Wrench Time

using the RPM method to manage maintenance

Fred J. Weber, P.E.

Book information

Wrench Time…using the RPM method to manage maintenance

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Background of Author

The background of any individual is really the sum of the effects that certain people have on their lives. For me, it was:

my wife, Joyce

(you don't want to miss anything in life)

my father, Albert

(he was the best production manager)

my mother, Margaret

(the best family CEO, she met the budget annually)

my bother, William

(a teamster, and knows we still need unions)

my sister, Diane

(computer manager, she knows everything isn't ones and zeros)

my mentor, Steve Breitweiser

(an inventor, he always asked why)

Also, the hundreds of people in maintenance and construction that have bailed me out throughout out my career by:

- teaching me that everything was not in my engineering books
- solving technical problems while making me look good doing it
- questioning my decision to make the job safer and easier

And finally, a special thanks to the person that helped to put this book together:

the Editor, Bruce Lea

(he somehow edited this book so you could understand it)

So, if you don't like me, blame them!

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Welcome to Wrench Time

Welcome to Wrench Time, using the RPM method to manage maintenance. The goals of this book are simple: to supply you the tools to produce a better work environment while reducing equipment downtime. This book takes a different approach to the traditional articles and books written about maintenance. One reason is that I was confused by the terminology and key indicators used to judge maintenance performance. Here are few terms used in maintenance today:

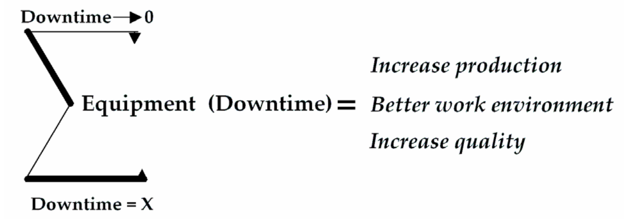
Wrench time - the time a mechanic is working with his tools to fix equipment. Today industry advertises "increasing your wrench time." If your equipment is running, your wrench time is down and it suggests that your maintenance fixes problems the first time. This one puzzled me so much I named my company Wrench Time, Inc.

Backlog - the number of open work orders for maintenance to do. "Someone" in industry stated that 6-8 weeks of backlog indicates good maintenance performance. What if you have 20 weeks of backlog? So what, if all the equipment is operating? Remember anybody can write a work order, which can pump up backlog (Example: WO # 98234 - Install a telephone in the restroom).

Number of screwdrivers per mechanic - pretty useless, just like most key indicators used to judge the performance of maintenance. They don't show the pride, knowledge and hard work of maintenance people. Instead of using your resources to "bird-dog" maintenance people, use that time and effort to supply your maintenance people a safe and effective plan to reduce downtime.

So what is required to approach zero downtime?

With an engineering background, I might offer an equation to explain it:



However, the purpose of this book is to look beyond equations and formulas to develop a common sense, systematic method for someone to follow. Who are the targets of this book? This book is for almost anyone who has been (or will be) put in charge of a maintenance department, large or small. It could be an engineer who went from crunching numbers to running an entire department. Or the reader might be a journeyman mechanic who suddenly finds himself in charge of a lot more than repairing equipment! It is also for the person interested in just finding a successful system. In short, this book is designed to provide a simple format that can be implemented to help you approach zero downtime.

Does my system work? Consider this: The initial status of the plant where I was hired had machine downtime at 35%, high scrap production, and an overall division "in the red".
After two years and great contribution from the men and women that worked with me, **WE** compiled the following list of accomplishments:

- Machine downtime went to 2%
- Production lines increased
- Scrap rate approached zero
- Division "in the black"
- No CMMS used

During this period, I received two achievement awards for "Reducing Downtime". Let me emphasize, one person did not accomplish these goals. I was proud to accept the awards on the behalf of the team of people that supported me. Of course, I had to remind my fellow employees that as a manager, I didn't receive any overtime, while the people working for me were often on *time and half* or *double time*! I figure those two awards are worth about $40,000 in overtime (but the bank still won't accept them for a mortgage payment!)

Seriously, the results listed above are real. They are an example that by applying sound maintenance management techniques, the course of the plant can be completely changed. It worked for me, and it will work for you, too!

1

"Management, meet Maintenance"

"Managing maintenance isn't rocket science, it's harder."

