

Chapter 1: Zero Breakdown Concepts

Introduction to Zero Breakdown Strategies

Are zero breakdowns really achievable at your plant or facility? Is it conceivable—or even desirable—to have zero breakdowns? If we think of quality initiatives, the goal is zero defects. While most companies never achieve this goal, many develop strategies or methodologies that come very close. In fact, six sigma quality is the stated goal for many quality programs.

We can compare maintenance to quality: quality focuses on producing a perfect product; maintenance focuses on providing reliable equipment capable of producing the perfect product. So if zero defects is the goal for quality, should not zero breakdowns be the goal for maintenance? In reality, most companies would never achieve zero breakdowns, so would it be possible to have six sigma reliability? If so, what would be the cost of six sigma reliability? When would the cost of equipment or asset reliability exceed the benefits achieved? How expensive would it really be to achieve zero breakdowns?

These questions can only be answered after clearly defining breakdowns, the business objective of the equipment or asset, and the determination of the steps necessary to achieve zero breakdowns.

Asset Utilization—The Business Objective

Asset utilization, commonly referred to as Overall Equipment Effectiveness, is a complete picture of how equipment or assets perform. It involves examining equipment availability, the equipment performance rate, and the quality rate. The asset utilization may also be referred to as equipment capacity.

Asset utilization is not just the responsibility of one department. It is the re-

sponsibility of the entire company. It has the focus of ensuring that nowhere in the world does another company have the same assets or produces greater capacity from those assets. It means being the best at getting the most out of the assets. The measurement of asset utilization is the overall equipment effectiveness. Overall equipment effectiveness is a holistic calculation that measures availability, performance efficiency, and quality rate.

Availability is defined as the percentage of time the equipment is available compared to the time that it is required to be available. Of course, breakdowns, equipment malfunctions, setups and adjustments, and even material shortages, are all possible reasons the equipment may not be available.

Performance rate of the equipment compares the current operating rate of the equipment to the actual design capabilities of the equipment. Many companies use some type of targeted performance, which usually fails to optimize the utilization of the equipment.

Quality rate is the percentage of good product or satisfactory service that the equipment provided compared to what the equipment should have delivered. So defects, rework, off spec product, or unsatisfactory service from the equipment all lower the quality rate.

For equipment to be fully utilized, a blend of all three parameters determines its actual performance. By examining equipment or assets in this manner, companies can avoid a one-dimensional focus on utilization of the asset. In many companies, decisions are made to increase production, which may boost performance rate but lower equipment availability due to a decrease in asset or equipment reliability.

On the other hand, if the maintenance department performs too much maintenance and lowers the availability, then even if the equipment performs as designed, the overall output is lower. This still puts the company in a noncompetitive situation when it comes to asset utilization.

So it is clear that the approach cannot be one dimensional. The true value of measuring the asset utilization in this manner is that it presents a holistic view of the asset or equipment.

Financial Considerations

Currently, most companies are evaluated by financial institutions using indicators such as Return on Net Assets (RONA) or Return on Fixed Assets (ROFA). Equipment or assets that are not performing as designed with maximum availability and acceptable quality will impact these indicators in one or both of the following methods.

1. Lack of asset performance will require excessive investment in redundant equipment, increasing the asset base value and thus impacting the indica-

tors in a negative manner (same profit / higher asset value).

2. The lack of asset performance will reduce the capacity of the equipment, reducing the company's ability to provide its product or service at the design capability of the equipment. This reduction in the output of the equipment will reduce the income generated, thus negatively impacting the indicators (lower profit / same asset value).

The solution to the above problems is to focus on optimizing the utilization of the assets by implementation of strategies to eliminate all equipment breakdowns. In reality, whether a function loss or a function reduction breakdown, all breakdowns impact a company financially. Zero breakdown strategies are designed to provide cost effective solutions to equipment problems that will allow companies to realize the maximum return on investment in their assets.

Major Equipment Losses

In reality, there are six major losses that impact asset utilization:

1. breakdowns
2. setups and adjustments
3. idling and minor stoppages
4. reduced speed or capacity losses
5. quality defects and rework
6. startup and shutdown losses.

When examining the losses closely, we find that some operational equipment experiences losses of product or quality during the startup and shutdown cycles. These losses are referred to as the *startup and shutdown losses*.

Quality losses occur for various reasons. They may be due to an equipment, operational, or even raw material problem.

Reduced speed or capacity losses occur because equipment is not operated at design levels. These losses may be caused by worn equipment, raw material issues, or even operational errors.

Idling and minor stoppage losses are caused by small problems with the equipment. These delays are typically less than five minutes in duration but may occur frequently.

Setups and adjustments, or product and process changeovers, occur when changing equipment to run different products or product mixes. Any unnecessary time spent on these activities is a loss.

Breakdowns seem self-explanatory, however, breakdowns can be far more encompassing than the other losses.

