employees
Type of equipment or processes
Type of operation (continuous or batch)
Operator-to-machine ratio
Work culture

If the companies have differences and the TPM effort is copied, then TPM won't fit. It is only when a company examines its equipment and determines what it needs to do to make it more effective that TPM is truly successful.

4. Lack of Maintenance Basics

TPM is built around doing the basics right. In fact, studies have shown that almost half of all equipment breakdowns in a plant are related to the basics of maintenance, such as cleaning, inspecting, lubricating, and proper fastening procedures. If the basics are neglected, then the results are never realized because the TPM process would be built on a flawed foundation.

5. Lack of a Critical Equipment OEE Focus

This problem illustrates the expression "a mile wide, but only an inch deep". The resources in the plant involved in TPM can be spread too thin, trying to do too much. When this happens, the results are small and have no major impact on plant or equipment throughput. Without the hard, tangible results, the TPM effort loses momentum and ultimately fails.

The focus of the TPM program, particularly during the early stages, must be on the critical bottleneck or constraint equipment. Unless this is the case, the results are not noticeable and the TPM initiative never produces quantifiable results. In turn, without results, the TPM resources are re-deployed in other company initiatives that are producing results.

6. Work Culture Not Evolved Properly

This problem is an issue in some plants that may have had adversarial workforce–management relations in the past. It takes time and effort on the part of both sides to rebuild the trust and mutual understanding that is necessary for TPM to be successful. If either the workforce or management feel that the other has a hidden agenda in implementing TPM, then the mutual trust and cooperation will not develop.

Only by developing a common focus on improving equipment effectiveness, to be the best, will the proper work culture and cooperation ever develop.

7. Lack of Changing the Rewards and Recognition Systems

One TPM expert says "You reward what you value." If you do not change the reward and recognition system to reflect the new focus that TPM provides the organization, then the new behavior is not reinforced. Unless the old behaviors in the plant change, it is only a matter of time until everyone goes back to the old way of doing things.

If having operators involved in some daily maintenance on their equipment is valued, then the company must find a way to reward it. If maintenance technicians doing more predictive and reliability analysis on the plant equipment is valued, then again the company must find a way to reward it. For as long as most companies can remember, they rewarded the heroes, those individuals who could quickly fix the equipment or make it run (even if at half-speed) until the end of the shift. If this is the behavior that is rewarded, then this is the behavior that the company will receive. However, if proactive and reliability work are what is valued, then the reward and recognition system must also be changed to reflect those priorities.

8. Lack of Management Knowledge of TPM

This problem is created by a lack of knowledge of what TPM really is, what is involved, and what changes are necessary to implement it in a plant or facility. In some companies, management takes the "fairy godmother " approach to implementing TPM. They come into a room, wave their magic wand over the group, bless the TPM initiative and then leave the room, believing that this is all they need to do to make the TPM effort successful.

The way to overcome this problem is training and education about what TPM is and what it isn't. This training is best done with mixed groups of upper, middle, and first-line management together and trained in TPM with the hourly workforce. This approach insures that everyone in the organization hears the same message, understands the issues, asks their questions, and gets the answers in front of their coworkers. Thus, any miscommunication and misunderstanding of the TPM concepts are prevented.

CHAPTER 12

Statistical Financial Optimization

This chapter covers a hybrid technique that blends statistical techniques specific to equipment maintenance with financial methodologies, thereby allowing for the most cost-effective solutions to be derived for a company's asset management policies. The concepts are based on quantifying maintainability and reliability calculations in financial terms. Some of the decision areas in which this technique can be applied are:

- Setting preventive maintenance inspection schedules
- Age replacement policies
- Preventive maintenance block replacement policies
- Capital equipment replacement policies
- Equipment overhaul policies
- Critical spares stocking levels
- Routine spares stocking levels

The first five decision areas are related to maintenance policies and schedules. Even a company that has followed the evolution of maintenance improvement is still making these decisions intuitively, sometimes supplemented by some RCM data. However, are the decisions being made based on the financial impact they have on the total company? Not likely, because the reliability principles have not been financially considered in the RCM process. Although the MTBF (Mean Time Between Failure) may be known from an RCM analysis, the following questions are still unanswered:

a. What is the cost to prevent the failure? (preventive maintenance labor and materials)
b. What is the cost when equipment fails? (repair costs and lost production costs)

c. What is the correct number of spare parts to keep in stock to insure part availability when required? (the holding costs, storage costs, stores labor costs, compared to the downtime costs for the stock out)
d. For the routine spare parts need for the service, what is the reorder level and reorder point? (holding costs, storage costs, stores labor costs, the discounted prices for quantity orders, compared to the downtime costs for the stock out)

It is in these areas that the RCM tools fall short. These areas also highlight the reason why statistical financial optimization is implemented after TPM. The optimization takes data from all parts of the organization (RCM from maintenance and engineering, stores costs from inventory and procurement, downtime costs from operations, and overhead and labor costs from accounting). Unless the organization has progressed through the levels described in the decision tree, it is highly unlikely that it has the maturity and focus to utilize the optimization techniques.

It is beyond the scope of this text to detail the various formulas utilized in the statistical optimization process; however, for reference, they are found in most of the maintainability, reliability, and operational engineering textbooks available in most technical book stores in major cities.

There are also engineering software packages that perform the mathematical calculations for the statistical financial optimization. However, it would not be responsible for the author to recommend a specific package.

What are some of the indicators used to evaluate the effectiveness of the statistical financial optimization process? The following are suggested.

1. Statistical Financial Optimization Implemented on Percentage of Critical Equipment Maintenance Tasks

This indicator examines the number of critical equipment maintenance tasks that are audited for financial effectiveness each year. It compares this number to the total number of critical equipment maintenance tasks. This measure indicates the level of tasks that are actually being financially optimized each year. It is important to review these decisions annually because cost data, such as downtime (due to market changes), can vary periodically. In addition, parts costs increase, lead times change, and so forth. Annual analysis insures financial optimization.

Number of Critical Equipment Maintenance Tasks Audited*
Total Number of Critical Equipment Maintenance Tasks

This indicator can be derived by dividing the total number of critical equipment maintenance tasks audited by the total number of critical equipment maintenance tasks. The result should be expressed as a percentage. This measure can be calculated annually and trended over a multi-year period.

Strengths

The indicator is useful for insuring that the statistical financial optimization program is closely monitored.

Weaknesses

The only major weakness is the availability of accurate data. The most devastating mistake would be to guess at any of these numbers. If the data is not available, it is best to consider an alternative technique.

2. Statistical Financial Optimization Implemented on what Percentage of Critical Equipment Major Spares Stocking Policies

This indicator examines the number of critical equipment major spare parts that are audited for financial effectiveness each year. It compares this number to the total number of critical equipment spare parts. This measure indicates the level of parts that are actually being financially optimized each year. It is important to review these decisions annually because cost data, such as downtime (due to market changes), can vary periodically. In addition, parts costs increase, lead times change and so forth. Annual analysis insures financial optimization.

Number of Critical Equipment Major Spare Parts Audited*
Total Number of Critical Equipment Major Spare Parts

This indicator can be derived by dividing the total number of critical equipment maintenance tasks audited by the total number of critical equipment maintenance tasks. The result should be expressed as a percentage. This can be calculated annually and trended over a multi-year period.

Strengths

The indicator is useful for insuring that the statistical financial optimization program for critical equipment major spare parts is closely monitored..

Weaknesses

The only major weakness is the availability of accurate data. The most devastating mistake would be to guess at any of these numbers. If the data is not available, it is best to consider an alternative technique.

3. Statistical Financial Optimization Implemented on Percentage of Critical Equipment Routine Spare Parts Stocking Policies

This indicator examines the number of critical equipment routine spare parts policies that are audited for financial effectiveness each year. It compares the number of critical equipment routine spare parts audited to the total number of critical equipment routine spare parts. This measure indicates the percentage of critical equipment routine spare parts that are actually being financially optimized each year. It is important to review these decisions annually because cost data, such as downtime (due to market changes), can vary periodically. In addition, parts costs increase, lead times change, and so forth. Annual analysis insures financial optimization.

$$\frac{\text{Number of Critical Equipment Routine Spare Parts Policies Audited*}}{\text{Total Number of Critical Equipment Routine Spare Parts}}$$

This indicator can be derived by dividing the total number of critical equipment routine spare parts policies audited by the total number of critical equipment routine spare parts. The result should be expressed as a percentage. This measure can be calculated annually and trended over a multi-year period.

Strengths

The indicator is useful for insuring that the statistical financial optimization program is closely monitored.

Weaknesses

The only major weakness is the availability of accurate data. The most devastating mistake would be to guess at any of these numbers. If the data is not available, it is best to consider an alternative technique.

4. Statistical Financial Optimization Savings Generated Through Changes in Equipment Management Policies

This indicator calculates the total savings from all statistical financial optimization studies. These savings will help an organization focus on continuously improving their equipment management policies, because the financial rewards are always highlighted. There is no real formula because the indicator merely totals all of the statistical financial optimization studies conducted throughout the company.

The results should be calculated annually and trended over a multi-year period.

Strengths

The indicator is useful for insuring that the cost benefits of the statistical financial optimization program are closely monitored..

Weaknesses

The only major weakness is the difficulty of collecting all of the data when multiple groups are performing the analysis.

Typical Problems with Statistical Financial Optimization

The techniques of statistical financial are valuable, but yet not utilized by many organizations. Why? The following are the most common reasons.

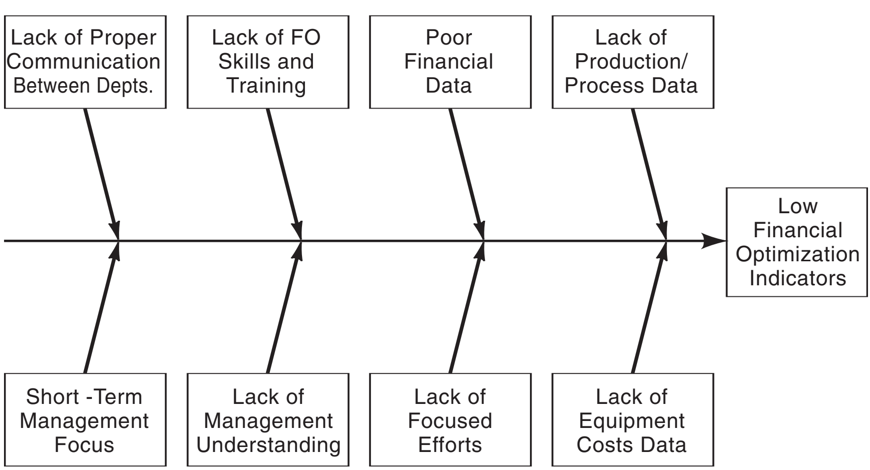


Figure 12.1 Financial optimization indicator tree

1. Lack of Production and Process Data

In many companies today, the production and process data are not kept in enough detail. Even companies that have extensive distributed process control systems in place find that data about flow rates, operating speeds, and operating efficiencies are not closely monitored and trended. In some cases, the actual sensors on the equipment are not working or even electrically connected. In these cases, the accurate data required to study the impact of falling flows and pressures on process is not available.

If the problem of falling efficiencies over time compared to the cost of lost throughput was financially optimized, then the data would be invalid, as would any decision to repair, replace, or overhaul the equipment. The production data play a critical role in most calculations. Without this data, there is little chance of accurate results. The only solution is to dedicate the necessary resources to accurately monitor and record the production or process data.

2. Lack of Equipment Costs Data

This data is the information typically found in the equipment history. It will contain the labor, material, and other costs associated with the maintenance of the equipment. If this data is not accurate, it indicates a problem with the data collection discipline in the organization. As expressed earlier, if the data collected is not accurate, then the analysis using the data will also be inaccurate. The only solution to the lack of equipment data is to go back and enforce the basics of data collection. The disciplines must be developed and enforced.

3. Poor Financial Data

The finance or accounting departments typically keep the relevant financial data. Some costs in this area include the original purchase price of the equipment, the current value of the equipment, the replacement value of the equipment, and possibly the cost of downtime or lost production. If this data is inaccurate or unavailable, then the financial optimization cannot be performed.

Another problem in organizations that have not matured to World-Class levels is the lack of sharing data between departments. In companies where the value of data has not yet been understood by all departments, there have been financial departments that have refused to provide downtime costs or to fairly calculate the cost of lost production. In these companies, the educational process needs to be developed to insure a clear understanding of the costs involved in equipment failures or inefficiencies.

If a company is at a level of maturity that it is utilizing statistical financial optimization, then issues about not sharing data should never be a problem. If they are, the company is not ready to use the tools.

4. Lack of Focused Efforts

This problem arises when a company is just starting the statistical financial optimization program. There are so many opportunities available, the individuals who are performing the analysis simply pursue what they perceive is the largest opportunity. This lack of discipline dilutes the resources and produces fragmented results. It also creates problems because the total analysis skills have not been developed. As the analysts work on problems, they make errors because they are not communicating with each other. The mistakes go undetected and the savings from the analysis are less than optimum.