Fred J. Weber

1.1 Objective of Maintenance

The word maintain can be defined as "to keep good repair; to preserve". Regardless of where you work, the Maintenance Department can typically be described as the folks who install, maintain, and repair the equipment of a particular facility. Depending on the site and its function, that can include welders, electricians, instrument technicians, millwrights, machinists…you get the idea. The titles and job functions can be numerous. However, most of the time, these craftsmen are in a maintenance department, and simply put, their objective is to use their skills to keep the plant running in the safest and most efficient manner possible. Usually, these maintenance crafts are combined, and are normally lead by a person such as a maintenance manager. To be successful, a manager needs a method to manage maintenance, while at the same time supporting individual & plant goals and priorities. Make no mistake; individual goals are different from plant goals. Yet, they also mesh. For instance:

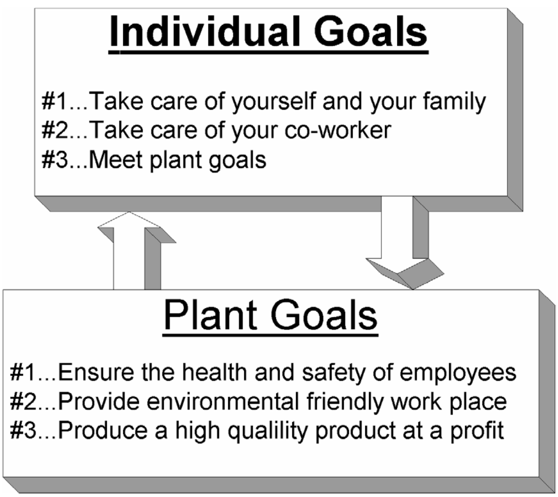


Figure 1.1 Individual and Plant Goals

So, while a person is working on personal goals, by working safely to meet production goals the plant goals are also met. By being an outstanding performer, the employee is making a major contribution to plant goals as well. So, what should maintenance managers use to develop strategies to meet objectives? Many things, such as:

- Team goals – develop a goal structure to support all departments
- People – these are the Manager's tools
- The RPM method - a work order priority system that determine where the "REAL" backlog is
- Maintenance ID – an equipment and maintenance identification system
- Equipment Part ID – a parts system to label and store parts for Maintenance
- Thinking of tomorrow - planning, preventive, and predictive maintenance
- Equipment history – a simple method to monitor equipment performance and design
- Cost centers – these answer the question…"What did maintenance do last year?"
- The Organization – a review of the maintenance structure in a company
- Dress for go, not for show- implementation
- Future of maintenance - looks at the direction of maintenance

These are the tools that maintenance management should have in their toolbox. In reality, these are just simple methods to manage people and equipment.

1.2 The Role of a Manager

What is a manager? While every company has different titles – foreman, supervisor, director, etc. – a definition of the term manager could be "someone who directs and supervises people." In this book, we will use the term "manager" because it describes an effective leader responsible for all aspects of the team productivity. The manager's goal and purpose:

Manager's Goal

Make employee's job as **SAFE and EASY** as possible

Figure 1.2 Manager's Goal

Don't make the misconception that every manager must be "hands on" to be effective. However, managers need to implement efficiencies to eliminate any unsafe or unnecessary work. The manager is responsible for increasing the quality of life of each of their employees through safe work practices, clean work environment and education (training).

How does a manager accomplish this? There is a path to attain these goals: SHUT OFF THAT COMPUTER, get out in the plant, and invite feedback from everyone. What does that mean? Assume you have a mechanic struggling with pump repair. A manager has two options to handle the problem. First, the manager could stand by with a stopwatch, telling him to hurry up. The other way is to roll up your sleeves and see if he has the tools, training, and information to do the job safely. If you choose to use a stopwatch, I suggest you monitor the productivity of your management team first!

Besides supplying information, a good manager should develop three personal qualities: listening, thinking and teaching.

Listening

Most solutions in your plant are at the tip of your employee's tongues. The problem is that nobody will listen and act on an employee's suggestions.

Part of being a good listener is learning to write it down! Writing down notes while a person is speaking shows, you are focused and interested in the problem. Carry a small notebook, index cards, a napkin - anything to write on!

If you make a promise like "I'll get back to you", keep it! Get back to that person. Follow-up is the closure to listening.

Have you ever used a consultant? Ever notice what they do? THEY LISTEN… As a start-up engineer, the first thing I would do when reviewing a problem at a customer's plant is to ask the technicians on site if they knew about the problem. The majority of the time, they not only knew about the problem, but had solutions too. However, nobody on site would ever listen…

When handling personal problems…keep it PRIVATE, listen carefully, be compassionate and keep your opinions to yourself.
When handling problem employees, you may consider "role reversal". Just like when you should get out in the field to better understand their issues, sometimes an employee will understand the problem when they have to walk in your shoes. Ask an employee into your office. Have them sit in your chair and act as the manager. Have them read their own file and recent grievance. Ask them how they would handle this problem?

