

Second Edition

Developing Performance Indicators for Managing Maintenance



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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.

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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

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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

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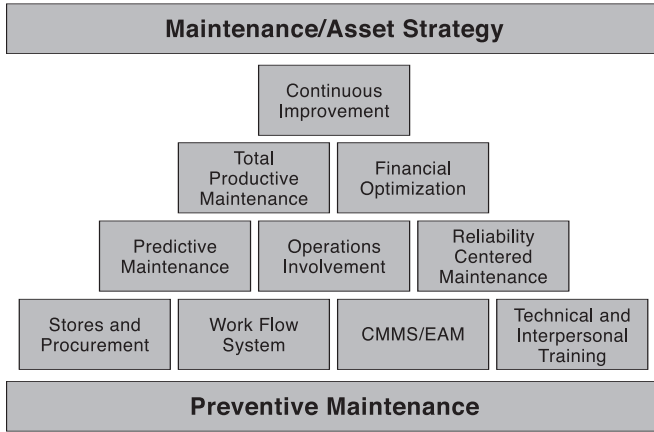


Figure 1-1 Highlights a comprehensive maintenance/asset management strategy.

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

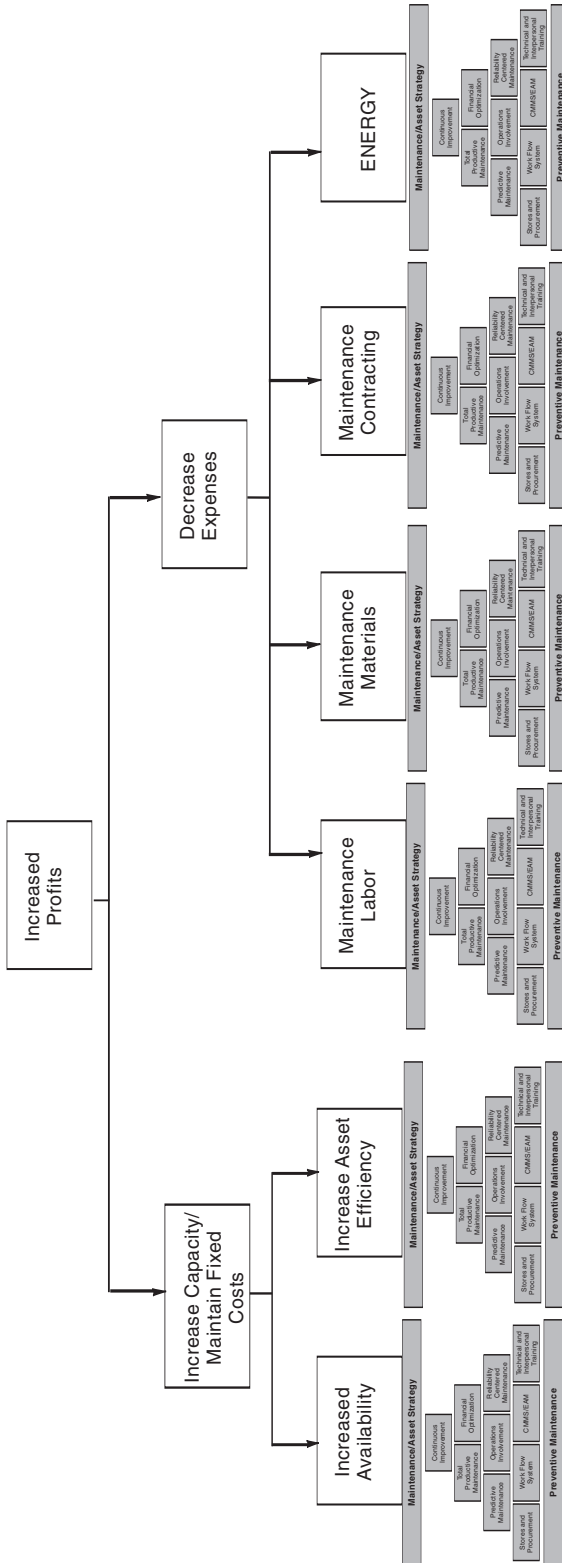


Figure 1-2 Maintenance / asset management strategy impact.
(Enhanced view of pyramid can be read from page 4.)

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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 effi-

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ciency 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

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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.

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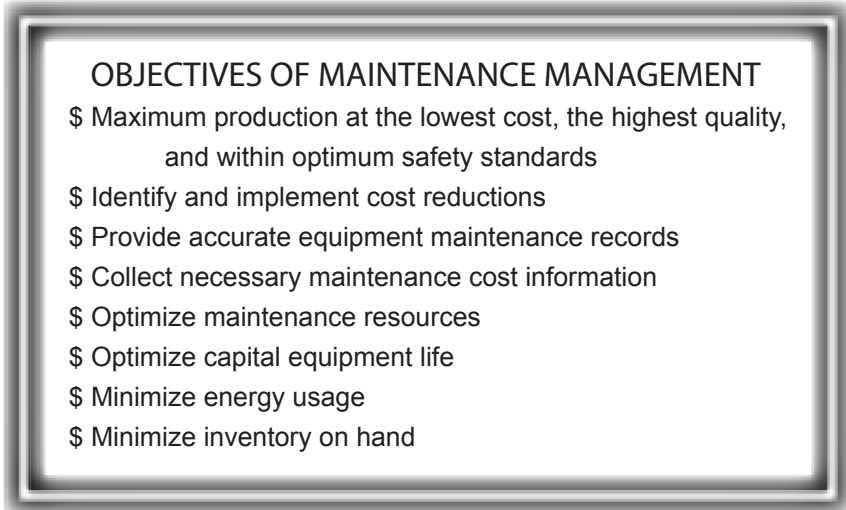


Figure 1-3

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 outside contract personnel. However, maintenance must still maintain the equipment, so they should be involved in any equipment installations or alterations.