The solution here is to stay focused and work as a team until the analysts skills are fully developed and a complete plan for the analysis is also developed.

5. Lack of Financial Optimization Skills and Training

Proper training in maintainability, reliability, and financial concepts must be provided anyone doing any of the statistical financial optimization analysis. If the skills are not properly developed, mistakes will be made and these mistakes will cost the company substantial amounts because operational policies are being changed based on the erroneous analysis.

6. Lack of Management Understanding and Support

This problem is related to the previous one in that education is critical. This does not mean that upper management will need to go through the same detailed technical training, although they could if they want to invest the time. However, they do need training to the extent that they understand the costs of statistical financial optimization and the benefits that will be achieved by properly using the tools. Unless this happens, the support required to change policies is never developed and the program fails due to the lack of support.

7. Lack of Proper Communication Between Departments

This problem is related to the third issue, in that there is little communication between departments, whether it is financial data or routine operational data. This problem should not exist if an organization is at the level of maturity that a company is considering statistical financial optimization. In the chapter on Total Productive Maintenance, the diagram showing the focus on the equipment highlights the need for each department to communicate with the others to maximize the equipment effectiveness. If that level of understanding, commitment, and communication exists, then this problem should not exist.

8. Short-Term Management Focus

This problem is actually created by our financial systems, starting with Wall Street. Investors expect quarter-to-quarter earnings increases. However, some equipment improvement programs require an initial investment that is not paid back for 6-to-12 months. If a company does not have the resources to invest in the improvement program, then the profits suffer and the stock value drops. On the other hand, if the investment is not made, the company starts a long-term downward spiral because the technical decisions and improvements cannot be made.

There is no short-term easy solution to this problem. The only real solution is to persuade the stockholders that the improvement initiative is an investment. Like any other investment, it has a pay back period. If this perspective can be clearly communicated to and understood by the stockholders, then the problem may diminish. If so, then the next real challenges will be to insure the payback.

CHAPTER 13

Continuous Improvement

Performance Indicators and Benchmarking

Continuous improvement is the process of never accepting the status quo of an organization. It is the ongoing challenge to look for incremental improvement that can be made to increase the company's competitiveness. Continuous improvement focuses on improving the company's internal capabilities and capacities. The activities must be conducted in a dynamic, ever-changing business environment. Any continuous improvement activity should be considered in the light of what impact it will have on the customer and how it helps to differentiate the company from its competitors.

One of the most effective continuous improvement tools for maintenance is benchmarking. A humorous look at benchmarking is:

Benchmarking is having enough humility to recognize that someone is better at something we do in our company and wise enough to learn how to be better at it than they are….

In reality, benchmarking is the ongoing process in which a company compares itself with another company anywhere in the world that is considered the best and then takes the knowledge gained to continually improve. Once the improvements are made, the process starts over again.

Lessons Learned from Benchmarking

Identifying performance indicators for each functional process is essential for any benchmarking effort. This is the key to understanding the relationship between benchmarking and performance indicators. Benchmarking projects cannot be quantified unless the performance is measured and the improvements are tracked.

It is difficult to find hard measures for soft areas; utilizing tools such as process mapping and maturity grids requires considerable effort. Again, if it can't be measured, it can't be managed. Soft areas are difficult to measure quantitatively. Therefore, the improvements are difficult to track.

All information needs to be evaluated for applicability to each organization; adaptation is a critical skill. No two organizations are exactly alike. You must be able to take what was learned during benchmarking, then adapt and apply it to your organization.

Benchmarking is a systematic and continuous process. Once it is started, it never stops. This is why it is part of continuous improvement.

Performance Indicators Versus Benchmarking

In most companies, there is considerable confusion about the difference between a performance measure and a benchmark. To understand the difference and how both should be used in an organization's effort to improve, it is necessary to define both terms, then examine their relationship.

Benchmarking

One definition for benchmarking is: An ongoing process of measuring and improving business practices against the companies that can be identified as the best worldwide. This definition emphasizes the importance of improving, rather than maintaining, the status quo. It addresses searching worldwide for the best companies. Most marketplaces have international competitors. It would be naive to think that best practices are limited to one country or one geographical location. Information that allows companies to improve their competitive positions must be gathered from best companies, no matter where they are located.

Companies striving to improve must not accept past constraints, especially the "not invented here" syndrome. Companies that fail to develop a global perspective will soon be replaced by competitors that had the insight to become global in their perspective. In order to make rapid continuous improvement, companies must be able to think outside the box, that is, to examine their business from external perspectives. The more innovative the ideas that are discovered, the greater the potential rewards that can be gained from the adaptation of the ideas.

Benchmarking opportunities are uncovered when a company conducts an analysis of its current policies and practices. Benefits are gained by following a disciplined process, composed of 10 steps:

1. Conduct an internal audit of a process or processes.
2. Highlight potential areas for improvement.
3. Do research to find three or four companies with superior processes in the areas identified for improvement.
4. Contact those companies and obtain their cooperation for benchmarking.
5. Develop a "pre-visit" questionnaire highlighting the identified areas for improvement. (See step 2.)
6. Perform the site visits to the three or four partners (see step 3).
7. Perform a "gap analysis," comparing the data gathered to your company's current performance
8. Develop a plan for implementing the improvements.
9. Facilitate the improvement plan.
10. Start the benchmarking process over again.

Benchmarking helps companies find the opportunities for improvement that will give them a competitive advantage in their marketplaces. However, the real benefits from benchmarking do not occur until the findings from the benchmarking project are implemented and improvements are realized.

To gain maximum benefits from benchmarking, a company should only conduct a benchmarking exercise after it has attained some level of maturity in the core competency being benchmarked. Clearly, a company would have to have some data about its own process before it performs a meaningful comparison with another company.

Without accurate and timely data, as well as an understanding of how the data is used to compile the benchmark statistics, there will be little understanding of what is required to improve the maintenance process. This is true whatever process is benchmarked.

The final step to ensure benefits from benchmarking is to use the knowledge gained to make changes in the competency benchmarked. The knowledge gained should be detailed enough to develop a cost-benefit analysis for any recommended changes.

Benchmarking is an investment that includes the time and money to do the ten steps described earlier. The increased revenue generated by the implemented improvements pays for the investment. For example, in equipment maintenance, the revenue may be produced through increased capacity (less downtime, higher throughput) or reduced expenses (efficiency improvements).

The revenue is plotted against the investment in the improvements to calculate the return on investment (ROI). To ensure success, the ROI should be calculated for each benchmarking exercise.

Performance Indicators

As previously discussed, performance indicators have been misunderstood and misused in most companies today. Performance indicators are just that, an indicator of performance. Performance indicators are not to be used for "ego gratification," that is, to be used for comparison with another company to show how much better one company is over another. Performance measures are also not to be used to show that "we are just as good as everyone else in our market, so we don't need to change."

Properly utilized, performance indicators should be used to highlight an opportunity for improvement in a company and for further analysis that would find the problem causing the indicator to be low. Ultimately, this analysis should point to a solution to the problem.

Properly conceived indicators are constructed not from the bottom up, but from the top down. The corporate indicators measure what is important to top management in order to satisfy the needs of the stakeholders or shareholders. That is, the corporate-level indicators help an organization focus its efforts on supporting a company's direction.

While corporate indicators set the direction, the subsequent indicators must focus on supporting that direction. If these indicators are not related to corporate level indicators, the overall organizational effort is less than optimized, endangering the corporation's survival.

In short, all performance indicators must be tied to long-range corporate business objectives. If a corporate indicator highlights a weakness, then the next lower level of indicators should give further definition and clarification to the causes of the weakness. When the functional performance indicator level is reached, the problem function should be highlighted. It will then be up to the responsible manager to take action to correct the problem condition. When the problem is corrected, the indicators, correctly monitored and recorded, will result in improvement at higher levels.

Companies need to put in place performance indicators that become ingrained in the culture of the business. This approach presents both opportunity and challenge. The opportunity is for each department to connect its operation to the overall business strategies of the company. The challenge is to find indicators that allow this goal to be accomplished easily. Again, the correct way to develop performance indicators is to work from the top or corporate level and develop indicators at each subsequent level. If the indicators are selected at the bottom and then built upward, they may be conflicting rather than supportive.

Coordination

Although benchmarks are not numbers used as an end goal, they can be compared to a destination. If the company has identified an opportunity for improvement, then studying (benchmarking) other companies and learning how to make the improvement becomes a corporate goal. At this time, performance indicators can be developed for charting the course between the present level of performance and the desired benchmark level.

As progress is made, the performance indicators reflect it, showing the improvement. When the benchmark is realized, the benchmarking process dictates that another area for improvement should be identified. Once the internal audit is conducted and benchmarking activities are completed, then the performance indicators are changed or modified to track the progress toward meeting and exceeding the new benchmark goal.

In summary, the performance indicators are key to the continuous improvement process. All of the material in this book builds to this point.

If performance indicators are to be used to continuously improve, what are some of the indicators that show improvements are being made by the organization? The performance indicator used to track the process should be the primary indicator that performance is improving.

The following indicators can be used as general indicators to show the organizational attitude toward continuous improvement.

1. Savings Realized from Improvements Implemented by Employee Suggestions

This indicator examines the savings realized by employee suggestions. The indicator is vital to companies wanting to gauge the effectiveness of their employee involvement activities. As with other aspects of improvement, a financial return on the investment in the program should be able to be shown. If not, then it will be necessary to investigate how to improve the suggestion program to make it more effective.

There is no direct formula for calculating this indicator. It is simply the total cost savings that have been achieved due to employee suggestions that have been implemented.

Strengths

The indicator is useful for tracking the benefits realized by employee suggestions and involvement. It is also beneficial to help motivate employees; they can clearly see their successes and contributions.

Weaknesses

The only major weakness to this indicator is collecting the data in a way that the benefits of the employee involvement can be clearly seen.

2. Savings Realized from Improvements Implemented that Were Generated from Benchmarking Activities

This indicator examines the savings realized by implementing improvements identified during benchmarking activities. This indicator is vital to companies wanting to monitor the effectiveness of their benchmarking activities. As with other aspects of improvement, a financial return on the investment in the benchmarking activities should be shown. If not, then it will be necessary to investigate the benchmarking process to find the problem. Benchmarking projects should produce results.

There is no direct formula for calculating this indicator. It is simply the total cost savings that have been achieved due to the benchmarking efforts. It may be that the improvement in the benchmarked performance indicator can be used to track the benefits.

Strengths

This indicator is useful for tracking the benefits realized by benchmarking projects. It can help foster support in the company for benchmark projects when those projects are properly quantified.

Weaknesses

There are no major weaknesses to using this indicator. The benefits should have been quantified as part of the benchmarking project. Therefore, data collection should not be a problem.

3. Percentage of Critical Equipment Involved in the Continuous Improvement Effort

This indicator examines the percentage of critical equipment items that have been impacted as part of continuous improvement process. It compares this number with the total number of critical equipment items. The resulting percentage indicates the level of continuous improvement efforts that are focused on critical equipment. It is important to review the focus of the continuous improvement program annually to insure the maximum benefits from the efforts.

$$\frac{\text{Number of Critical Equipment Items with Continuous Improvement Activities*}}{\text{Total Number of Critical Equipment Items}}$$

This indicator can be derived by dividing the total number of critical equipment maintenance items where continuous improvement (CI) activities were performed by the total number of critical equipment items. The result should be expressed as a percentage. This indicator can be calculated annually and trended over a multi-year period.

Strengths

The indicator is useful for insuring the monitoring of the continuous improvement program.

Weaknesses

The only major weakness is quantifying the benefits. The tracking, which may need to be supported with the cost-benefit results, may be more difficult to obtain.

Problems for Continuous Improvement Activities

The following problems are common to continuous improvement efforts. Although the majority focus on problems with benchmarking programs, most have application to all forms of continuous improvement.

1. Only Using Competitive Analysis

This problem occurs when continuous improvement efforts focus on doing only what your competitors are doing. For example, some companies want to

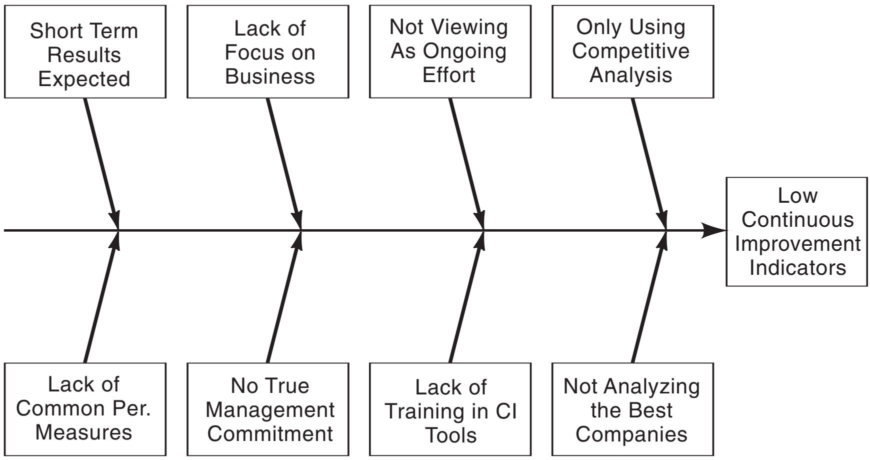


Figure 13.1 Continuous Improvement indicator tree

benchmark only with their competitors. You hear perspectives such as "We don't do it this way in our industry." In reality, a quantum leap in improvement comes when a company goes outside its industry, finds a best practice, and is the first to adapt it to its industry. If companies chase only their competitors, there will be only incremental improvements.