Thinking

Think before you speak. Remember, what you say to a person today will be talked about in the break room, on the shop floor, and at their dinner table tonight!

Think before you act. People can handle a disagreement, but be consistent to your overall game plan.

Think into the future. People need a focal point of where they are going. As a manager don't worry about why a pump failed, think about how you are going to prevent it from happening again.

Instill creative thinking…if a person brings a problem to you, ask them for three solutions.

Tracking employee performance. Look at any employee's file, and typically, it contains only "bad" stuff (disciplinary action, reprimands, etc.). Break tradition…fill their file with "good" performance activities.

There are also some "Manager Traps" to avoid. When discussing company policy, you become a referee. The "game" is company policy, and the rulebook you follow is the employee handbook. An example would be that the employee handbook might state that a person must work 12 hours before receiving a meal ticket. Much like a rule in any sport, you may not agree with it. However, explain that the employee only has three options: Accept the rule, change the rule within the system, or change the game (i.e. company you're working for).

In money matters, don't be too cheap! Pay your maintenance people the maximum allowable amount. Remove any money issue that may be a stumbling block. I've seen maintenance people complain and slow down over 5 cents an hour. How about overtime? It's simple. When the plant was running poorly, you gave money to the maintenance folks to get it fixed. Why not the same when it's outperforming expectations? Company policy dictates maintenance wages, but generally you control overtime. Just make sure the overtime activities support plant goals.

Teaching

Teaching people is about the only thing you have control over as a manager. Company policy dictates employee's pay, incentives and health care. You control the personnel development and education of the people working for your department.

Teach your employees how to make decisions, instead of making all the decisions yourself. Also, share all the information about the plant. Education of your workforce is the key to your success…the more they know, the smarter you become!

Teaching…it takes no effort to fire someone, but it's hard work to teach someone.

Maintenance people are bored easily. Challenge their minds…get them involved in other maintenance disciplines, engineering or quality control.

Delegating can be defined as giving a person the responsibility, knowledge and opportunity to do something…but supplying a net to catch them if they need it! How about taking the "Delegation Test"…does the plant and your department function the same whether you're there or not? If it does… Congratulations! If it doesn't, you have some work to do.

What Else?

While listening, thinking, and teaching are the "big 3" things that managers need to develop, there are other personal behaviors considered essential in good leadership as well. Excellent managers are often found to follow certain unwritten guidelines, such as:

- be self-confident… wave your own flag, but don't let anybody see it. Blow your own horn, but don't let anybody hear it
- don't over react
- get dirty… walk in their shoes
- try not to say "I don't care"…the day you don't, nobody else will
- be honest… admit your mistakes
- be a buffer… don't let other people discipline your group
- stop talking about the past…no more "the way it used to be" … it happened yesterday, drop it.
- use manners…i.e. please, thank you
- use the word "because" … it gives a reason for why the task must be done
- demand safety… make sure both manager and employee are comfortable with how to achieve a task
- demand quality… in maintenance, it has to be right the first time. For instance, a pipe fitter must have clean welds, level and square pipe, and unstressed piping. An electrician should finish with level conduit, wires labeled and tie wrapped. A mechanic's parts should be cleaned

and inspected, with tight tolerance and in alignment. If an instrument tech is finished, his calibration should meet specs, with the data recorded. As simple as quality control….

Final Thoughts

Last but not least: managing in construction and maintenance has taught me three general rules (I call them Weberisms) for maintenance management (and of course, I had to learn them the hard way!):

Don't fool with a man's family…realize people have families and lives, and keep your opinion about someone's family to yourself.

Don't fool with a man's money…never under pay, and never be late with a paycheck.

Don't fool with a man's tools…provide them the tools to do the job, and if you borrow a tool, return it immediately.

1.3 Teamwork & Ownership

Let's assume that a company's entire management team is outstanding. The managers have focused on a safe and environmentally friendly workplace, and now turn their talents to increasing productivity. The common industry tools for increasing productivity include downsizing, reengineering, and individual pay for performance. These techniques are not effective in most organizations. Maintenance people must be rewarded based on teamwork, technical knowledge and company profit to be effective.

The Maintenance Management Paradox

As a manager, you need to ask yourself "What motivates maintenance?" That will lead you to the Maintenance and Management Paradox. Depending on your particular system, determine if the following questions and answers apply at your place of business:

- What is the benefit for a maintenance person to do the job correctly the first time or to solve a repeating problem? None - if they do the job incorrectly, they keep their job, and maybe overtime to do it again!
- What is the benefit for maintenance to identify problems before they become a failure? None - more job security and overtime.
- What is the benefit for an older maintenance person to teach a younger person? None - if the younger person is paid less and now has the same job knowledge as the older individual, whose job is secure?
- What is the incentive for any individual to train another person? None… you're being paid for performance and knowledge, not training.
- What is the incentive for a person to try something different, if there is a possibility of failure? None…
- What is the incentive for maintenance to reduce overtime? None…
- What is the incentive to "sucking up" to the boss? A lot!