One dictionary defines a breakdown as “the act of failing to function or continue.” If this definition is applied to equipment or assets, then anytime the

equipment or asset fails to perform when required—at design capacity and with satisfactory quality—it is broken.

Breakdowns

Based on the above definition, all losses are breakdowns. This would also indicate that there are two types of breakdowns: the function loss and function reduction breakdown. Function loss breakdowns occur when all the equipment functioning stops. This is the type of breakdown that most people are familiar with. However, setups and adjustments also stop all equipment functioning. Idling and minor stoppages also stop all equipment functioning even if just for a brief time period. Therefore, any loss that is created when all equipment functioning stops can be considered a function loss breakdown. Of the six major losses, breakdowns, setups and adjustments, and idling and minor stoppage losses would be considered function loss breakdowns.

The second type of breakdown would be a function reduction breakdown. This breakdown is when efficiency losses occur. The equipment may be operating, but it is not achieving design specifications. The analogy would be an automobile in a 60 mph speed zone only achieving 30 mph. In plants or facilities, function reduction losses impact the asset utilization to a point that backup or redundant systems may be utilized. Of the six major losses, idling and minor stoppage losses create function reduction breakdowns. Reduced speed or capacity losses create function reduction breakdowns since efficiency is lost. Quality problems, whether defects or rework, create lost efficiency, so they are considered function reduction breakdowns. Startup and reduced-yield losses also create lost efficiency, and are also considered function reduction breakdowns.

Most companies concentrate on function loss breakdowns, since when the equipment is not functioning, it is quite easy to detect. However, these same companies ignore, or give low priority to solving, function *reduction* breakdowns. Yet, studies have shown that function reduction losses make up the largest part of total overall equipment losses.

In this book, both function loss and function reduction breakdowns are considered. Both types of breakdowns are caused by organizational issues and technical issues. Methodologies to eliminate the losses categorized in the two types of breakdowns will be presented.

Zero breakdown strategies can be categorized into five activities:

1. maintaining basic conditions
2. maintaining operating standards
3. restoring or preventing deterioration
4. improving or eliminating design weaknesses
5. preventing human error.

These will be systematically covered in detail in Section 2.

Regardless of the zero breakdown strategy utilized, the key to being effective is to truly understand the root causes of the breakdown. For example, if a bearing fails, the question “why?” should be asked *five* times. This leads to the root cause of the failure. Consider the following example.

Q. The bearing fails. Why?

A. It was out of lubrication.

Q. Why was it out of lubrication?

A. It was missed on the p.m. inspection.

Q. Why was it missed on the p.m. inspection ?

A. The p.m. did not have enough details, and it was missed.

Q. Why didn't that p.m. have enough detail ?

A. We did not spend enough time developing the p.m.

Q. Why didn't we spend enough time?

A. We didn't have enough resources.

The “five why's” is a simple method of root cause analysis. This method tends to be effective for the majority of analyses that companies need to do on their equipment. While other more advanced types of analyses will be discussed later, the “five why's” will form the basis of a zero breakdown strategy root cause analysis.

Introduction to Zero Breakdown Enablers

There are four major enablers to a zero breakdown initiative. These are areas each company would do well to examine before starting to implement zero breakdown strategies:

1. Preventive Maintenance Program
2. Organizational Structure
3. Skills of the Workforce
4. CMMS or EAM Usage and Support.

Preventive maintenance is the foundation of every successful maintenance program. An effective preventive maintenance program is essential if the goal of zero breakdowns is to be achieved. The primary objective of good preventive maintenance is to prevent interruptions to the equipment operations, thus helping to increase the overall equipment capacity. This can be accomplished by good inspection, cleaning, and servicing, all of which are part of a good preventive maintenance program.

Currently, in the United States, almost 80% of the companies have insufficient or ineffective preventive maintenance programs. A preventive maintenance pro-

gram is considered effective if less than 20% of all maintenance resources are expended (on a weekly basis) on reactive or unscheduled work activities. There are several major causes of this problem, and it is serious, since the preventive maintenance program forms the foundation for all zero breakdown strategies.

Preventive maintenance endeavors to eliminate the root cause of problems before they can cause any downtime of equipment. One of the most essential parts of any preventive maintenance program is training the correct personnel to develop, implement, and execute the preventive maintenance activities. There are two key people in a preventive maintenance program: the maintenance technician and the planner.

Maintenance Technician and Planner. The technician should be familiar with the equipment and have good craft skills. The familiarity with the equipment enables the technician to know when something is malfunctioning. They should be able to spot most equipment problems before they progress to a point that the equipment breaks down. Their inspection results should be turned in to a planner, who in turn will plan and schedule the repairs necessary when they won't interfere with production or facilities. This could be on a scheduled downturn, a nonoperating turn, or any period when the equipment or asset is not being used. The technician should note on the inspection how long a period of time (in the technician's estimation) that the equipment can continue to run before the repairs must be made. This is important for it gives the planner a time frame to work in. Without this estimation, the planner may wait too long before scheduling the repairs, and the equipment may break down.