In continuous improvement, companies must look beyond their competitors.

2. Not Analyzing the Best Companies

In some continuous improvement efforts, and especially in benchmarking, some companies pick up the local telephone book to find a company to visit and observe. This approach is not effective, especially in benchmarking. How would a company know if that competitor was good, average, or bad? What could it hope to learn? When starting a continuous improvement program, especially benchmarking, always focus on the company with the best practice. Don't select companies for a continuous improvement effort because they are conveniently located (or located in a vacation area).

3. Not Viewing as an Ongoing Effort

Some companies talk about having "done" benchmarking. When asked about their results, they point to a three-ring binder on the bookshelf as the result of the study. They have the data, but have never done anything with it.

Their benchmarking effort failed because the effort was viewed as a one-time information gathering activity. The way to overcome this problem is to start with education on what benchmarking is and what improvements are going to result from the effort.

4. Lack of Training in the Continuous Improvement Tools

Numerous continuous improvement tracking and monitoring tools are available. They include:

affinity diagrams
matrix diagrams
force-field diagrams
cause and effect diagrams
tree diagrams
process flow charts
scatter diagrams
histograms

Perhaps no one uses all of these tools, but the list highlights how many continuous improvement tools are actually available. For continuous improvement projects to be successful, the right tools must be used at the right time. Proper training is the answer to this problem.

5. Lack of Focus on the Business

This problems occurs when a continuous improvement effort is not connected to the business. There is no clearly-defined business reason for the project. This lack of focus leads the project team into interesting but unnecessary types of activities. For example, painting the workers' lunch area, re-landscaping the front of the building, or rearranging offices address morale issues, but they are not directly focused on the business. Surveys have shown that seven out of ten teams fail to produce the results that the team was formed to produce. The main reasons were lack of focus on the business and proper training. Having a business focus to the continuous improvement process is important to the success of continuous improvement.

6. No True Management Commitment

This problem occurs when continuous improvement activities are part of a program-of-the-month type of management. The program may be the latest thing someone read about in a magazine or book and, as a result, the company is going to get into some type of continuous improvement or benchmarking program. As soon as the cost of such a project is truly understood, managers then look for some cheaper way of doing the project or they start looking for another project.

The solution here is to research and educate before starting any new improvement initiatives. This insures that everyone has a clear understanding of the level of effort and cost before any new project is undertaken.

7. Short-Term Results Expected

This problem occurs when proper education about what continuous improvement and benchmarking involve is not provided before starting the project. Without a clear understanding that continuous improvement is a long-term project, with only limited short-term benefits, management may apply pressure to see immediate results. The improvement teams might then take shortcuts and either reduce or eliminate the benefits that they should have achieved.

8. Lack of Common Performance Measures

This problem occurs in benchmarking., especially when someone wants to benchmark as a result of reading an article or report that lists a particular benchmark number, and then pushes the organization to achieve that number. The problem is that the organization may be in a different business, operate under different conditions, or even employ dissimilar workforces. Unless time is taken to make a fair evaluation, trying to get the "apples to apples" comparison, the benchmark is useless and the organization could suffer trying to achieve it. Education and training are again necessary if this problem is to be avoided.

CHAPTER 14

Developing Performance Indicators For Maintenance Management

After a close look at the maintenance function and its various functional components, as well as the related functional performance indicators, it would be beneficial to review the performance indicator pyramid presented in the introduction. The correct way to develop performance indicators is to work from the top or corporate level, then develop indicators at each subsequent level to allow the indicators to be connected. If the indicators are selected at the bottom and then built upward, they may be conflicting rather than supportive.

Corporate Indicators

These indicators are the long-term strategic indicators that upper management utilizes for business planning. The window of planning is typically for the three-to-five-year strategic plan.

Total Cost to Produce (Manufacture)

This indicator compiles all the costs needed to produce a product. It is used to calculate the profit margin because the difference between this cost and the sales revenue is profit. This cost is important to the maintenance function because maintenance makes up a percentage of this cost. This cost is further analyzed by the following financial indicators:

Total Cost of Occupancy

This facility measure compiles all the costs needed to occupy a facility. This cost is important to the maintenance function, which makes up a percentage of this cost. This figure is further analyzed by the financial indicators.

Return on Net Assets (RONA)

This indicator measures the profit earned compared to the net value of the company assets. The impact that maintenance has on profits is a major factor in calculating the return. This will be highlighted in the financial indicators.

Return on Fixed Assets (ROFA)

This indicator compares the profit earned to the net value of the fixed company assets. The impact that maintenance has on profits is a major factor in calculating the return. This will be highlighted by the financial indicators.

Financial Indicators

These indicators are used to insure that the departments in a company are meeting the financial goals set in the strategic plan. These indicators are monitored annually. If the annual figures are not in compliance with the forecast, then the analysis would start at the next level in the hierarchy. Some of the indicators that are used to financially monitor the maintenance department are listed below. No organization will use all of these indicators, but will choose the ones that support the selected corporate indicators.

Maintenance Cost per Estimated Replacement Value of the Plant or Facility Assets

This indicator is becoming standard. It is an accurate measure for plants and facilities because the cost is usually fixed. This aspect also makes the indicator easy to use to trend any increases over time. If the percentage of maintenance costs increase, then the efficiency and effectiveness indicators should show which maintenance area caused the increase.

Stores Investment as a Percentage of Estimated Replacement Value

This indicator is also becoming standard for measuring stores investment. The indicator is easy to use to trend any increases over time. If the percentage of stores costs increases, then the efficiency and effectiveness indicators should show what maintenance or stores function caused the increase.

Value of Asset Maintained per Maintenance Employee

This indicator is another measure for plants and facilities because the asset cost is usually fixed. The indicator is easy to use to trend any increases over time. If the value of the asset maintained decreases, then the efficiency and effectiveness indicators should show which maintenance area caused the decrease.

Contractor Costs as a Percentage of Total Maintenance Costs

This indicator is useful for trending contractor costs as a percentage of total maintenance costs. If the costs remain stable, then the contractor usage is stable. If an increase or decrease is indicated, then the efficiency and effectiveness indicators should highlight the reason for the change

Maintenance Cost per Unit Processed, Produced, or Manufactured

This indicator, which is the maintenance costs divided by the volume of production, is a common measure of maintenance performance, although it is not necessarily one of the best. The production volumes vary for reasons not under the control of the maintenance department. If the maintenance department is held accountable for this indicator, then poor decisions will be made related to the maintenance strategies. The organization will be upsized, downsized and otherwise impacted due to the fluctuations of the indicator. This indicator is good for a broad, trending indicator, but should never be used as a sole performance indicator.

Maintenance Costs as a Percentage of Total Process, Production, or Manufacturing Costs

This indicator is a more accurate measure because its costs of manufacturing are a total calculation, not a per unit calculation. Maintenance will be a percentage of the cost, but is generally fixed. Therefore, the indicator provides a more accurate financial measure of maintenance. It is easy to trend the percentage of total costs that is maintenance. If this percentage increases, then the efficiency and effectiveness indicators should show which maintenance area caused the increase.

Maintenance Costs as a Percentage of a Sales Dollar

This measure is also accurate because the percentage is usually fixed, which also makes this indicator easy to trend any increases over time. If the percentage of maintenance costs increase, then the efficiency and effectiveness indicators should show which maintenance area caused the increase.

Maintenance Cost per Square Foot Maintained

This indicator is also an accurate measure for facilities because the cost is usually fixed, which makes the indicator easy to trend any increases over time. If the percentage of maintenance costs increases, then the efficiency and effectiveness indicators should show which maintenance area caused the increase.

Efficiency and Effectiveness Performance Indicators

Effectiveness emphasizes how well a department or function meets its goals or company needs. It is often discussed in terms of the quality of the service provided, viewed from the customer's perspective. In the case of maintenance, effectiveness can represent the overall company satisfaction with the capacity and condition of its assets.

Efficiency is acting or producing with a minimum of waste, expense, or unnecessary effort. Efficiency compares the quantity of service provided to the resources expended: Is the service provided at a reasonable cost? Efficiency measures concentrate on how well a task is being performed, not whether the task itself is correct. Effectiveness concentrates on the correctness of the process and whether the process produces the required result.

A common problem in efficiency and effectiveness performance measurement is the reporting of process measures (workload) or input measures instead of output measures (e.g., effectiveness and efficiency). Indicators such as maintenance personnel per dollar of asset value, maintenance personnel as a percentage of total plant personnel, and number of work orders completed may be useful in understanding how busy a maintenance department is, but they do not measure results. This data is easily gathered and, without clear definitions or communication, are often reported as performance measures for organization efficiency and effectiveness.

These indicators should examine the efficiency and effectiveness of the tactical functions within maintenance. They can help insure that the tactical performance indicators stay in line to support the annual financial performance indicators.

The following is a list of the efficiency and effectiveness indicators from the previous chapters of this book. These indicators all highlight an impact on the efficiency and effectiveness of maintenance. No organization will use all of these indicators, but will choose the ones that support the selected financial indicators. Indicators marked with one asterisk * are expressed as a percentage; those with two asterisks ** are expressed as ratios.

Preventive Maintenance

$$\frac{\text{Downtime Caused By Breakdowns*}}{\text{Total Downtime}}$$

$$\frac{\text{Manhours Spent on Emergency Jobs*}}{\text{Total Manhours Worked}}$$

$$\frac{\text{Direct Cost of Breakdown Repairs*}}{\text{Total Direct Cost of Maintenance}}$$

$$\frac{\text{Desired Equipment Uptime – Downtime*}}{\text{Desired Equipment Uptime}}$$

$$\frac{\text{Hours Worked as Overtime*}}{\text{Total Hours Worked}}$$

$$\frac{\text{Maintenance Work Orders on Hold Awaiting Parts*}}{\text{Total Number of Maintenance Work Orders}}$$

Work Order Systems

Percentage of Work Distribution by Type of Work Order

$$\frac{\text{Emergency Work Orders}}{\text{Total Work Orders}} \qquad \frac{\text{Preventive Work Orders}}{\text{Total Work Orders}} \qquad \frac{\text{Corrective Work Orders}}{\text{Total Work Orders}}$$

Technical and Interpersonal Training

$$\frac{\text{Total Downtime Attributed to Operational Errors*}}{\text{Total Downtime}}$$

$$\frac{\text{Total Downtime Attributed to Maintenance Errors*}}{\text{Total Downtime}}$$

$$\frac{\text{Estimated Lost Time Due to Lack of Knowledge or Skills*}}{\text{Total Time Worked}}$$

$$\frac{\text{Maintenance Rework Due to Lack of Knowledge or Skills*}}{\text{Total Maintenance Work}}$$

Operational Involvement

$$\frac{\text{Maintenance-Related Equipment Downtime (current period)*}}{\text{Maintenance-Related Equipment Downtime (previous year same period)}}$$

$$\frac{\text{Actual Equipment Throughput (current period)*}}{\text{Actual Equipment Throughput (previous year same period)}}$$

$$\frac{\text{Current Maintenance Costs*}}{\text{Maintenance Costs Prior to Predictive Program}}$$

Reliability-Centered Maintenance

Savings Attributed to the RCM Program

Equipment Uptime

Equipment Capacity

Maintenance Labor Resources

OSHA

$$\frac{\text{Citations/Notices per Inspection (Current Year)*}}{\text{Citations/Notices per Inspection (Previous Year)}}$$

EPA

$$\frac{\text{Citations/Notices per Inspection (Current Year)*}}{\text{Citations/Notices per Inspection (Previous Year)}}$$

ISO-9000

$$\frac{\text{Notices of Non-conformance per Inspection (Current Year)*}}{\text{Notices of Non-conformance per Inspection (Previous Year)}}$$

Total Productive Maintenance

Overall Equipment Effectiveness

$$\text{Availability} = \frac{\text{All downtime}}{\text{Scheduled Time}} \quad - \qquad \text{(should be at least 90\%)}$$

$$\text{Performance Efficiency} = \frac{\text{Actual Output for Scheduled Time}}{\text{Design Output for Scheduled Time}} \quad \text{(should be at least 95\%)}$$

$$\text{Quality Rate} = \frac{\text{Total Production–Defects or Rework}}{\text{Total Production}} \quad \text{(should be at least 99\%)}$$

Goal for Overall Equipment Effectiveness: 90% X 95% X 99% = 85%

Tactical Performance Indicators

The tactical performance indicators monitor the function indicators in a longer-term window of a quarterly or 90-day timeframe. This window allows time for trends to develop. By monitoring the tactical indicators, companies can identify required changes highlighted by pyramiding of the functional indicators. Changes can then be made to the maintenance processes before the efficiency and effectiveness of the maintenance organization is impacted to the degree that the annual financial performance indicator targets are missed.