So, if maintenance works beyond expectations, what is the reason? It's not because of management. It's simple… the team concept among themselves and PRIDE IN THE JOB…

Teamwork

When trying to break the paradox, one group exemplifies the proper way to approach teamwork is. You have to look no further than a race car team. This group demonstrates a good example of maintenance and management people working under the same umbrella of the team concept. The rewards for the team begin with the PRIDE IN THEIR JOB. The entire team will be concentrating with the same focus.

What would be the goals of a racing team? First would be safety…nobody gets hurt. Next, keep the car running for the entire race. Finally, be the first car to finish. What tools would they use to accomplish their goals? Team safety, teamwork, quality workmanship, and continuous improvements allow the team to progress.

What would happen if negative behavior of either or both the management and maintenance team crept into the picture? Obviously, it could directly affect the success of the race team. So, with that in mind, how would a car owner answer these questions?

- Does owner pay crew only by wrench time?
- Does the owner lay off half the crew when the car is running good?
- Is one individual rewarded for winning races?
- Do you think pit members stand around and say, "That's not my job"?
- Do they wait for a work order to get involved?
- Are the transmission parts stored with the engine parts in the back of one of the trucks?

The answer to all these questions is "NO".

So how is your maintenance department different then a race car maintenance team? Imagine your maintenance team repairing a piece of equipment like an NASCAR pit crew.

- All safety precautions have been taken to ensure no personal injury
- Spare parts are at the machine before shutdown
- Maintenance personnel are previously trained on the equipment
- All tools have been inspected and are at the machine before shutdown
- All operating equipment data has been reviewed
- All equipment information is nearby if required… service manuals, drawings, etc.
- Equipment is inspected for other problems while shutdown

What a concept, huh? You can make it happen. Everybody with the same common goals, both individual and plant goals.
So why can't we do this in industry? Look at our reward system. A paycheck? The employees get the same paycheck if they get the job done or not…hell, you're even paying them overtime if they don't do it right first. Management needs to promote teamwork, ownership and quality. If you're going to use a reward system, keep a few things in mind:

- Split the benefits, especially the monetary ones
- Recognize activities that benefit everybody in the organization. Just don't look to see if people are moving, see what they are doing when they move
- Match the reward to the activity you want

Ownership

A big problem with achieving ownership is that maintenance management and supervision in industry today will not let go of the "power". So many managers feel that no technician is capable of planning, organizing, and meeting a schedule on their own. Wrong again … the insecurity of management is holding the maintenance team back (another lesson I had to learn the hard way!).

Your maintenance people have more capability than you might imagine. A typical maintenance person in industry today comes to work, gets one work order, completes work order, waits for the next work order, then goes home. The lack of ownership forces the mechanic to ignore many other concerns during the completion of his work order. During this time the mechanic saw and heard:

- a pump packing leaking
- an operator that didn't understand how a piece of equipment operated
- the warehouse misplace a spare part
- a pipe flange with missing bolts
- a damaged electrical conduit
- a noisy solenoid

With the management direction of doing "exactly what the work order states", the expertise of the mechanic is stifled and level of ownership is minimal at best. The mechanic's work order said, "replace leaking valve", so that's what they did. The supervisor tells the mechanic "Replace the valve…that's it. No more, no less", so he does just that.

Altering the approach of management would allow the mechanic to display the ownership felt as operating within a team concept. As part of a team the mechanic would have:

- tightened the leaking packing on the pump
- instructed the operator on how the equipment works
- informed the warehouse about the misplaced part because the mechanic may need it in the future
- picked up the bolts at the warehouse and then installed the missing bolts on the pipe flange
- told the electrician about broken conduit
- told the instrument tech or operator about noisy solenoid
- completed the original work order!

Wrench Time Story…. "get the hell out of their way!"
It starts with a young manager that thought he knew everything (actually, it was me!). I would sit in my office and listen to the production line. When the line stopped, I would jump out of chair and run around looking for maintenance to fix the problem. This activity could go on my whole career if I didn't change. I knew this program wasn't the one to follow. I selected a mechanic that always sat around waiting for his supervisor to assign him work (sounds like he was just fitting in to the system!). He was slow, not motivated or technically very good at troubleshooting equipment problems. I placed this mechanic in charge of HIS production line. His activities included preventive maintenance, troubleshooting equipment and production problems, training, safety, operation, and maintenance. When the production line stopped, it was because the mechanic planned the activity with operations. That "dumb" technician made an insecure, bullheaded, stupid, and pompous manager look smart. Thanks for the lesson, Dwayne!