Routine Service. In addition to inspections, the planner must schedule routine maintenance service. If any equipment is to remain productive, there must be a routine maintenance program. This routine (or scheduled) program should consist of certain checks and services that should be performed at specific time intervals. It might be compared to the service intervals on an automobile. These services usually fall into five categories: daily, weekly, monthly, semiannually, and annually. The planner must pay attention not only to the quality and detail of the inspections but also the scheduling time frame on these routine items.

Basic routine items and their service intervals are recommended by the manufacturer of the equipment. It's best to follow these recommendations (combined with the technician's recommendations and historical records) when setting routine service intervals. If in doubt, contact the manufacturer; they're very considerate and want their equipment to provide the best service possible. The planner should be someone who is familiar with both the maintenance repair work and also the production/ facilities schedule. This will enable them to best fulfill their assignments. The planner is responsible for maintaining the records for and scheduling the following items:

- inspections of equipment
- routine maintenance of equipment
- repair assignments to the maintenance technicians
- scheduling the followup inspections of the performed work.

It's beneficial if standard forms are provided for the inspections. This makes it easier for all involved. These forms are usually provided by some form of computerized maintenance management system (CMMS). (Additional information on CMMS will be presented later in this section.)

In addition to these scheduling assignments, the planner needs to keep a record of all breakdown repairs. This is commonly referred to as the equipment history and is built from the work order system. This will enable the maintenance supervisor to keep track of all problem areas. If a certain piece of equipment has an abnormal number of breakdowns, the supervisor (in conjunction with the planner) may change some aspect of the routine maintenance performed to eliminate the problem. Detailed inspection of all equipment failures to determine the cause will help eliminate continued breakage of the same component. The technicians can be used to do this type of inspecting. This takes considerable practice, but once the technician becomes proficient at this type of inspection they can save considerable time and money spent on repetitive repairs.

Nondestructive Testing Inspection Techniques. Nondestructive testing and monitoring is another method of inspection that is becoming prevalent in industry. These techniques are usually divided into four basic categories: particle dye, ultrasound, vibration analysis, and oil or lubricant analysis.

Particle dye tests are used to check for defects in equipment. They usually consists of a magnetic dye and a powerful magnet. The dye is spread on the piece of equipment, the magnet is turned on (or placed on the equipment), and the excess is brushed away. Any cracks or defects in the equipment will draw the dye inside. Then some type of light (usually ultraviolet) shows the inspector the location of the cracks or defects. The repair or replacement can then be recommended.

Ultrasound utilizes sonic waves to locate leaks and spot defects in material and equipment components. It may be used to find air leaks, steam leaks, and even some fluid leaks. It is also a useful tool in spotting subsurface defects in equipment without costly disassembly or surprising breakdowns.

Vibration analysis uses a vibration monitor to determine if defects are developing in equipment. The analyzer usually displays waves on a screen according to the type of vibration it senses. By using charts, the inspector can pinpoint what's causing the vibration, and can make recommendations to eliminate the vibration.

Another type of analyzer uses a transmitter with a plug-in meter. The meter

gives a numerical output on its display. The technician reads the display, compares it to the chart, and can determine the condition of the particular component. If accurate records are kept, the equipment's gradual deterioration can be charted and a schedule can be set up for replacement of components. This will help prevent unsuspected equipment breakdowns.

Oil or lubricant analysis consists of taking oil samples from drive systems or hydraulic or pneumatic systems, and analyzing them to pinpoint any wear in the system. This can be done by part of the maintenance department or, if the equipment is not available, by an outside company (there are presently several that specialize in this type of testing). This is an effective method of discovering defective components before they fail during production.

All testing equipment is very important to the technician. If they can't spot potential problems during inspections, the maintenance program will not function properly. If good communication is lacking between the technician and the planner, the program will suffer. If the inspections and scheduling are both performed correctly, the benefits will be self-evident.

Preventive maintenance is becoming so important that most industrial plants are investing in computerized systems that help control preventive maintenance activities. These systems are commonly referred to as Computerized Maintenance Management Systems (CMMS). As the systems have evolved and are used as part of an overall company strategy, they are referred to as Enterprise Asset Management Systems (EAM).

Organizational Structure is an overlooked area for organizations attempting to adopt Zero Breakdown Strategies. How a company decides to organize the maintenance function can enable or disable their ability to properly care for the assets/equipment. Organizational design for maintenance includes the following decision points:

- Definition of Maintenance
- Objectives of Maintenance
- Organization and Staffing
- Roles and Responsibilities.