Tactical indicators focus on the individual processes within the maintenance function. However, optimizing one process may have a negative impact on other processes. Therefore, the efficiency and effectiveness indicators are important; they evaluate the overall maintenance function whereas the tactical indicators evaluate only one of the eleven maintenance specific processes.

The following list of tactical indicators, previously mentioned in this book, focus on evaluating the specific maintenance function. No organization will use all of these indicators, but will choose the ones that support the selected efficiency and effectiveness indicators.

Preventive Maintenance

$$\frac{\text{Preventive Maintenance Tasks Completed*}}{\text{Preventive Maintenance Tasks Scheduled}}$$

$$\frac{\text{Breakdowns Caused by Items that Should Have Been Inspected, Serviced, or a Part of the PM Program*}}{\text{Total Number of Breakdowns}}$$

Inventory and Procurement

$$\frac{\text{Total Annual Dollar Amount of Stores Usage**}}{\text{Total Inventory Valuation}} \quad \text{(expressed as a decimal)}$$

$$\frac{\text{Total Number of Orders Not Filled on Demand*}}{\text{Total Number of Orders Requested}}$$

$$\frac{\text{Total Number of Items Filled on Demand*}}{\text{Total Number of Items Requested}}$$

$$\frac{\text{Total Number of Rush Purchase Orders*}}{\text{Total Number of Purchase Orders}}$$

Work Order Systems (Planning and Scheduling)

$$\frac{\text{Maintenance Work Orders Planned*}}{\text{Total Work Orders Received}}$$

$$\frac{\text{Maintenance Hours Scheduled*}}{\text{Total Maintenance Hours Worked}}$$

$$\frac{\text{Total Hours Estimated on Scheduled Work Orders*}}{\text{Total Hours Charged to Scheduled Work Orders}}$$

$$\frac{\text{Number of Work Orders Completed (Greater than 20\% of Estimated Labor)*}}{\text{Total Number of Maintenance Work Orders}}$$

$$\frac{\text{Number of Work Orders Completed Exceeding the Estimated Material Costs by (+/-) 20\%*}}{\text{Total Number of Maintenance Work Orders}}$$

$$\frac{\text{Work Orders Overdue*}}{\text{Total Work Orders}}$$

Computerized Maintenance Management Systems/EAM Systems

$$\frac{\text{Total Maintenance Labor Costs in CMMS/EAM System*}}{\text{Total Maintenance Labor Costs from Accounting}}$$

$$\frac{\text{Total Maintenance Material Costs in CMMS/EAM System}}{\text{Total Maintenance Material Costs from Accounting}}$$

$$\frac{\text{Total Maintenance Contracting Costs in CMMS/EAM System*}}{\text{Total Maintenance Contracting Costs from Accounting}}$$

$$\frac{\text{Total Maintenance Costs Charged to Individual Equipment Items*}}{\text{Total Maintenance Costs from Accounting}}$$

Operational Involvement

$$\frac{\text{Hours of Preventive Maintenance Performed by Operators*}}{\text{Total Preventive Maintenance Hours}}$$

$$\frac{\text{Hours of Maintenance Activites Performed by Operators (current period)*}}{\text{Hours of Maintenance Activities Performed by Operators (previous year same period)}}$$

$$\frac{\text{Hours of Equipment Improvement Performed by Operators*}}{\text{Total Hours Worked by Operators}}$$

Reliability-Centered Maintenance

$$\frac{\text{Number of Equipment Breakdowns**}}{\text{Total Hours in Time Period}}$$

$$\frac{\text{Number of Repetitive Equipment Failures*}}{\text{Total Number of Equipment Failures}}$$

Functional Maintenance Indicators

Functional indicators derive their name from the word function. Simply put, the indicators show how one of the eleven maintenance-specific functions is performing. The following list reviews the specific functions required of or expected of a maintenance organization in most companies.

Preventive Maintenance
Stores and Procurement
Asset Management Systems (EAM)

Work Flow Systems
Operational Involvement
Predictive Maintenance
Technical and Interpersonal Training
Continuous Improvement
Statistical Financial Optimization
Reliability-Centered Maintenance (RCM)
Total Productive Maintenance (TPM)
Computerized Maintenance Management Systems (CMMS) and Enterprise

The following functional indicators, mentioned previously in this book, show how well the parts of the function are doing in supporting the tactical issues. No organization will use all of these indicators, but will choose the ones that support the selected tactical indicators.

Preventive Maintenance

$$\frac{\text{Number of PMs Overdue*}}{\text{Total Number of PMs Outstanding}}$$

$$\frac{\text{Estimated PM Task Cost*}}{\text{Actual PM Task Cost}}$$

$$\frac{\text{Total Number of Work Orders Generated from PM Inspections*}}{\text{Total Number of Work Orders Generated}}$$

Inventory and Procurement

$$\frac{\text{Inactive Stock Line Items*}}{\text{Total Stock Line Items}}$$

$$\frac{\text{Total Dollar Value of Maintenance Spare Parts in a Controlled Stores Location*}}{\text{Total Inventory on Hand (Controlled + Uncontrolled)}}$$

$$\frac{\text{Total Number of Single Line Item Purchase Orders*}}{\text{Total Number of Purchase Orders}}$$

Maintenance Material Costs Charged to a Credit Card*
Total Maintenance Materials Costs

Work Flow Systems

Maintenance Labor Costs on Work Orders*
Total Maintenance Labor Costs

Maintenance Material Costs on Work Orders*
Total Maintenance Material Costs

Maintenance Contract Costs on Work Orders*
Total Maintenance Contract Costs

Maintenance Downtime on Work Orders*
Total Maintenance Downtime Charged

Maintenance Labor Cost Charged to Standing Work Orders*
Total Maintenance Labor Costs

Materials Costs Charged to a Standing Work Order*
Total Maintenance Materials Costs

Total Charges for a Specific Equipment Item Written to a Standing Work Order*
Total Charges for a Specific Equipment Item

Planning and Scheduling

Maintenance Labor Costs Planned*
Total Maintenance Labor Costs

Maintenance Material Costs Planned*
Total Maintenance Materials Costs

Computerized Maintenance Management Systems/EAM

Total Number of Equipment Items in CMMS/EAM System*
Total Number of Equipment Items in the Plant

<u>Total Number of Part Items in CMMS/EAM System*</u>
Total Number of Part Items in the Plant

<u>Total Number of Preventive Maintenance Tasks*</u>
Total Number of Equipment Items in the Plant X 3

<u>Number of Maintenance Employees or Full-Time Equivalents**</u>
Number of Supervisors or Coaches

<u>Number of Maintenance Employees or Full-Time Equivalents**</u>
Number of Maintenance Planners

<u>Total Number of Maintenance Overhead Personnel**</u>
Total Hourly Maintenance Personnel

Technical and Interpersonal Training

<u>Total Training Dollars**</u>
Total Number of Employees

<u>Total Technical Training Dollars**</u>
Total Number of Employees

<u>Total Interpersonal Training Dollars**</u>
Total Number of Employees

<u>Total Number of Training Employees**</u>
Total Number of Maintenance Employees

<u>Total Training Dollars*</u>
Total Plant Payroll

Predictive Maintenance

For Hours

<u>Hours of Predictive Maintenance Activities*</u>
Total Maintenance

For Costs

$$\frac{\text{Predictive Maintenance Costs*}}{\text{Total Maintenance Costs}}$$

Reliability Centered Maintenance

$$\frac{\text{Number of Failures Where Root Cause Analysis Was Performed*}}{\text{Total Number of Equipment Failures}}$$

$$\frac{\text{Number of Preventive Maintenance Tasks Audited*}}{\text{Total Number of Maintenance Tasks}}$$

$$\frac{\text{Number of Predictive Maintenance Tasks Audited*}}{\text{Total Number of Predictive Maintenance Tasks}}$$

Total Productive Maintenance

$$\frac{\text{Critical Equipment Items Covered by Design Studies*}}{\text{Total Number of Critical Equipment Items}}$$

$$\frac{\text{Critical Equipment Items Covered by 5 S Activities*}}{\text{Total Number of Critical Equipment Items}}$$

Statistical Financial Optimization

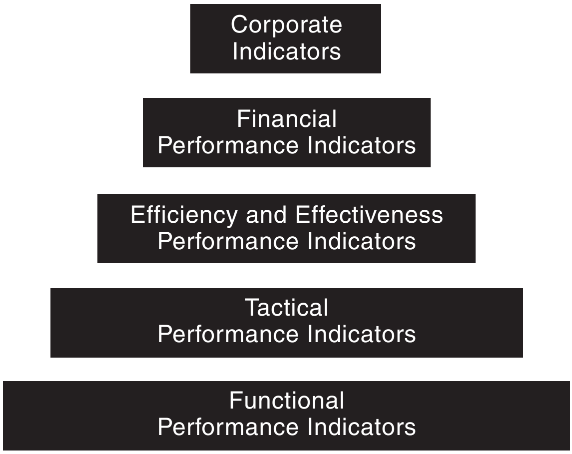
$$\frac{\text{Number of Critical Equipment Maintenance Tasks Audited*}}{\text{Total Number of Critical Equipment Maintenance Tasks}}$$

$$\frac{\text{Number of Critical Equipment Major Spare Parts Audited*}}{\text{Total Number of Critical Equipment Major Spare Parts}}$$

$$\frac{\text{Number of Critical Equipment Routine Spare Parts Policies Audited*}}{\text{Total Number of Critical Equipment Routine Spare Parts}}$$

A company striving to be the low cost producer in its respective market.

The corporate mandate is to keep the costs low while insuring the long-term viability of the company assets. Each company function that contributes to production costs must be as efficient and effective as possible. The tactical focus is one of insuring optimization of the overall maintenance costs on a quarterly basis. The functional support focuses on the optimization of each component of the maintenance process. Figure 14-1 illustrates the relationship among these different levels of indicators.



The scenario is as follows.:

The corporate cost-to-produce indicators begin to increase. The factors making up these indicators are examined. These include the individual financial indicators for each of the factors making up the cost-to-produce indicators. Upon examination, one particular financial indicator, Maintenance Costs as a Percentage of Total Manufacturing Costs, is checked and was found to have increased over the last quarter.

The efficiency and effectiveness indicators for maintenance are examined next. Upon examination, the Desired Equipment Uptime indicator has declined and is below an acceptable level.

The tactical indicators impacting the Desired Uptime indicator are now examined. As the indicators are checked, the Preventive Maintenance Compliance indicator is found to be lower than acceptable and trending downward.

Next, the functional indicators for the Preventive Maintenance program are examined. The PM Tasks Overdue indicator is high and trending even higher. Upon reviewing the indicator factors, it is found that the equipment is not being released by production for preventive maintenance. Here is the task that is hindering the execution of the preventive maintenance services. This, in turn, is leading to increased equipment breakdowns, which lower the uptime, which raises the maintenance costs, which impacts the cost-to-produce indicator.

This example shows how the performance indicators are linked. If the indicators are not linked to performance at either a higher level or a lower level on the indicator pyramid, then the wrong indicators are being used.

Remember: No one uses all of the indicators. Use only the ones that connect to the corporate indicators. The use of non-connected indicators will obscure the real problems and the solutions required. When this happens, organizations flounder, never making the correct improvements or changes.

CHAPTER 15

Scorecards and Performance Indicators

As companies have progressed with performance indicators, they have attempted to consolidate the indicators into displays in which multiple indicators can be shown and analyzed simultaneously. There are two main methods currently utilized: dashboards and scorecards.

Dashboards

Dashboards are displays that are patterned after automobile dashboard displays. They are capable of displaying performance indicators in much the same way that automobile dashboards display the operating conditions of the automobile. Performance indicator dashboards are typically set up to provide information based on the user's position or responsibility descriptions. For example, a planner might have one dashboard, a supervisor a different one, the maintenance engineer another, and the maintenance manager yet another. Each dashboard would display the performance indicators that would be utilized as they carry out their assignments.

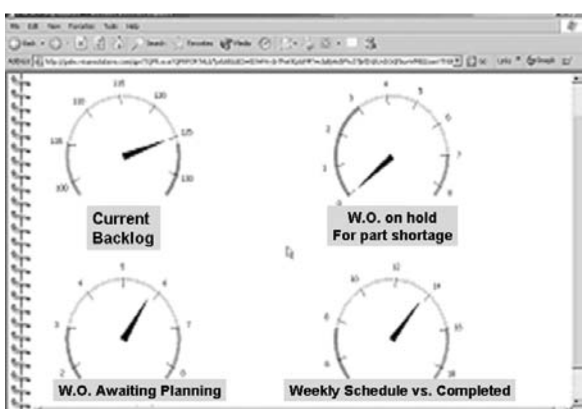


Figure 15-1 Example of Planning Dashboard

Therefore, a planner might need a dashboard that displays the current backlog of work by craft or crew, number of jobs awaiting planning, number of work orders on hold waiting on parts, and current scheduled versus completed work orders for the week. Figure 15-1 provides an example of a planner dashboard.