As a manager, you must realize that you can't do everything by yourself; I've tried. You need the help from your people, not only to fix the problems, but to find them. As a manager, it boils down to setting goals and developing a method to achieve them. Basically, delegate responsibility and get the hell out of their way!

1.4 Team Goals

Most people will agree that teamwork and ownership generate an excellent work environment. However, upper management in industry continually uses tools such as "pay for performance" (affectionately known as "what's in it for me?") to break up any type of team concept.

Another tool management uses as part of a reward scheme are plant and departmental goals. The goal structure is designed so that the department goals are supposed to support the plant goals. This system supports pay for performance thinking, which is "what is in it for my department?" Department heads do what ever it takes to meet their goal, even at the sacrifice of another department. This type of thinking starts at the top and rolls down to all the employees.

To illustrate, here is a simple example. A maintenance person observes a new operator incorrectly feeding a piece of equipment. The maintenance person reviews departmental goals and sees that training an operator is not on the list, so he walks away and says nothing.

- Did this action affect the bottom line? Yes.
- Did this action affect maintenance goals? No

From this example, it seems the problem lies in the departmental goals.

This happens between departments in every organization: Sales and Manufacturing, Operations and Maintenance, Warehouse and Maintenance, Engineering and Sales, etc.

A typical goal structure is plant goals with supporting department goals as shown below.

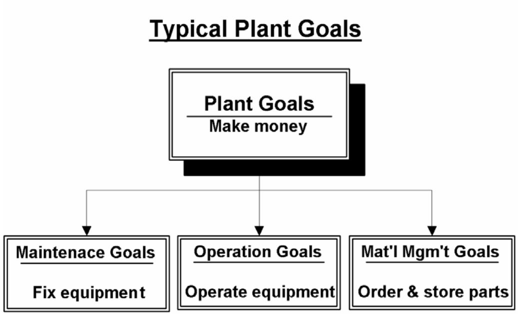


Figure 1.4a Typical Plant Goals

The solution to enforce the team concept starts at the top by using "TEAM GOALS"…

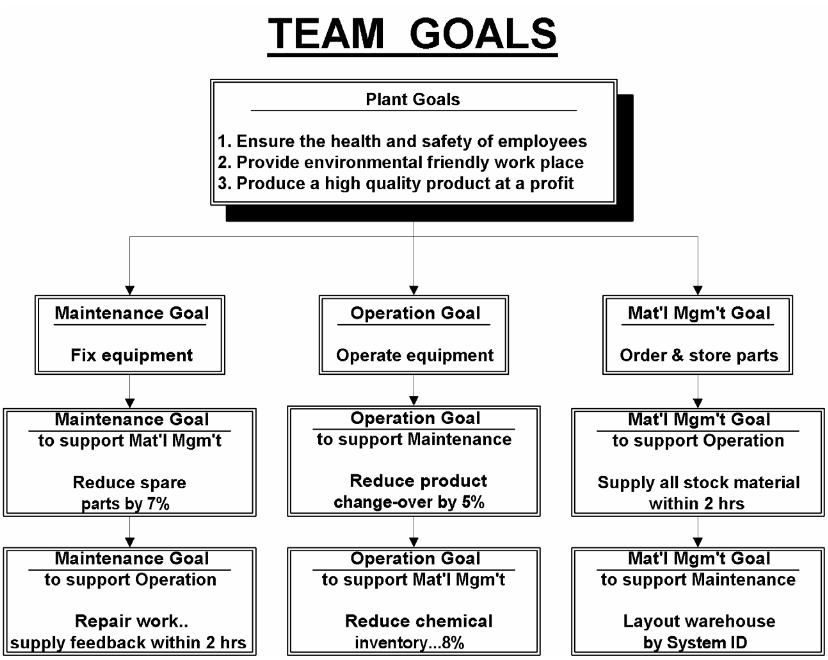


Figure 1.4b Team Goals

Team goals are an extension of your present goals, plus the responsibility to support other departments.

How does the team concept work? Team Goals point out how the Maintenance department can impact goals for other departments. For instance, we have established that the Maintenance goal was to fix equipment. To meet this goal, maintenance would probably stock the warehouse with every spare part possible. They would essentially store a spare plant in the warehouse! Of course, team goals are different. The Material Management goal for Maintenance may be to reduce inventory by 7%. This means less "money" lying on the shelf, as well as less parts to catalog and maintain. Therefore, the team goal for Maintenance from Material Management forces maintenance to reevaluate the number of spare parts they can place in the warehouse.