Definition of Maintenance. Maintenance is defined as all actions or activities necessary for keeping a system or equipment component in a desired operational state or restoring it to that state. A maintenance activity may fall into one of the five following categories:

1. Preventive maintenance
2. Corrective maintenance
3. Reactive maintenance
4. Predictive maintenance
5. Maintenance prevention.

Preventive maintenance activities focus on basics. They include proper inspections, proper lubrication, and proper fastening procedures. Preventive maintenance activities should be so effective that at least 80% of all maintenance activities occur on a planned and scheduled basis.

Corrective maintenance activities are generated from preventive maintenance inspections, operational requests, and routine service requirements. These activities should be able to be planned and scheduled at least one week in advance.

Reactive maintenance activities are those that must be performed immediately upon notification. Reactive maintenance activities are responses to equipment breakdowns, especially breakdowns of critical equipment, and situations that do or can lead to production interruptions.

Predictive maintenance activities monitor and trend equipment conditions. This allows proactive replacements of worn or defective components before a failure occurs. A commonly understood difference between preventive and predictive maintenance is that predictive maintenance usually uses a monitoring technology, whereas preventive maintenance is usually more of a manual task.

Maintenance prevention activities focus on changing the design of equipment components so they require less maintenance. Maintenance prevention activities usually are supported by the maintenance engineering group.

Objectives of Maintenance. In order to determine the proper goals and objectives for the maintenance organization, it is first necessary to define its responsibilities. Close examination reveals that the true goal of maintenance is to maintain the capability of the company's assets to perform their designed function.

The second goal of maintenance is to be as efficient and effective as possible in carrying out the repairs and services that are required. By controlling maintenance costs, the maintaining function ensures that no unnecessary expenses are incurred. Keeping costs down maximizes profitability and prevents wasted dollars. However, if the maintenance activities are neither effective nor efficient, it is more economical to contract them out. So, in fact, by being efficient and effective, the maintenance organization ensures the employment of its members.

All five types of maintenance activities must be focused on the objectives of the maintenance organization. While the objectives of maintenance may vary from organization to organization, some typical maintenance objectives are listed below.

1. Maximize production at the lowest cost, the highest quality, and within the optimum safety standards. This statement is very broad, but it is important for maintenance to have a proactive vision to help focus its activities, and this statement should be tied to any corporate objective statements.

2. Identifying and implementing cost reductions is sometimes an overlooked aspect of maintenance. However, there are many ways a maintenance organization can help a company reduce costs. For example, a change in a maintenance policy may lengthen production run times without damaging the equipment. This reduces maintenance cost and, at the same time, increases production capacity.

3. Providing accurate equipment maintenance records allows a company that wishes to track equipment in engineering terms such as *mean time between failure* or *mean time to repair*—and many do—to track this information accurately. Success in this endeavor, however, requires accurate records of each maintenance repair, the duration of the repair, and the run-time between repairs. In larger organizations, this activity produces a tremendous amount of paperwork. That is why most large organizations use some form of a computerized maintenance management system to track this information. But whether a computer is used or not, the information must be accurately tracked. Tracking the data is an important activity for the maintenance department.

4. Collecting necessary maintenance-cost information allows companies to track engineering information such as life-cycle costs. Using life-cycle costing information, companies can purchase assets with the lowest life-cycle costs rather than lowest initial costs. In order to accurately track life-cycle costs, all labor costs, material costs, contracting costs, and other miscellaneous costs must be accurately tracked at the equipment level. Again, to accurately track this information, all equipment-related records must be tracked. This is primarily an activity for the maintenance department.

5. Optimizing maintenance resources includes eliminating waste with effective planning and scheduling techniques. In reactive maintenance organizations, it is estimated that up to one-third of maintenance expenditures are 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 over \$300,000. When 80–90% 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.

6. Optimizing capital equipment life means maintaining equipment so that it lasts 30–40% longer than poorly maintained equipment. It is a goal or objective of the maintenance department 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 goal of the maintenance department will then be to perform the correct level of maintenance on the equipment to achieve that maximum life. The focus must be

to perform enough maintenance to achieve this without performing excessive maintenance. One way to determine if there is a problem in this area is to examine new equipment purchases. If equipment purchases are to replace equipment in kind, is it possible that the purchase of the equipment could 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 on the equipment, and the maintenance tasks should be revised.

7. Minimizing energy usage is a natural result of well-maintained equipment. Well-maintained equipment requires 6% (to as much as 11%) less energy to operate than poorly maintained equipment. These percentages were established by international studies, and indicate that it would be beneficial for maintenance organizations to monitor constantly 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 will consume more energy when heating or cooling. HVAC systems that are not properly maintained will require more energy to provide proper ventilation to a plant or facility. Even small things can have a dramatic impact on energy consumption, e.g., the alignment of couplings in a plant that has a large amount of rotating equipment.