There are alternative examples of components for dashboards. For simple visual go/no-go decisions, red and green indicators can be used, as shown in the upper right portion of Figure 15-2. This display has multiple tabs that can be accessed by all, or could be security protected so that individuals can only

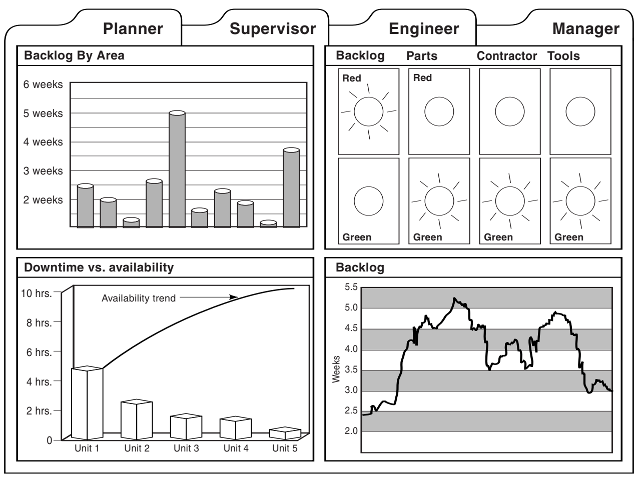


Figure 15-2

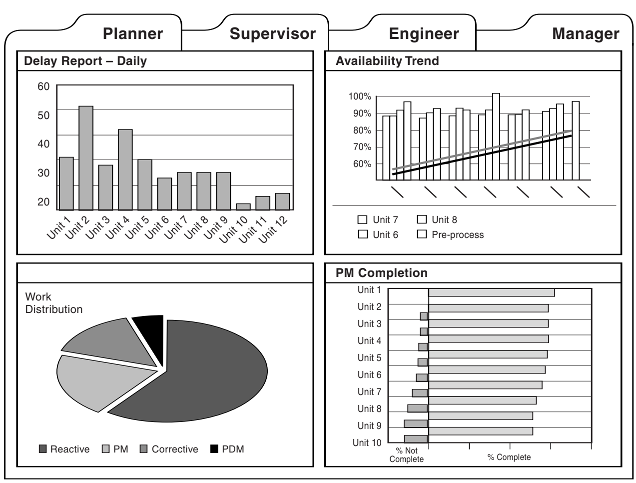


Figure 15-3

see their page of the display.

Figure 15-3 highlights some additional displays that may be utilized. Some may be better at showing trends or data distributions. What is important is to utilize the proper type of visual indicator for the data being displayed. Although the types of graphs and charts are almost endless, keep the complexity to a minimum when designing dashboards. The easier the dashboard is to interpret, the more likely it is that it will be used effectively.

The Balanced Scorecard

In their textbooks The Balanced Scorecard and ," authors Robert Kaplan and David Norton advocate a measurement system that can be utilized to communicate corporate strategies to all levels in the organization. They advocate that all strategies in various departments within a company must be linked to the overall corporate strategy. Their focus was to develop scorecards for business processes that must be performed exceptionally well for the company to succeed.

The authors believe their approach has evolved from a measurement system into a core management system. Their Balanced Scorecard approach translates an organization's strategy into a comprehensive set of performance measures that provide a strategic framework for a strategic measurement and management system. The balanced scorecard measures performance in four areas that provide a balanced perspective. The four areas are:

Financial
Customers
Internal business processes
Learning and growth

When these four areas are understood, developed, monitored, and then acted upon, the company should be competitive.

The Four Perspectives of the Balanced Scorecard

Financial

For most companies, financial objectives generally represent clear long-range targets for profit-seeking organizations operating in a purely commercial environment. These companies focus on indicators such as return on net (or fixed) assets, return on equity, or profit-losses indicators. Financial considerations for public organizations are rarely the primary objective for business systems. Success for public organizations is typically measured by how effectively and efficiently they meet the needs of their constituencies. Therefore, in the government, the financial perspective emphasizes cost efficiency, i.e., the ability to deliver maximum value to the customer.

Customers

This perspective captures the ability of the organization to provide quality goods and services, the effectiveness of their delivery, and overall customer service and satisfaction. In the public sector, the principal driver of performance is different than in the strictly commercial environment; namely, customers and stakeholders take priority over financial results

Internal Business Processes

This perspective focuses on the internal business results that lead to financial success and satisfied customers. To meet organizational objectives and customers' expectations, organizations must identify the key business processes at which they must excel. Key processes are monitored to ensure that outcomes will be satisfactory. Internal business processes are the mechanisms through which performance expectations are achieved.

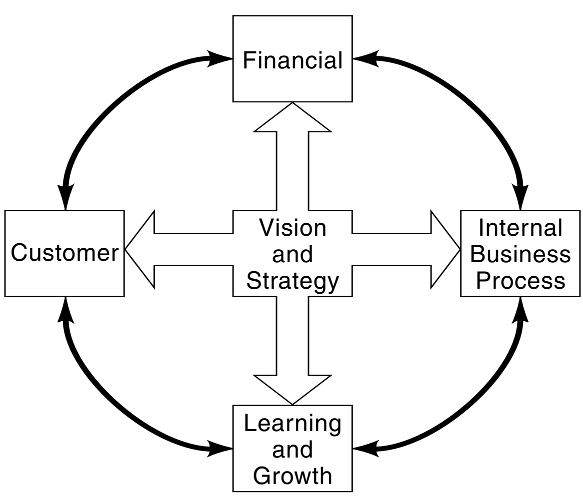


Figure 15-4 Balanced scorecard concepts

Learning and Growth

This perspective looks at the ability of employees, the quality of information systems, and the effects of organizational alignment in supporting the accomplishment of organizational goals. Processes will only succeed if adequately skilled and motivated employees, supplied with accurate and timely information, are driving them. This perspective takes on increased importance in organizations that are undergoing radical change. In order to meet changing requirements and customer expectations, employees may be asked to take on dramatically new responsibilities, and may require skills, capabilities, technologies, and organizational designs that were not available before.

The relationship among the four parts of the balanced scorecard and the company's vision and strategy are pictured in Figure 15-4.

Maintenance/Asset Management and the Balanced Scorecard

How does maintenance/asset management related to the balanced scorecard? It is similar to the process of linking indicators that was previously discussed in the introduction to performance indicators. It starts with the communication and clear understanding of the company's vision and strategy. Corporate-level measures are very important, but they aren't going to have much impact unless they are cascaded all they way down to front-line employees. This is important if the organization is going to be focused and aligned.

With some exceptions, such as market share, what you measure at the top is what must be measured at all levels. However, the specific measures will change with every business process and organizational level because managers doing different jobs need different information to make different decisions.

The same methodologies used to develop measures at the corporate level should be used to cascade the measures down to front-line managers, supervisors, and employees. However, as you go down the organization chart, the focus is on operations or processes. Strategy is incorporated into operational measures by giving more weight to the measures that are strategically important. This communicates strategy to all employees by translating it into operational terms: a primary objective of the Balanced Scorecard.

As the maintenance/asset management function is examined, how do the performance indicators relate to the balanced scorecard? It can be understood by examining the four components to the balanced scorecard.

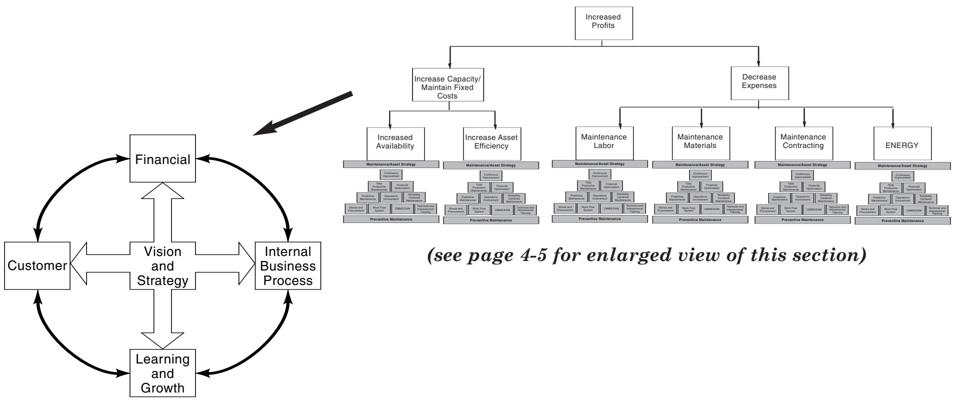


Figure 15-5 Balanced scorecard and maintenance/asset management

Financial

Figure 15-5 links Figure 1-2 (from Chapter 1) to the balanced scorecard. This linkage show how the ability of the maintenance/asset management function will contribute to achieving the overall corporate financial objectives. The maintenance/asset management function will enable companies to increase their asset capacity while maintaining current fixed costs. Concurrently, the maintenance/asset management function will enable a company to decrease operating expenses. Reducing the maintenance labor and materials expenses, the contracting expenses, and the energy expenses allows the savings in these areas to drop to the bottom line as profit dollars. What are some of the indicators that could be utilized to show the saving impact? Consider:

Maintenance Cost per Square Foot Maintained
Maintenance cost per estimated replacement value of the plant or facility assets
Contractor costs as a percentage of total maintenance costs
Maintenance costs as a percentage of total process, production, or manufacturing costs
Maintenance Costs as a percentage of a Sales Dollar

Each of these indicators have been explained previously, so the linkage of the maintenance/asset management scorecard to the financial component of the corporate scorecard becomes clear.

Customers

Figure 15-6 links the maintenance/asset management pyramid to the balanced scorecard. However, a problem occurs when trying to build the linkage to the customer block. It is the understanding of "Who is the true customer for the maintenance/asset management function?" Some companies view the customer as operations. This perception is common in organizations with an immature view of the maintenance/asset management function. The true customer for the maintenance/asset management function is the shareholders of the company. After all, who really owns the assets? Whose money bought the assets? Of course it is the shareholders or owners. If the assets are properly maintained, then their value is always going to be greater than if they are run to destruction. It is only when maintenance, operations, and engineering are focused and work together that any company achieves a "Best in Class" status.

With this understanding, how does this customer perspective link to the corporate customer perspective? Again, the text "The Balanced Scorecard" can add clarity. It defines three categories of attributes that organize the value propositions to the customers. They are:

Product or service attributes
Customer relationship
Image and reputation

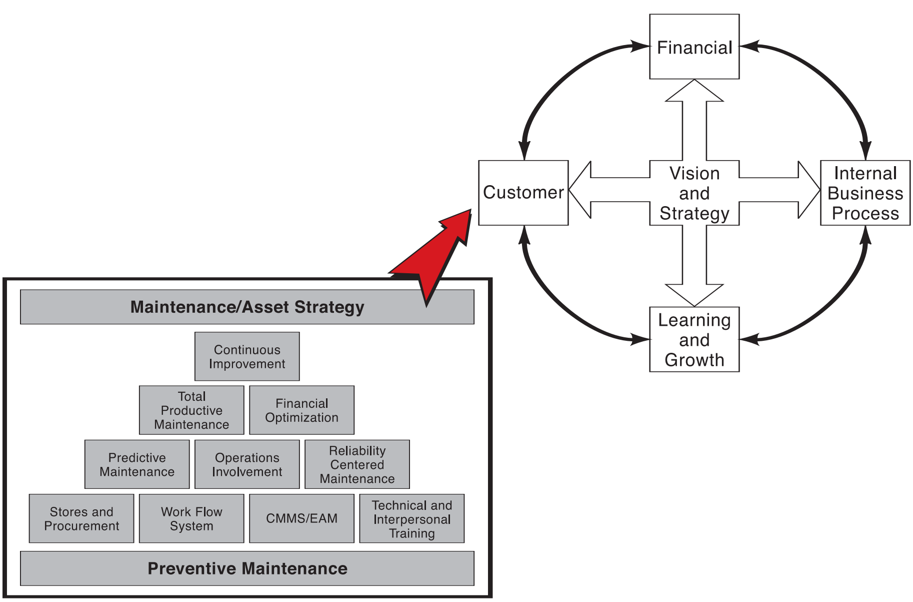


Figure 15-6 Balanced scorecard and maintenance/asset management

The product or service attributes deal with the functionality of the product or service, its price, and its quality. While the maintenance/asset management function does not directly impact the functionality, it has a direct impact on the price and quality of the product or service. As shown by Figure 15-5 (see figure 1-2 in Chapter 1 for details), the maintenance/asset management function allows the company to increase capacity while decreasing expenses. This will have a direct impact on the pricing model for any product or service. Concerning the quality issues, the common saying "You can produce quality products on poorly maintained equipment" would apply. This impact is not open for any debate, when considering that equipment/asset condition is always considered in ISO-9000 or QS-9000 certifications.