How about the team concept between operations and maintenance? Maybe the operations goal for Maintenance is to get 2-hour feedback on all repair work orders. As before, Maintenance goal is to fix equipment. To meet this goal, Maintenance would typically fix the equipment when it was easy for them. As a mechanic once said to me, "when the equipment is down I own it, not operations". However, the Maintenance goal from Operations forces Maintenance to respond back to Operations within two hours for all repair work orders. In addition, it may mean that Maintenance comes in at midnight for repairs, because that's when the system would be least affected.

Team goals, not departmental…

TEAM GOALS will start conflicts, force discussions and end with compromises / solutions. Implementing Team Goals between departments develops communications, attaches responsibility, defines staffing and equipment requirements, and identifies training issues. In short, it forces department heads to sit in the same room and iron out any problems.

2

Manager's tools… People

2.1 Players
2.2 Hiring
2.3 Safety
2.4 Training
2.5 RECOGNITION and discipline
2.6 Evaluation

"Delegating …giving a person the responsibility, knowledge and opportunity to do something but supplying a net to catch them if they need it!"

Fred J. Weber

2.1 Players

The purpose of this module is to discuss the “players” – more commonly known as the employees. This module should also serve as a reminder to all businesses that the most important tool in maintenance is

“PEOPLE !”

It is vital that you remember that your most important tool is not your computer management system - I haven’t seen a computer rebuild a damned pump yet!
Also, stop looking at your people as a box on a spreadsheet. For instance, you see:

EMPLOYEE	SALARY
Cox, Robert	$47,900
Johnson, James	$43,640

Table 2.1 People

What you don’t see is this:

Robert Cox – divorced father of two; children are Ed and Jane; Ed will need a serious operation within three months. Or this:

James Johnson – wife Sharon; James and Sharon are providing primary care for Sharon’s mother whom is afflicted with Alzheimer’s disease.

What difference does this information make? You must realize that your “players” are human, and have lives filled with problems, responsibilities, etc. You must realize that some employees are "high touch" and require a lot of attention, while others are “low touch”, needing very little. Don't be afraid to ask, "How is the family?" and really mean it! Show a genuine interest. Why bother? Because it’s *people* that make the job happen...

2.2 Hiring

It's often said that in real estate, there are three things to remember:

"Location, Location, Location…"

Hiring and retaining quality maintenance personnel demands that you remember three things:

"Respect, Respect, and Respect…"

The hiring process is one of the maintenance manager's most important functions. Hiring an individual for your team is much like a marriage; it is imperative that both parties know all they can about the other before joining. The question becomes "How do I hire good people?"

Most companies today have a dedicated Human Resources Department that is normally in charge of initiating the hiring process. Typically, HR is responsible for the pre-employment medical and drug testing, verification of education, past employment, criminal record, workers' compensation claims, etc. However, even if this is the case in your company, you should remain involved in the entire effort.

The Maintenance manager and HR department should work closely in writing a job description. This job description should contain enough detail to ensure that HR can filter out unqualified individuals. When writing a job description, avoid being too generic. For instance, here is a job description:

"Wanted: Plant Electrician"

This type of description qualifies anybody who is an electrician. The job description you really want should be detailed enough to filter out individuals that do not have the technical skills you require.

A better example is:

"Wanted: Plant Electrician" Requirements as follows:

- Minimum one year of experience with Modicon PLC
- Able to read electrical drawings, PLC and SAMA logic
- Familiar with paper mill process
- Experience with 6900v and 480v breakers and switchgear
- Experience using megger, DC high pot or VOM
- Two years of electrical construction supervision

This skills description is much more representative of your needs in an employee, and can become the tool that you and HR need to pre – qualify candidates.

Remember, maintenance management personnel are responsible for ensuring that the candidate:

Meets adaptability requirements

Able to work 1st, 2nd, or 3rd shift? Able to work in various environments, including dusty, hot, cold, noisy, etc. Able to work overtime, including evenings, weekends, holidays, etc? Is the employee to be on call – its possible 24 hours a day and 7 days a week may be required.

Understands Safe Work Habits

At this time, we want to test the individual's knowledge of general safety. While it is a fact that you will orient a newly hired employee to your safety program, the candidate should be somewhat knowledgeable about various safety areas, including (but not limited to): discussing information on an MSDS sheet, describing what is required to work safely in an empty vessel, or how to safely work mechanical or electrical equipment. Obviously, although responses will vary due to the individual's background, here you are looking for the candidate to demonstrate their general knowledge of safety and to show ability to follow safe work habits.