8. Minimizing inventory on hand is another waste-eliminating objective for maintenance organizations. Approximately 50% of a maintenance budget is spent on spare parts and material consumption. In organizations that are reactive, up to 20% of spare parts cost may be waste. When organizations become more planned and controlled, this waste is eliminated. Some typical areas of waste in the inventory and purchasing function include:

- stocking too many spare parts
- expediting spare part delivery
- allowing shelf life to expire
- single line item purchase orders
- vanished spare parts.

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

While this is not a comprehensive, all-inclusive list, these goals or objectives highlight the impact a proactive maintenance organization can have on a company. Maintenance is more than a “fix it when it breaks” function. Unless the maintenance organization is given or develops a proactive list of goals and objectives, it will always be suboptimized.

Maintenance Evolution

Reactive to Preventive to Operations Involvement to Predictive to TPM/TPR/EAM



Companies trying to improve maintenance policies and practices realize, in most cases, that it is an evolutionary process not a revolutionary process. Most organizations began with some form of a reactive maintenance program. Reactive maintenance only repairs equipment when it breaks; there's very little attention paid to the prevention of failure. Rather, the goal is only to repair failures. Organizations in a reactive mode develop a "fix it when it breaks" or "if it isn't broken, don't fix it" mentality. Reactive maintenance is a costly way of doing maintenance. Studies show that organizations using reactive maintenance experience costs two to four times greater than those of a proactive organization. In reactive organizations, the production or operations group is usually not satisfied with the level of service it receives from the maintenance organization. There is constant conflict between the two groups and, in most cases, the maintenance organization loses. This conflict often leads to restructuring, downsizing, changing reporting lines, and excessive contracting out. The key to limiting reactive maintenance is the development of a good preventive maintenance program.

Preventive maintenance activities are designed to prevent equipment from failing. A basic preventive maintenance program includes good inspections, lubrication, and proper fastening techniques. Studies show that as much as 50% of all equipment malfunctions have a root cause in one of these three areas. When an effective preventive maintenance program is developed and implemented, the number of equipment failures are dramatically reduced. Unfortunately, the workload for the maintenance department increases dramatically when all preventive maintenance procedures are correctly developed. Then, the maintenance department often becomes preoccupied with the basic servicing of the equipment and does not have the time to develop higher-level predictive or reliability activities for the equipment. To compensate for the heavy load of preventive maintenance, many companies today look for some form of operations or production involvement to free up some of the maintenance resources to concentrate on higher-level maintenance activities.

Involving operators in performing maintenance on their equipment allows maintenance personnel to concentrate on higher-level maintainability, reliability, and availability activities. The exact activities that the operators might perform, however, vary dramatically from company to company. In some companies, the operators merely fill out work requests and help with some of the maintenance paperwork or computer work. In other companies, operators may

actually perform minor maintenance, such as cleaning, inspecting, or servicing of the equipment. The exact level of operations involvement in maintenance activities must be determined for each company individually. Unfortunately, some companies have made the mistake of attempting to use operations involvement to downsize the maintenance organization. When downsizing is the goal, operations involvement usually fails. Operations involvement only succeeds when the focus is on relieving the maintenance people to perform higher level activities.

Predictive maintenance activities are maintenance activities that usually include the introduction of a new level of technology. For example, vibration analysis is typically used on rotating equipment. This technology is useful for determining the wear on components in rotating equipment. By being able to plot and trend this wear, maintenance personnel can then plan and schedule repair or replacement activities with minimal disruption to production or operations. This approach further reduces the amount of production loss, and since the activities are planned and scheduled, it reduces the overall cost of maintenance. Another common predictive tool is thermography. Among other applications, thermography detects heat in electrical connections. The heat is typically generated by a loose connection or a defective component. By determining that there is a problem before the failure occurs, the maintenance department can make the appropriate repair. Oil analysis is a third type of predictive maintenance activity. With oil analysis, two tests can be performed. One test looks at the wear particles in the oil and determines what components in the system are wearing and generating these particles. The second kind of test analyzes the condition of the oil itself to determine whether it needs to be filtered or changed. While these three predictive tools are the most common, there are many other tools available. Maintenance technicians should be the people to decide which predictive tools to use to monitor which pieces of equipment.

In the evolution of maintenance from reactive to predictive, usually only the maintenance and operations groups are involved. However, if the organization is to evolve the maintenance function further, there are other parts of the company that must become involved. For example, consider how purchasing could impact maintenance and operations as they try to maintain equipment. If appropriate spare parts are not kept in stock, unnecessary delays occur when parts are needed but have long lead times. Another way the purchasing department can impact the maintenance and operations groups is in capital equipment procurement. If the purchasing department always purchases equipment from the lowest bidder, the life-cycle costs for the equipment may be higher than necessary. Low-bid purchasing can fail to address proper operational and maintenance concerns during the plant design stage. But it is not the intention here to single out only the purchasing function within organizations. Functions such as design engineering,

project engineering, and even production scheduling can impact the operations and maintenance groups. If the equipment or assets are to be truly optimized, then all functions within a company that in some way affect the equipment must be involved in taking a proper maintenance focus.