The customer relationship attribute deals with delivery and response time for the product or service. Insuring equipment reliability and capacity is part of the maintenance/asset management mission. There can be no effective just-in-time strategy with poorly maintained equipment. Equipment and assets that are properly maintained also have high availability and efficiency. This allows high production and service schedules compliance which, in turn, make the delivery timing and pricing more accurate, resulting in higher customer satisfaction.

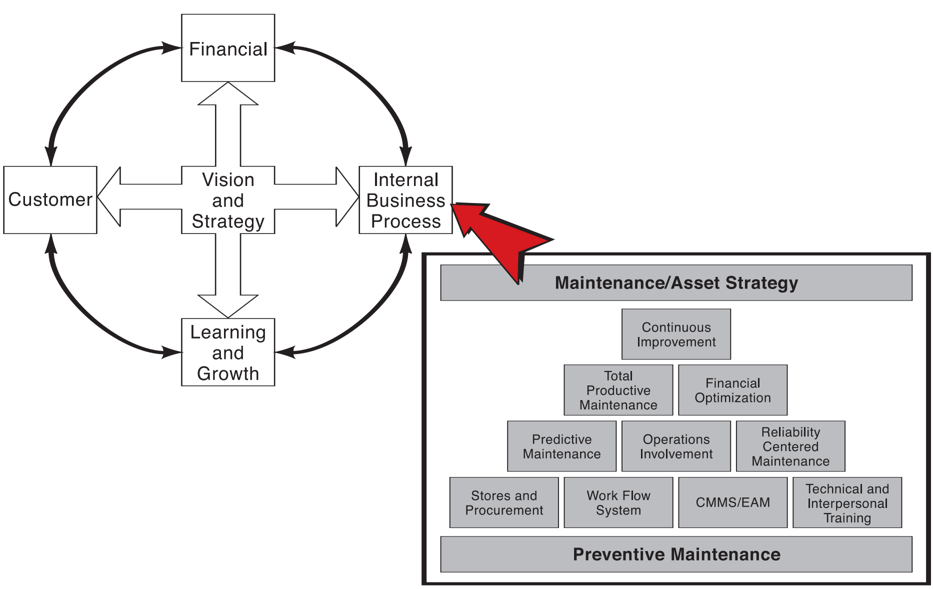


Figure 15-7 Balanced scorecard and maintenance/asset management

The image and reputation attribute can have several dimensions. One comes when the delivery quality and services from the company's products are recognized as superior. The maintenance/asset management function contribute directly to the product and service delivery time and quality. A second aspect of image and reputation is the safety, health, and environmental reputation of the company. Companies with well-maintained equipment assets have fewer environmental violations, fewer OSHA recordables, and a better safety record.

Figure 15-6 helps illustrate that a comprehensive maintenance/asset management strategy will support the customer requirement for the balanced scorecard. What indicator could be used to measure the maintenance/asset management contribution to the customer? The Overall Equipment Effectiveness indicator listed below is one recommendation. This indicator was reviewed in Chapter 12.

All Downtime

Availability = Scheduled Time (should be at least 90%)

$$\text{Performance Efficiency} = \frac{\text{Actual Output for Scheduled Time}}{\text{Design Output for Scheduled Time}}$$

(should be at least 95%)

$$\text{Quality Rate} = \frac{\text{Defects or Rework}}{\text{Total Production}}$$

(should be at least 99%)

90% X 95% X 99% = 85%

Why this indicator? It measures the condition of the equipment and the assets. Providing well-maintained production- and service-capable assets is the primary responsibility of the maintenance/asset management function. This indicator provides a clear measure of whether or not this is being accomplished.

Internal Business Process

These are the processes which, when optimized, insure that the business process is successful in achieving their mission and objectives. This relationship of the maintenance/asset management function is highlighted in Figure 15-7. This figure indicates that it takes a comprehensive maintenance/asset management strategy to support the internal business process component of the scorecard. It is this component of the scorecard that not only supports the vision and strategy, but also insures that the customer goals and the financial measures are achieved. The explanation of the maintenance/asset management pyramid was covered extensively in Chapter 2. If there is any uncertainty as to how the maintenance/asset management pyramid supports the internal business process component, it would be good to review Chapter 2.

Which indicators would be useful in measuring the internal business process? The answer depends on which part of the maintenance/asset management strategy is being measured. This list of indicators is too extensive to revisit in this chapter, but reviewing Chapters 3 to 13 will provide sufficient indicators to measure any part of the maintenance/asset management strategy.

Learning and Growth

As previously discussed, the learning and growth component of the scorecard focuses in three areas. They are:

Employee skills
Quality information systems
Organizational alignment

Figure 15-8 shows that although the overall pyramid supports this part of the measurement system, there are several specific relationships between the

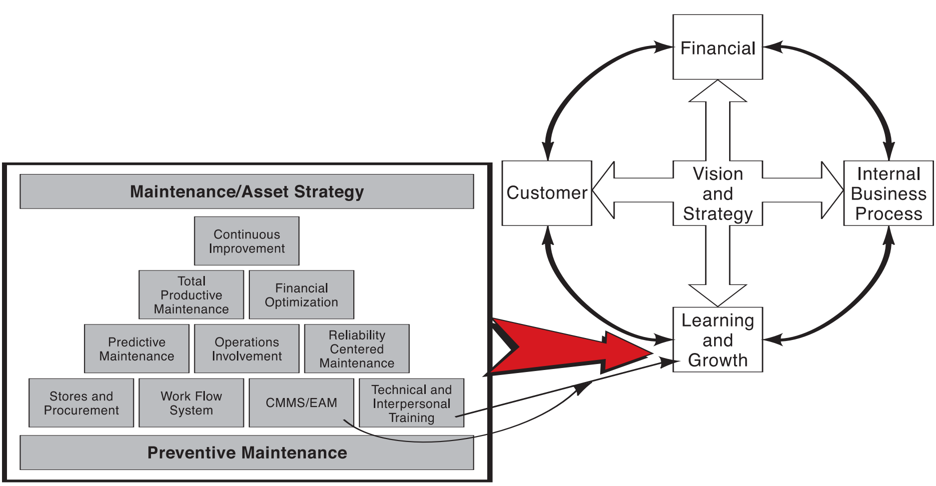


Figure 15-8 Balanced scorecard and maintenance/asset management

maintenance/asset management strategy and the learning and growth components of the scorecard. The first is the training and interpersonal skills for the maintenance technicians. This is covered in the strategy development (Chapter 2); specific indicators for training and development are provided in Chapter 7. It is only when an organization has a highly-skilled and motivated workforce that it is capable of achieving a "Best in Class" status.

Figure 15-8 also shows a clear linkage between the CMMS/EAM system and the learning and growth component of the scorecard. Because quality information systems are required to support the employees, they need to be given particular emphasis. Employees need accurate and timely information to make decisions about the maintenance/asset management function. They must have open access to functionally robust, yet simple to use CMMS/EAM systems. Unless this information is readily available and accurate, the employees will be unable to make accurate and timely decisions about the assets and equipment.

Organizational alignment was discussed in detail in Chapter 1. Unless the organization is properly focused, has proper geographic distribution, has a proper reporting structure, has roles and responsibilities properly defined, and is properly staffed, no effective measurement system can be in place.

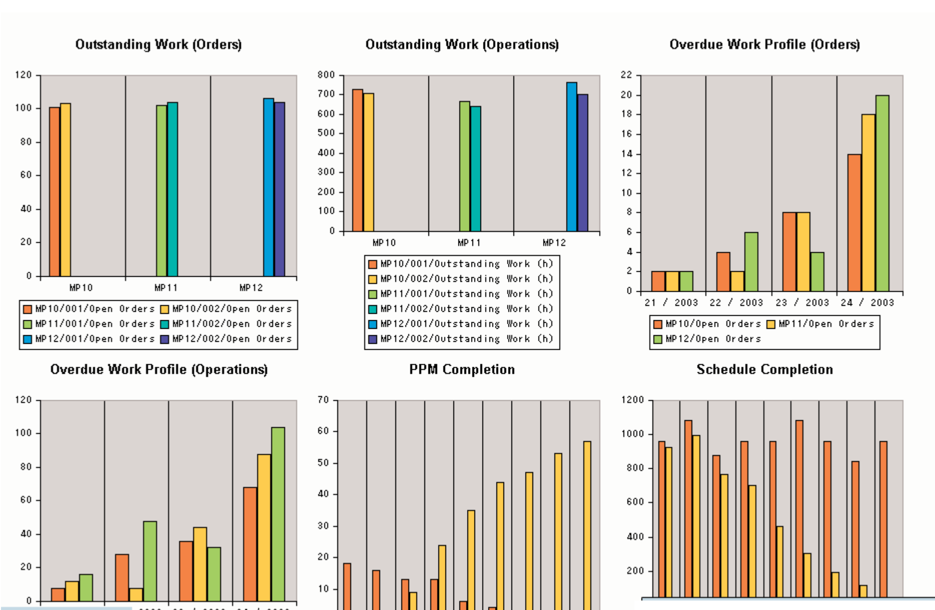


Figure 15-9 This chart supplied by SAP AG

What indicators would be useful in measuring learning and growth? For the technical and interpersonal training, consider the indicators in Chapter 7. For the CMMS/EAM system, consider the indicators in Chapter 6. For the organizational alignment, consider the main points covered in Chapter 1.

Conclusion

As various measurement systems are considered by companies, they need to be clearly understood to be properly implemented. It does not matter if a company is using performance dashboards or more sophisticated measurement systems such as a balanced scorecard. Unless employees are clear about why the indicators are important, how they can be used to improve performance, and how they are to be developed and maintained, the indicator system has little chance of being sustainable. The clearer the understanding that employees have of the performance indicators, the higher the probably will be of successful utilization of performance indicators.

CHAPTER 16

The Future

Where is the future of maintenance headed and what will be the trends of the future? This chapter will examine three major areas in which many organizations are focusing their current improvement initiatives. The areas are:

Back to the Basics
Cost-Benefit Analysis
Enterprise Resource Planning (ERP)

Back to the Basics

Many organizations today are returning to the basics. As technology changed the focus of many companies' manufacturing and process efforts, so too did it distract many maintenance organizations. The technology of inspection and detection increased and the maintenance organizations focused on the new tools and how to use them. As they did, they either hurriedly handed off the basic tasks of maintenance to the operators or they did not do them anymore. The result was that when vibration analysis indicated there was a problem with a bearing, all that took place was that the bearing was changed. Upon examining the bearing, however, it was found that the real problem was caused by a lack of lubrication.

The question is: Do maintenance organizations need technology to tell them that they are ignoring basic maintenance procedures and requirements on their equipment? It seems this is an expensive way to be reminded. One survey showed that over 50% of the equipment malfunctions and breakdowns occur due to the neglect of the basics of maintenance. As discussed in the preventive maintenance chapter, if the basic issues are not addressed, then little, if any, sustainable improvements will ever be achieved in equipment reliability.

This topic also ties in with training. Few maintenance management courses focus on the real basics of maintenance and how to meet those requirements. This area will need to be addressed for the new workforce. Many companies have aging workforces. When the current employees leave through retirement, who is prepared to take their place? There are companies today that are facing serious situations in the next three to five years as they experience turnover of their older, higher-skilled employees. If the basics of maintenance are not getting the attention required now, how will they ever be understood enough to get the required emphasis in the future?

A 1989 survey of best maintenance companies, found the first enabler that made the companies successful:

The best do the basics very well. Even among the best, there is still room for improvement.

Given this finding, companies would do well to ask themselves, "Are we doing the basics well?"

Cost-Benefit Analysis

Although it is improving in maintenance, the area of cost-benefit analysis is still in its infancy. This area provides the ability to cost justify maintenance improvements. There are two main areas in which maintenance impacts a company financially. These are expenses (cost avoidance) and creating capacity (more throughput with the same overhead costs).

In the expense area, anything that maintenance can save by being more effective and efficient is money that did not have to be spent. Because this money is now available, it can be applied to the bottom line as profits. Studies have shown that, depending on a company's cost structure, an expense dollar saved equals ten to twenty dollars in increased sales at the bottom line. Therefore, saving maintenance dollars by being efficient and effective is important.

In the creating capacity area, the fixed costs to produce a product are stable and a fixed part of the cost-per-unit calculation. In most companies, reducing expenses has been the focus of how to impact that calculation. However, progressive companies are now examining the other side of the indicator: the number of units. The are asking, "If the equipment ran closer to design speed without breakdowns, is it possible that more units could be produced with the same fixed costs, thereby lowering the cost per unit?" Companies that are asking that question are finding that the answer is yes.

In addition to increasing capacity, companies that are working in this area are finding secondary benefits. The need to purchase new equipment to keep pace with market demand is reduced, saving capital dollars. Such savings also have an impact on the ROFA and RONA calculations.

Another area of consideration is the impact that proper equipment maintenance has on energy costs. A well-maintained equipment unit requires from 5% to 11% less energy to operate than does a poorly-maintained equipment unit. Reducing energy costs for a company saves expense dollars. The impact on profitability is undeniable.