Technical Knowledge

This is the time and place to assess the individual to determine their technical knowledge. Remember, earlier we showed an example of a comprehensive job description for a plant electrician. Assuming you are assessing an electrician, you may test:

- PLC knowledge - show a typical ladder logic diagram and ask them to describe how it works.
- Piping & Instrument Diagram knowledge – give the candidate a P&ID and ask them to describe system flow, pressures, pump gpm, etc. by looking at the P&ID.
- Industrial experiences - ask candidate questions about the basic process (paper mill, power plant, etc.) and associated types of equipment they are familiar with.
- 6900v and 480v experience - this phase is best accomplished in the field. Go into the plant and ask the prospect to point out the components of 480v motor starter.
- Test equipment - ask individual to describe test procedure for a 50 hp. @ 480v motor.

Miscellaneous Skills

Does the candidate have previous supervisory skills? How about knowledge of planning and scheduling? Any particular ideas on teaching or mentoring? How would they trouble shoot a problem?

It is important to remember here that testing the individual's technical knowledge is <u>not</u> used to embarrass a candidate. The test is to make sure that you get a knowledgeable individual that will not harm the equipment, themselves, or others. Basically, you want an employee that is worth the money you will be paying.

Depending on the company, HR may give the pre – employment skill assessment as well. Assuming the prospective employee gets this far, it is generally a much better idea for the manager and his designees to administer the skill assessment as part of the job interview process. The important point here is that a comprehensive skills application assessment <u>must</u> be given by someone. Again, this is the perfect time and method to eliminate unqualified candidates.

During the interview, promise only things you have control over… and keep your promises. Things such as dayshift, pay raise after six months, or company truck can be promised at this phase. Don't make a mistake here…and don't promise if you can't deliver.

If your company has a probationary period, make it clear to the employee that they will be on a probation period for a certain amount of time. Also, make it clear that fellow employee feedback will account for the bulk of the input during the probationary period, and as such will determine whether the new employee stays or goes. Co-workers will know more than management if the candidate is a good fit.

Assuming you find an employee that meets your requirements, hire him! In addition, don't be bashful about paying a good wage. Remember, along with respect and job satisfaction, money is a great motivator!

Let's say you have been fortunate enough to find the right employee. The new hire reports on his first day of employment. What should they expect? Most companies today have a formal orientation procedure for new employees. If not, here are few things that would be helpful to a new maintenance person:

- Safety procedures & safety equipment
- Company benefits package
- Emergency procedures
- Organizational chart with photos
- Photos and names of people in their department or area
- Plant tour
- Plant layout drawing
- Personal area and tool location with their name
- Location of break rooms, parking lots, and rest rooms
- Company hat, coffee mug & shirt

2.3 Safety

Safety is the most important aspect of anyone's job. Today's high production requirements combined with a reduction in manpower have placed a tremendous burden on supervision to "get the job done" with no injuries. It would be nearly impossible to stress safety too much. How can you achieve a safe workplace? Here is a brief list of items that could be required of your employees. They should:

- Establish a clean and safe work environment.
- Develop an emergency response procedure (medical, fire, chemical, etc.)
- Ensure that all safety systems and monitoring instrumentation are operational and functional (no "jumpers", no safety relief valves gagged, no forced or modified computer logic)
- Review materials and environment for workers (MSDS, confined spaces, job hazard analysis, etc.)
- Inspect equipment often and monitor it closely
- Develop a safety incentive program
- Operate all equipment within design parameters (pressures, temperatures, vibration, etc.)
- Be supplied with proper safety equipment and trained in correct use
- Develop safety-training classes (be sure to bring them to the plant floor as well as the classroom)
- Maintain tools and equipment, inspecting them regularly and using them properly
- Know and utilize proper procedures for locking out, tagging out, venting, draining, etc. These must be established for each piece of equipment and system.

Most people in industry think safety training is just the understanding of OSHA requirements, MSDS sheets, safety equipment, etc., etc., etc. While these are all very important parts of safety training, this is only a partial list. When you teach someone the proper way to use tools, operate equipment, use test equipment, to understand a process drawings, or calibrate equipment, it should also be considered "safety training". After all, understanding and demonstrating these items will not only keep the maintenance personnel safe, but also everyone else as well.

Remember, safety is an attitude. The worst mistake you can make as a supervisor is to jeopardize the health and safety of your people. Be sure your employees know how serious safety is. I assure you, anyone who has ever seen an industrial accident will never forget it – avoid injuries at all costs.