This total organizational focus can have different names in different companies. For example, the following are some of the common terms used to describe an equipment-centered focus:

- Total Productive Maintenance
- Total Productive Manufacturing
- Total Process Reliability
- Enterprise Asset Management.

It is not what an equipment-centered program is called but rather the results sought that must be its focus. When the total organization focuses on optimizing its assets, then the organization can truly become a world-class competitor. However, this improvement evolution takes time. A company does not progress from being reactive to being world-class in a few short days. In fact, companies that have made the transition from reactive to world-class say that it is a three- to five-year journey, and the journey doesn't end there. The real focus is continuous improvement.

Organization and Staffing

In this age of downsizing, organization and staffing are among the most critical issues affecting maintenance and its ability to contribute to Zero Breakdown Strategies. How is the maintenance organization properly staffed? While companies have tried many different staffing formulas over the years, the only perennially successful one is to staff 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 it never works. The only true measure of backlog is based on hours of work to be done. To calculate the backlog, in addition to knowing the hours of maintenance work needed, it is also necessary to understand current workforce 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 workforce is ten technicians who each work 40 hours per week plus 8 hours of overtime per week. Total hours worked per week by the technicians is, then, 480 hours. The company also uses two outside contractors for 40

hours each per week—another 80 hours. So the total capacity for the workforce 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. So, 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, there are routine assignments—lube routes, rebuilds, and other routine activities. Also, there are 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. This, of course, is unacceptable. One can only imagine the reaction of the production department when it submits a work order that it expects to be done within two to four weeks, and is told it may take as long as three-and-a-half months to complete the work.

While this scenario is bleak, there is a second, more important problem: 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 performed an equipment walk down throughout your entire plant today, how much work that needs to be done, but is not recorded, could be identified? There may be hundreds, if not thousands, of hours of work that need to be performed and are not recorded. This leads to underestimating the backlog and, ultimately, to insufficient staffing of the maintenance department. The organization would revert to a reactive condition, since current staff can never accomplish the required work in a proactive mode.

The goal, then, is 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 needs to 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 workforce. 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.

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. While an organization may not use each of the individual job titles listed in the following section, each of the task lines must be assigned. So, while an organization may not have a front-line maintenance foreman or supervisor who has a responsibility for each individual line item, the line-item task descriptions are essential if maintenance is to be managed and, ultimately, the company's assets cared for.

Maintenance foreman. Tasks that are typically the responsibility of a front-line maintenance foreman or supervisor include the following.

1. Direct the maintenance workforce and provide 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 maintenance foreman should be able to provide the guidance. The maintenance foreman is also responsible for making individual job assignments and tracking the progress of individual craft assignments.

2. Ensure that work is accomplished in a safe and efficient manner. The maintenance foreman 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.

It is a responsibility of the maintenance foreman 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 maintenance foreman performing clerical paperwork as the major part of his or her work.

Again, it is not the purpose of this text to determine organizational structures for every company. However, roles must be assigned and performed if maintenance is to be properly supervised. The question each organization must ask is: who has the responsibility for supervising the maintenance function?

Maintenance planner. Another individual in a maintenance organization is the maintenance planner. The maintenance planner is different from a supervisor or foreman. While the supervisor manages the maintenance craft workers, the planner provides logistic support to them.

This highlights the typical responsibilities of a planner. Again, if the organization does not have planners, then who is responsible for all of the logistics coordination? If maintenance is to be performed economically and efficiently, good planning and scheduling is essential. In many organizations, a common mistake is to make the maintenance foreman supervise and plan. However, when a maintenance supervisor has a full load—typically 8 to 12 craft workers—that supervisor will not be able to properly supervise and plan. Since a 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 workforce and providing the support needed to make them efficient and effective. However, now the transition is 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 job description entails making these data focus on achieving zero breakdowns.

Maintenance engineer. 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 no organization that has the same kinds of assets as his company gets more production from their assets than his company does. This person provides the technical focus and support that is required to achieve zero breakdowns.

Skills of the Workforce

Technical training and the resulting skill levels in maintenance comprise one of the largest weakness of the present maintenance structure in the majority of companies. It has been estimated that a company should spend approximately \$1,200 per year for training of maintenance supervisors, and should spend approximately \$1,000 per year for each technician. In fact, if you don't provide some training for a technician in an 18-month time period, his skills become dated. When was the last formal training program for your technicians? For your supervisors? For your planners? The importance of training cannot be overstated.

Without good quality training programs, a maintenance organization will never be cost-effective.

Craft technician training programs. The first level of training must be the technician apprentice training program. This level of training takes the "man on the street" and gives him the training necessary to become a skilled technician. The training program must be a combination of on-the-job training coupled with classroom training. Most good programs will be three to four years in length, with hands-on lab sessions used with the classroom settings.