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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.

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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.

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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.

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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.

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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

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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 tol-

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erances 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).



Figure 1-5

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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

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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.

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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

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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

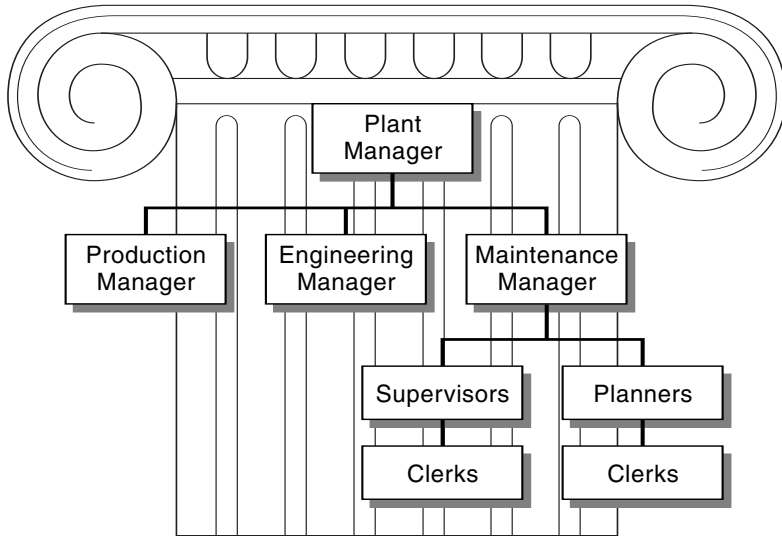
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Figure 1-6 Typical Maintenance-Centric Organizational Structure.

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.

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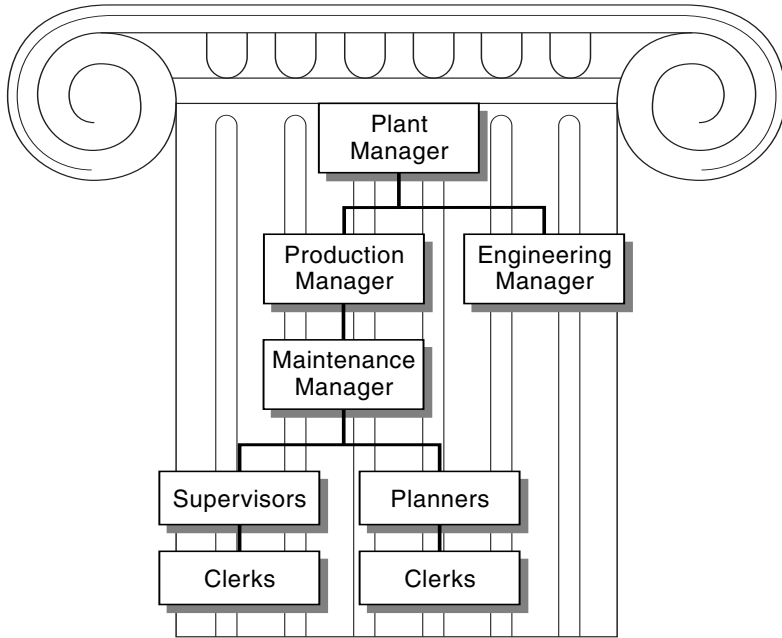


Figure 1-7 Typical Production-Centric Organizational Structure.

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.

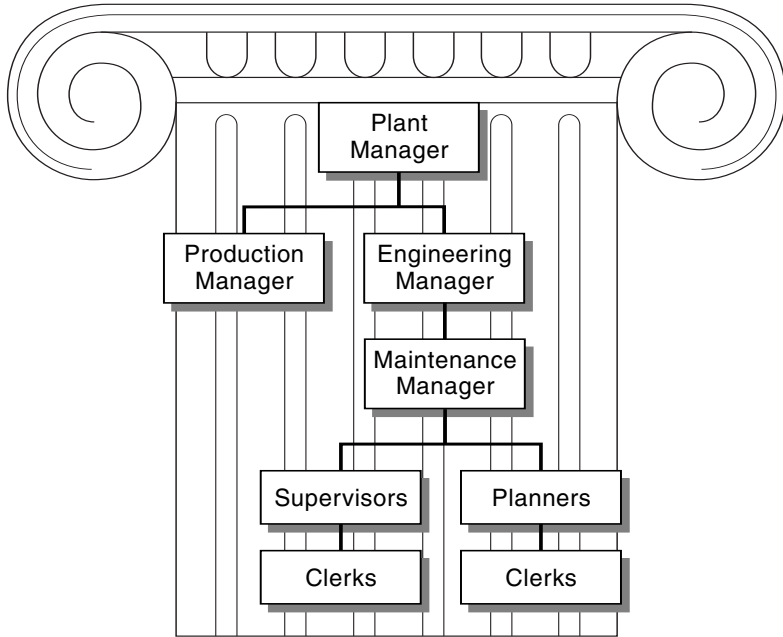
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Figure 1-8 Typical Engineering-Centric Organizational Staff.

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 organiza-

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tional 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.

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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 fore-

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man 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?

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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

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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.

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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.

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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,

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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.

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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.

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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

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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:

$$\text{Backlog} = \text{identified work (in hours)} \div \text{craft capacity per week (in hours)}$$

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.

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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

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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.