The more that companies understand the impact that maintenance has on their bottom line profitability, the more they are likely to agree that equipment maintenance is the last of the million-dollar savings strategies.

Enterprise Resource Planning (ERP)

In the early years of the 21st century, enterprise resource planning (ERP) is skyrocketing in popularity. Its focus is to help streamline all systems in a company so that they communicate more closely and are more closely coordinated, and so that the information systems used to manage the separate functions in the organization are completely integrated.

These goals can now be facilitated through the use of an Enterprise Resource Planning system. There are two theories as to how to develop these systems. One is that a vendor produces a massive software program with all of the functions that you might need to run your business; in turn, this vendor supplies your software system. The second theory is that a system integrator finds the "best of breed" solutions for each of the functions in the company and integrates them into a seamless solution. There are strengths and weaknesses to each theory.

The single vendor has a fully-integrated system with all modules required to run the business as a part of the system. The strength is usually the completeness of the integration. The weakness is usually the lack of functionality of some of the modules of the system. For example, most of the integrated systems do not have a strong maintenance module. However, this is changing. Several of the major ERP vendors have invested considerable resources upgrading the functionality of their packages. This has led to an almost-level playing field when functionality of the maintenance module is considered.

The "best of breed" solution allows the customer to select from a group of stand-alone packages. Once the best of each is found, the integrator puts them all together. The strength is that customers get a solution made up of the modules that best suit their needs from a functionality standpoint. The weakness is that many of the systems are difficult to integrate and, in many cases, don't work as well as promised when they are finished.

It really doesn't matter which solution a company selects because one issue will always be raised: How do we reengineer the organization to take advantage of the new tool? This is the issue that most companies have a problem addressing. Many companies think they can implement an ERP system and keep doing business the way they always have done it. This is not the case. Organizations will have to change some of their business processes to meet the requirements of the system and evolve to Best Practices. If they are not willing to change, then the implementation ends in frustration for everyone.

A second major issue is the commitment to use the system, all of the ERP system. This commitment takes time and resources. The ERP system requires each department to input all of its data so accurately that it matches and verifies the data put in by other departments. Unless everyone who uses the system commits to this, the data accuracy suffers and the system is never utilized. Without full utilization, the return on investment for the system purchase is never realized and the system implementation is termed a failure. Time and resources are required. They must be planned for if the ERP system is to be successful.

But what about the maintenance function in organizations? They will, in the future, be more fully integrated within an organization. In the same way that companies are turning to fully-integrated ERP solutions with maintenance as a part of the solution, most companies will integrate maintenance and operations even more closely. Even now, many companies don't have maintenance departments; instead, they have capacity assurance departments. Some companies, employing a process team concept, don't have Total Productive Maintenance, but instead Total Process Reliability. The focus is on maximizing the equipment assets, not on managing maintenance. Although the highly-skilled and talented maintenance technicians will always be required, how their work is integrated into operations, and how focused they are on data collection and analysis, will change.

The competitiveness of organizations world wide, will require companies to increase their abilities in the maintenance/asset management business process if they are to survive into the next decade.

Introduction

In today's business environment, every conceivable advantage is being pursued by companies. They have implemented improvement tools and techniques, such as Total Quality Management (TQM), Just-in-Time Manufacturing (JIT), Total Employee Involvement (TEI), benchmarking, time-based competition, outsourcing, partnering, reengineering, and change management. In the first decade of the 2000s, many companies are shifting their focus to the optimization of their assets. Because companies realize that the majority do not have "stealth" assets or processes, they must be more efficient and effective than their competition in utilizing the assets and processes.

This competitive focus involves virtually all parts of the organization that impact the effectiveness of the asset. The group within the company that has the largest impact on the assets is the maintenance department, as well as those responsible for the maintaining function in a company. Because the maintenance function has the greatest impact on the condition and, ultimately, the capacity of the asset, companies are searching for the best method of managing maintenance.

Companies have tried different organizational structures, changing reporting structures, upsizing, downsizing, contracting out, and empowering teams in an attempt to manage maintenance. However, the majority of companies have not been able to effectively manage maintenance. The single largest contributing factors to this have been the lack of a proper understanding of the maintenance function and the development of measurement and control systems for maintenance.

Performance Measures

Performance measures have been misunderstood and misused in most companies today. Performance indicators are just that, an indicator of performance. They are not to be used to show someone is not doing their job in the company and how, now that they are exposed, they can be dismissed. Performance indicators are also not to be used for ego gratification," that is, to be used for comparison with another company to show how much better one company is than another. Nor are performance measures to be used to show "we are just as good as everyone one else in our market, so we don't need to change."

Properly utilized, performance indicators should highlight opportunities for improvement within companies today. Performance measures should be used to highlight a soft spot in a company and then be further analyzed to find the problem that is causing the indicator to be low. Ultimately, they can point to a solution to the problem.

This implies that there should be multi-level indicators. One layer of indicators is at a corporate strategic level. A supporting level is the financial performance indicator for a particular department or process. A third level is an efficiency and effectiveness indicator that highlights what impacts the financial indicator. A fourth level is a tactical level indicator that highlights the departmental functions that contribute to the efficiency and effectiveness of the department. The fifth level of indicator is the measurement of the actual function itself. The pyramid in Figure I-1 shows this tiered approach to performance indicators.

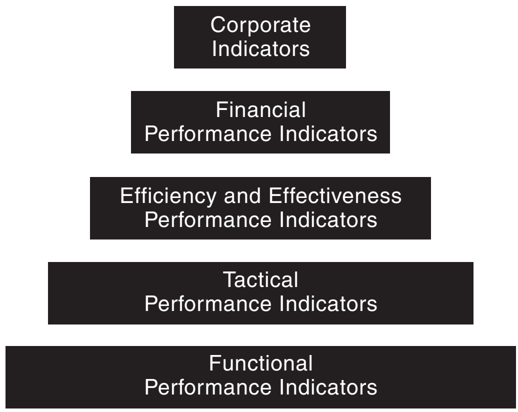


Figure I-1 The Hierarchical Performance Indicators

While the pyramid provides the hierarchical relationship of the performance indicators, it should be noted that the indicators are determined, not from the bottom up, but from the top down. The corporate indicators are measuring what is important to senior management to achieve the corporate vision. Corporate level indicators will require the entire organization to focus their efforts on achieving the corporate vision..

The corporate indicators will vary from company to company, depending on their current market condition, business life cycle, and corporate financial standing. Even different parts of a corporation may be measured with different indicators. For example, in energy exploration and production, a particular field will be measured based on where it is in its life cycle. A new field will tend to have higher spending levels for operations and maintenance; whereas a field that is nearing the end of its life cycle tends to have lower operating and maintenance expenses.

Because corporate indicators focus on achieving the long-term vision, all subsequent indicators must focus the organizational levels on supporting the corporate direction. If the indicators are not connected, the overall organizational effort is sub-optimized, endangering the corporation's survival when faced with competitors who have greater focus.

Rule Number 1:
All Performance Indicators Must be Tied to the Long-Range Corporate Vision.

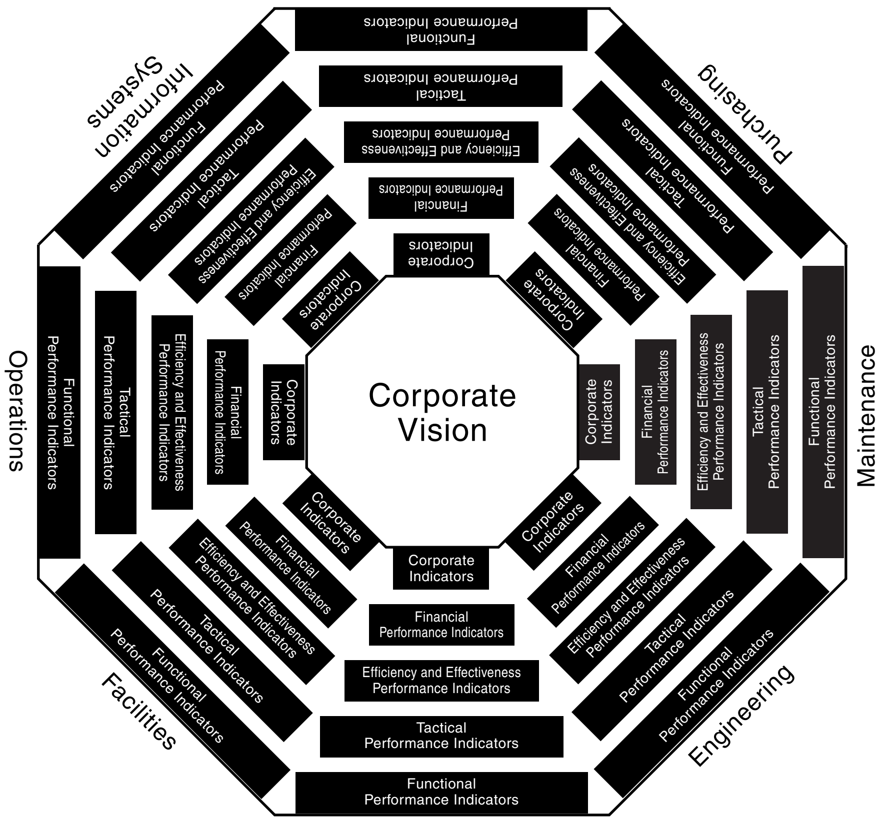


Figure I-2

One company has taken the performance indicators linkage to a higher level, in that it believes that all business functions should also be linked. This company's indicator structure is highlighted in Figure I-2.

This client believes its indicators should not only be linked vertically, but also circularly because each business function impacts related functions in the company.

If a corporate indicator highlights a weakness, then the next lower level of indicators should give further definition and clarification to the cause of that weakness. When the functional performance indicator level is reached, the particular problem function should be highlighted. It will then be up to the responsible manager to take action to correct the problem condition. When the problem is corrected, the indicators should be monitored for improvement at the next vertical level to insure the action taken was appropriate. If the appropriate action was taken, the improvement should be noticed as it impacts the hierarchical indicators up to the original corporate indicator.

The importance of timely change when utilizing hierarchical performance indicators is clear in examining the improvement process. If changes made at the functional level do not result in a change in the tactical performance indicator, then it is obvious the changes made were incorrect. This should be apparent quickly so that the organization will not have to wait until the end of the month or end of the quarter to evaluate the effect on the corporate indicator.

Developing Comprehensive Performance Indicators

Companies today face tremendous competition in a global market. They have made rapid changes in organizational structures, reporting systems, and, in some cases, operational and production processes. Often they have struggled with the performance measurement systems. How can rapidly changing companies focus on improvements when there is no system to tell them if they are making progress? This question highlights the need for measurable and consistent performance indicators

Objectives of Performance Indicators

Performance indicators should be integrated and interdependent in order to provide an overall perspective on the company's goals, business strategies, and specific objectives.

During the process of developing performance indicators, the following should considered:

1. Make strategic objectives clear, in order to focus and bring together the total organization. Senior manager must clearly communicate the company vision.
2. Tie the core business processes to the objectives.

   Maintenance is a core business function if you have assets or equipment.
3. Focus on critical success factors for each of the processes, recognizing the re will be variables.
4. Use the indicators to track performance trends and to highlight progress and potential problems.
5. Identify possible solutions to the problems.

Many companies need a performance indicator system that truly pulls together all parts of the organization in a strategic model. This model allows for optimum return on the investment in the business, thus constantly attracting investors. Keeping the five points above in mind will assist in assuring development of a good performance indicator system.

Categories of Performance Indicators

Performance indicators will vary according to the firm's needs, but will likely include: corporate, financial, efficiency and effectiveness, tactical, and functional indicators.

Implementing Performance Indicators

The process of implementing new performance indicators so that they become ingrained in the culture of the business presents both opportunity and challenge. The opportunity is for each department to connect its operation to the overall business of the company. The challenge is to find indicators that allow this connection to be clearly communicated. Effective implementation requires the following steps:

1. Recognize the need for performance indicators by identifying new challenges (e.g., loss of market share to competitors, excessive cost to produce, low return on investment for the shareholders). In some cases, this need may be a requirement to be able to measure a business function.
2. Ensure top management support and commitment by actively involving them in the development of the new indicators. Their communication should involve the need for the performance indicators. They should be directly involved with the implementation team. This step can be facilitated by obtaining from them a clear directive as to the corporate indicators. Using that information, a clear linkage can be developed to the functional indicators. Communicating this linkage will help to gain and maintain management support for the indicator system.
3. Create an implementation team that can develop and communicate a common understanding of the company's strategic direction. The team should actively solicit input from all levels of the company and be able to refine the input into a cohesive plan. They should develop the complete set of key corporate performance indicators. The indicators should then be cascaded throughout the corporation.
4. Develop a departmental performance model that can put the departmental goals, strategies, objectives, critical success factors, and performance indicators into context by viewing first the corporate strategic direction, and then tie the departmental performance indicators to this direction. The linkage developed in Step 2 can be modified to facilitate communication at this level.
5. Develop an understanding of the departmental strategies and objectives. Then for each strategy and objective, define the functions required to achieve it. Chapter 1 will develop this process in detail.
6. Define the supporting activities that will have the largest impact on the department's strategies. These activities will deal with deployment and other issues that impact the department's efficiency and effectiveness and, ultimately, its financial contribution to the corporate strategies.
7. Develop the performance indicators to measure the strategies and activities. Consult with different levels of management to determine who will be tracking the indicators, how the information should be tracked, tracking frequency, and the performance targets.