Some companies work with local vocational schools to fill entry-level craft technician positions. This allows the company to specify some of the material that must be covered in the program. The vocational school benefits because of the assistance in placing the students when they complete the program. Another

option is university level training, but this is generally used for more advanced training, later in a craft technician's career.

Journeyman training. Journeyman training is usually related to specific tasks or equipment maintenance procedures. Journeyman training courses can be conducted by in-house experts, vendor specialists, or outside consultants. The training may address a new technology, new equipment, or even a refresher course in basic skills.

Cross-training or pay for knowledge. This subject is included in the training section, since it is becoming increasingly common in progressive organizations. It is a sensitive subject, since it generally involves crossing craft or organizational boundaries. This type of program is essential if maintenance efficiencies and costs are going to be brought in line with the costs incurred by aggressive competition.

The cost savings and other benefits are found in planning and scheduling the maintenance activities. For example, consider a pump motor change out. In a strict craft line environment, it would require:

1. a pipe fitter to disconnect the piping,
2. an electrician to unwire the motor,
3. a millwright to remove the motor, and
4. a utility person to move the motor to the repair area.

The installation would proceed as follows:

1. a utility person to bring the motor to the job area,
2. a millwright to install the motor,
3. an electrician to wire the motor,
4. a machinist to align the motor, and
5. a pipe fitter to connect the piping.

As can be seen, not only are many people involved, but the coordination to ensure that all crafts are available when needed without delay will become extremely difficult. In a "multiskilled" or "cross-trained" environment, there would be one or possibly two technicians sent to the job to complete all the job tasks. The advantages of reduced costs and better coordination are obvious.

The coordination (or lack of) would contribute to higher than necessary maintenance costs, but this is only the start. The resulting delay in repairing or servicing the equipment will result in lost capacity to the equipment for the time period. This cost will be the driver for making the change to a multiskilled environment.

Training is important to all levels of the maintenance organization. Unfortunately, in a volatile financial environment, maintenance programs are the first to be cut back. This is especially true of programs that are per-

ceived by management as nonessential, which includes (in most organizations) training. This short-sighted philosophy must change if maintenance is to be able to fully contribute in a zero breakdown initiative.

CMMS or EAM Usage and Support

Computerized maintenance management systems are tools that help facilitate the management of maintenance and equipment for a company. That is, the goal in implementing a CMMS is to install a tool to better manage maintenance and the company's assets.

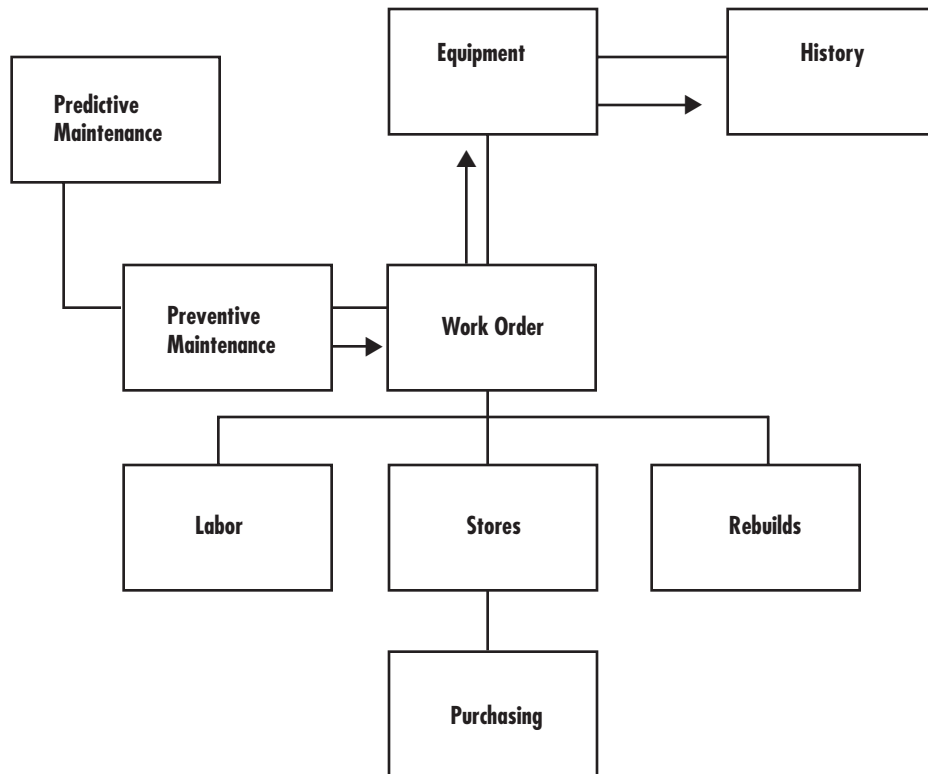
To help ensure that the goal is clear, let's review the flow of maintenance information and compare it to a CMMS. The figure below shows a flow diagram for a typical maintenance-information system. As the diagram shows, the goal is to post information against a piece of equipment; that information is eventually stored in the equipment history. It is from this equipment history file that the data are typically derived to analyze items such as the equipment's life-cycle costs, mean-time-between-failures, and mean-time-to-repair. The data to do this analysis are collected against a work order which is written against a piece of equipment. The work order becomes the vehicle to collect the information from various sources.

For example, all labor for work performed on a piece of equipment must be charged to a work order. All spare parts used to repair a piece of equipment must be charged to a work order. The cost of these spare parts is usually provided to the store room from the purchasing department. Any rebuilt spare parts used to repair a piece of equipment must be charged to a work order. Any work that a contractor performs on a piece of equipment must be charged to a work order. Preventive maintenance tasks are usually written as a work order and charged against a piece of equipment. Even predictive maintenance systems that collect information, usually through the preventive maintenance program, are tied to work orders to collect repair costs, labor costs, and material costs against a piece of equipment through the work order system. It is clear, then, that all information must be collected by the work order against a piece of equipment and charged to the history.

It is this information flow that maintenance uses to capture equipment data. These data are computerized when one implements and uses a CMMS. It is beneficial to understand this basic flow when considering a CMMS. If this flow diagram is clearly understood, the need for a CMMS in a zero breakdown initiative is clear.

If the true root cause of problems on company assets/equipment is to be determined, complete and accurate data are required to be input into the CMMS. However, this is not being given the proper level of attention in most companies today.

Maintenance Management System



Consider for a moment the work order module of a CMMS. The work order module allows for different types of work orders to be initiated and tracked to completion with the costing and repair information being charged to the correct piece of equipment or facility location. The use of the work order module requires information from all other modules of the CMMS. Some of the information required on a work order includes:

1. the equipment or facility location where the work is being performed
2. the labor requirements (personnel)
3. the parts requirements (inventory)
4. the priority of the work
5. the date the work is needed by (not ASAP)
6. contractor information
7. detailed instructions.

Without accurate information, the work order module cannot collect the required data. Without accurate and complete data, the work order module cannot post accurate information to equipment history. Without accurate data in the equipment history, the organization cannot make timely and cost-effective decisions.

The importance of data collection and analysis to the corporation is highlighted by the following:

- to manage, you must have controls
- to have control, you must measure
- to measure, you must have reporting
- to have reporting, you must collect data.

The timeliness and accuracy of the data collected by a CMMS and the use of the data by the company determine success or failure for the zero breakdown initiative.

As highlighted previously, a CMMS is designed to provide a completely integrated data collection system. However, even among mature users, many are not getting complete (and thus accurate) data from their CMMS. In a survey, respondents were asked about their use of the various modules of their CMMS. One set of responses showed that the majority of the respondents are using less than 70% of their systems. A second question broke this into modules with the following results:

Inventory —52% use the CMMS inventory module
Purchasing—32% use the CMMS purchasing module
Personnel—35% use the CMMS personnel module.

Since the CMMS modules are not being used for these functions, what *is* being used? Some companies are using other corporate systems to deal with these functions, but more than 25% of the respondents are not using any method to collect this information. Even when other corporate systems are used, are the data being accurately posted in the equipment history? In the majority of the cases, the posted data are not accurate (or not even posted), so the equipment history is incomplete or inaccurate.

Some companies have set the CMMS information flow so that the material costs or labor costs are not shown on the work order or equipment history. Any decisions they make will be based on inaccurate or incomplete data, and there will be mistakes. The financial implications of these decisions could spell disaster for a company by placing the company in a condition where it cannot compete with a company making full use of a CMMS and obtaining the subsequent cost benefits.

The solution to CMMS installations, where the data are not being properly

collected, is to reevaluate the current use of the system. What data are being collected accurately? What data are incomplete or missing? What parts of the CMMS are being used incorrectly or not at all?

Evaluating the answers to these questions and then working to provide accurate data collection will make CMMS use beneficial to the bottom line. In the competitive marketplace, in which every company currently finds itself, it is unacceptable to make guesses about when data can be provided. The cost benefits obtained by making correct decisions will help to make a company more competitive. Wrong decisions could put a company out of business by taking them out of a competitive position.

Since management requires measurement, and measurement requires data, each company must fully use its CMMS to obtain required data. Without data, a decision is only someone's opinion. Discussions require factual data. Arguments occur when emotions and opinions are involved.

Summary

This chapter pointed out the scope of Zero Breakdown Strategies. It began with the true definition of a "breakdown" and showed that substandard performance cannot be tolerated from any company asset. It also dealt with the enablers required to support Zero Breakdown Strategies. It concluded with information concerning the criticality of good CMMS usage and the need for complete and accurate equipment maintenance data.