8. Establish the underlying technology (typically a CMMS) necessary for the performance indicators. Consider what is required, the level of detail, frequency of reporting, the amount of data required, and its source. This step is critical because most companies do not utilize their CMMS/EAM systems sufficiently to allow for high level of confidence in the data. Without accurate data from the CMMS/EAM system, the performance indicators will not be accurate.

9.Reevaluate the reward and recognition system to insure that it is consistent with the new performance indicator system. This will insure that all employees are focused on supporting the company and departmental strategies.

10. Ensure continuous improvement by updating the system, keeping in mind that the business needs of the company and what is critical to competitiveness may change. The indicators should always be aligned with any updated strategies.

Challenges

The challenge for management is to put into place new performance indicators that will contribute the success of their companies in the ever-changing business environment. Included among the challenges that management faces are:

1 Developing awareness of the need to modify existing performance measurement styles
2 Procuring top management support and commitment
3 Gaining cross-functional support
4 Obtaining resources necessary to the design and development of the performance indicator system
5 Assuring accurate, timely, and useful data
6 Linking new indicators to long-term economic value
7 Assessing the new system's effects

Most departments cannot be evaluated with one indicator. Most effective efforts rely on multiple measures and multiple forms of measurement. The simple application of a proven measure from one department to another may also be a poor strategy, given the variances in departments and services rendered. Considerable effort may be required to develop an elegant solution: a relatively small number of indicators, easily managed, that capture the intended departmental performance.

An ideal performance measurement system requires:

1. Long-term cooperation on defining and implementing goals and measures. The entire organization must be involved.
2. Connections between the measures and resource allocation decisions. You must be able to support the indicators you implement.
3. Measures that are easily developed, understood and valid. The information systems (particularly the CMMS /EAM Systems) should allow for the accurate assessment of costs and other measures.

Maintenance Performance

Because the theme of this book is maintenance performance, it is only fitting to adapt the previous concepts to the maintenance process for a corporation. The book is organized in the following manner. First, an overview of maintenance management is presented. Second, the steps to implement a maintenance management program are discussed. Third, performance indicators are highlighted for each of the functions of the maintenance management program. Fourth, the hierarchical indicators typically used will be examined, with each one's strengths and weaknesses discussed. The material is designed to help each company choose the correct indicator for its business needs..

Glossary

5 S - organization, tidiness, purity, cleanliness, and discipline; focused on the work place, they are derived from five Japanese words beginning with the letter s

A

absenteeism - the act of missing work; being absent from a scheduled work shift

accounting - a functional department within a company with the task of compiling and analyzing all of the financial records for the company

asset management - the oversight of the life of an asset to achieve the lowest life cycle cost with the maximum availability, performance efficiency, and highest quality

B

benchmarking - a continuous improvement process of examining companies that are more effective in a specific process, learning how they became more effective, and then adapting their methods to your company's process, with the goal of being better at the process than the company that was benchmarked

best practice - a practice that leads to superior performance in a specific process

breakdown - an unexpected interruption to the service of a particular asset

breakdown maintenance - maintenance performed in response to a breakdown; typically costs two-to-four times as much compared to the same maintenance performed in a planned mode

C

cleaning - the act of removing contamination or other materials from an asset

CMMS (Computerized Maintenance Management System) a software package designed to help manage the maintenance function

CMMS usage - the utilization of a CMMS; many companies achieve only a 50% utilization rate, preventing a realization of the full return on the investment in the software

competitive analysis - a comparison of a company's process with a specific competitor or group of competitors

continuous improvement - the act of constantly making a company's business processes better

contractor - an individual or company that has a legal agreement to provide a specific service or task corporate indicators - measures that are used to determine how successful a corporation is in its particular business

credit cards - ordinary credit cards, such as VISA, Mastercard, and, American Express, that are used to purchase small items for a plant or facility, usually for maintenance activities

critical spares – major spare parts that have high value and long lead times, usually carried in stock to prevent excessive downtime in case of a breakdown; average about 10% of inventory items, but may comprise up to 50% of the inventory value

D

data collection – the gathering of information to develop and support a performance indicator

downsizing – the reduction of a company's workforce; may be due to a department closure or market share reduction, but is commonly used incorrectly as a quick method or reducing company expenses

downtime – the time period during which a particular asset is not performing to design specification; asset may actually be in a breakdown condition or may be not be capable of producing at design specification

E

EAM – (Enterprise Asset Management) – a software package designed to help manage the maintenance function at an enterprise level; unlike the CMMS, which manages maintenance at the departmental level, EAM focuses on standardizing information, policies and practices for the corporation.

early equipment management – a management philosophy that examines closely how equipment or assets will be required to perform during their life cycle to insure that the design specifications are adequate

early equipment management and design – a management philosophy that gathers data from existing equipment performance and feeds the data to the design process for the next generation of equipment being developed

emergency – a type of equipment problem where a breakdown has occurred and immediate attention is required; Usually safety, health, or process integrity is involved

EPA (Environmental Protection Agency) – a U. S. government agency charged with enforcing governmental environmental regulations

equipment capacity – the ability of equipment to produce a product or provide a service at a given rate over a specified time period.

equipment uptime – the time period during which an equipment item is performing at design specification; the inverse of downtime.

ERP (Enterprise Resource Planning)– the planning of all resources of a corporation to insure that products and services are produced and provided at lowest total cost

F

FEMA (Failure and Effects Mode Analysis) – examination of failures and the resulting effects; makes possible implementing changes to prevent or trend any future failures

financial indicators – measures that connect the business process with the overall corporate goals; the structure of the indicators allows analysis for continuous improvement

financial optimization – an analysis technique that compares the total cost of an activity to a company; includes factors such as profit generated, cost of maintenance, cost of production, quality costs, and energy costs; goal is to achieve the optimum financial balance for the company

functional maintenance indicators – measures that examine the individual functions of the maintenance processes; they then support the tactical indicators.

I

idling and minor stoppage – a type of equipment loss caused by small interruptions of the equipment; causes are usually small, requiring little effort to repair or reset; losses can be significant when accumulated over time

inventory – spare parts or equipment component kept in case of an equipment break down or for replacement when the part or equipment component wear out

inventory and procurement – a function within an organization that is responsible for obtaining and storing spare parts, equipment and. in some cases, raw materials; required to support the maintenance function if maintenance activities are to be carried out effectively and efficiently

ISO-9000 – standards for quality systems, insuring consistency in quality production

J

Just-In-Time (JIT) – an operating philosophy that focuses on reducing lead times and work in process in manufacturing operations

L

lean manufacturing- a system of manufacturing that focuses on minimizing the resources necessary to produce a product or provide a service

life cycle costing – a technique that examines the total cost of ownership of an asset; costs are calculated from the design phase to the disposal stage; this technique usually produces dramatic savings for companies used to buying from "low bid" vendors

lubricant condition - a technique that examines the condition of the lubricant to insure the lubricant is capable of performing its designated function

M

MTBF (Mean Time Between Failure) – the average time between failures for an asset or component on an asset

MTTR (Mean Time To Repair) – the average time needed to restore an asset to full operation after a failure

maintenance management implementation decision tree – a methodology for improving maintenance

maintenance performance - comparing the results of the maintenance function to the goals and objectives set for it

maintenance prevention – a design change or activity focusing on reducing or eliminating the maintenance needs of an asset

mechanical fastening – some form of a device that joins or fastens two components together; includes bolts, studs, screws, and locking devices

minor maintenance – small maintenance activities that are low cost and of short duration

N

NASCAR – a racing circuit in the United States that focuses on maximizing equipment utilization through structured teamwork and discipline

O

OEE (Overall Equipment Effectiveness) – a measurement that compares the availability, performance efficiency, and the quality rate of an asset

oil analysis - one of two techniques; the analysis of the actual lubricant for its condition or the analysis of the wear particles in the oil to determine what part of an asset is wearing

operational involvement – the use of operations personnel in some aspect of maintaining their equipment or assets

operations personnel – employees who work in the operations department

operator involvement – the extent to which employees who run equipment are also engaged in some aspect of maintenance of their equipment or asset

OSHA (Occupational Safety and Health Administration) – A U. S. agency focus on providing a safe and healthy workplace for all employees

Overall Equipment Effectiveness (see OEE)

P

Pareto - an analysis performed to show which 20% of the equipment or assets creates or contributes to 80% of the problems the company is experiencing

PDM (see predictive maintenance)

performance indicators – measures to determine the performance of a function within a company

performance measurement – a function that compares organizational achievements to its stated business objectives.

performance measures (see performance indicators)

planned and scheduled – maintenance activities for which resources are determined in advance and time is estimated to carry out the work; estimates are then built into a weekly schedule for the maintenance staff

planner – a designated individual who plans maintenance activities

PLC (Programmable Logic Controller) - electronic control system used in facilities and plants to control assets

Predictive Maintenance (PDM) - an advanced preventive maintenance technique that is focused on using technology to determine the condition of equipment or assets

preventive maintenance – activities designed to eliminate or reduce wear on asset or equipment systems

PSM (Process Safety Management) – special regulation designed to increase the safety and environmental control of process system

purchase orders – forms produced by the purchasing department to obtain materials for the company

purchasing – the functional department responsible for securing the material necessary for the company to produce its product or provide its service; often called procurement.

Q

QS-9000 – quality standards for the U. S. automotive industry; similar to the ISO-9000 standards

quality defects or rework – products that are not usable or need additional work to be usable

R

RCM (see Reliability-Centered Maintenance)

reactive – maintenance activities that occur with little or no notice; these activities interrupt the weekly maintenance schedule and cost two-to-four times as much as when they can be planned and scheduled

reduced speed or capacity losses – losses incurred when equipment or assets are allowed to perform at less than design speed or capacity

reliability – the probability that equipment or an asset will perform its designed function without a failure for a period of time under specific conditions

Reliability-Centered Maintenance (RCM) - a technique designed to enhance and improve the preventive and predictive maintenance programs

ROFA (Return On Fixed Assets) – the profit a company generates factored by the value of the fixed assets that produced the profit

ROI (Return On Investment) – the financial return on any investment that is made

RONA (Return On Net Assets) - the profit a company generates factored by the net value of the assets that produced the profit root cause analysis – a technique used to discover the true cause of an equipment or asset problem, malfunction, or breakdown

routine lubrication - the act of carrying out lubrication on an equipment or asset on a regular schedule

routine spares – spare parts that are used on a regular basis to maintain equipment or assets

S

service level - the percentage of time spare parts are in stock in the storeroom when they are required

set up and adjustment – the process of changing from running one product to running another

sonics – the use of ultrasound to detect thickness of materials, and other techniques such as leak detection

start up and shutdown losses – equipment losses occurring when equipment is shut down and started up; losses occur when the process is destabilized and then stabilized

start up inspections - inspections that are typically carried out by operational personnel while starting up the equipment

statistical financial optimization – a technique that blends the financial controls and the reliability statistics to forecast the lowest total cost for various maintenance decision

stock out – an event that occurs when a part is required and is not available

stores - also referred to as inventory; the function within a company that is responsible for maintaining the inventory of spare parts

stores and procurement – also called inventory and purchasing; the function in a company responsible for ordering, purchasing, and maintaining spare parts for the company

supervisor – a first-line manager usually responsible for a group of 8-to-12 employees in a traditional organization

T

tactical indicators – measures that highlight weaknesses in an organization; require the merging of functional processes within the maintenance function to improve

technical and interpersonal training – training programs that address the technical skills of the personnel and “soft” skills such as team building and diversity training; both types of training are required to produce a workforce capable of performing at world-class levels

technical training – training in technical trades areas such as electrical, mechanical, and fluid power thermography – The use of infrared technologies to measure temperature differentials

Total Productive Maintenance (TPM) – an operational strategy focusing on maximizing overall equipment effectiveness; requires full organizational participation to be successful.

U

ultrasonic – the use of sonics technology to discover equipment and asset problems

uptime – the time equipment or assets are available to perform their designed function

V

vibration analysis – a predictive maintenance technology focusing on vibration of rotating equipment to discover and then trend wear of mechanical components, allowing maintenance activities to occur before a breakdown

visual systems – a technique utilized to highlight operating conditions, such as pressure, flow, and fluid levels; makes inspection and tracking equipment conditions easier and lessens the risk of a mistaken reading.

W

wear particles – a type of lubricant analysis that examines particulates suspended in the lubricant; allows wear to be identified and corrected before a failure occurs.

work flow – the process of requesting, planning, scheduling, and tracking all maintenance activities.

work order – a document used to request, plan, schedule, track, and report on all maintenance activities

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