Wrench Time Story… "know your priorities"
I had been fortunate. Despite working for several years in construction and manufacturing, I'd never had a major accident on one of my work sites. Two things contributed to this, excellent people and a little luck. One afternoon, our ironworker superintendent and I were walking back to our trailer to eat lunch. A contractor working near us screamed, "Get a clean 5 gallon bucket and four bags of ice." We ran up to the second floor of the building with ice and bucket. There we proceeded to place a man's severed arm in the bucket and pack it with ice. I still remember…

2.4 Training

Training is the teaching, testing and implementing of information. In an industrial atmosphere, it's hard to separate training from your normal job duties, since you should be teaching or learning in everything that you do. However, training is typically divided into two basic ideas: *classroom training* and *applied training*.

Classroom training - the terminology here speaks for itself. Classroom training is usually held in a facility or location that is not necessarily the normal work area. In the classroom setting, you will generally have overhead projectors, chalk boards, televisions, etc. to help support your training goals. There is usually a single instructor or a team of instructors responsible for designing and developing training. Get to know them, and don't be afraid to suggest topics for training.

Other methods commonly used to teach employees in a classroom setting include:

- Seminars - equipment suppliers and consultants have classes on basic maintenance technology or equipment. Strongly recommend using ones that are hands-on type. Local vocational tech schools - in most areas there is a community college or technical school that has courses on the basic training … welding, machine shop, HVAC, electrical, or instrumentation.
- Equipment sales vendors - most vendors have classes on their equipment. Note: If you are buying any equipment, make sure you negotiate for training… some vendors will give free training if they get the order.
- Internet and software - the Internet is becoming a great tool for information for equipment. Most vendors have e-mail address to help solve technical problems.
- Video–one tool that maintenance has neglected. Maintenance will write a ten page procedure on how to repair something, but won't make video… isn't there a saying *"a picture is worth…"*

Application training can be described as “hands on”, or even better, "mentoring". Mentoring is really nothing more than the “guild system” first established hundreds of years ago. The theory is that a new, young employee (an apprentice) comes to work eager to learn. The employee apprentices under an older more experienced employee (journeyman) to learn his trade.
Mentoring in some form was how most maintenance people learned their job. We learned from someone. Downsizing, resizing and retirement has caused maintenance to lose one of their greatest asset… PEOPLE ! Reshaping of corporate structure and zero reward for teaching people has almost caused mentoring to become a lost art.

Equipment training is one of the key tools for maintenance to use in increasing plant performance. By equipment training, I don’t mean a generic vendor training class, but a training class on YOUR piece equipment. Be careful, because vendors typically supply generic training for nothing, but charge thousands of dollars for training on your equipment. The class should include discussion on safety, control logic, and maintenance issues that will make your maintenance personnel nearly as knowledgeable as the factory service rep on your equipment. Vendors should also supply drawings and detailed service manuals.

When you get equipment information, use it! I read that a national service manger is able to turn down sixty percent of warranty claims because of customer ignorance of their equipment. From the view of the customer, this amounts to “vendor abuse”. Certainly, there are many honest and helpful vendors out there. Yet, the lack of knowledge on your part should not constitute an emergency on the vendor’s part! The changes in information processing have been dramatic over the last few years. In the past, everything was simple relays and switches. Today, equipment control is often accomplished with hidden or over-complicated computer logic that only the vendor understands. Just look under the hood of your car!

Speaking of cars, probably the best example to explain system training is in the auto industry. The auto industry trains each mechanic on the general understanding of the basic automobile systems…cooling system, emission system, etc., then takes it to the next level when the mechanic is then trained on the specific ignition system for a specific model before he works on it.

In industry today, most plant maintenance people typically understand the generic working of the systems that they work on, and then are handed the service manual. Hopefully, they can figure out the rest!

Establish tests to ensure complete understanding. Several things can be used to test an individual, including the standard written test. Other ways to measure subject matter knowledge include testing or repairing equipment, planning an outage, or directing a small workforce.

Be aware that the "old fart" that is retiring soon is taking a lot of information with him. He may not move as fast as a "young gun", but he only needs to shoot once! It's important that the younger employee respect the older employee. Demand that if an older and a younger employee are doing a job, the younger one should be carrying the tools and sweating more!

As a manager, are you giving your employees the training, tools and opportunity? If not, why not? Too busy putting out fires? Therefore, the employee can correctly assume that training may not be very important to the company. In other words, whose fault is it? Employee? No, <u>management.</u> Remember your employees are not plants; they can't learn it by osmosis. If a maintenance person can read, is given the training, tools, and opportunity they will be able to achieve the skills you desire.

Finally, have you ever heard this…"As a manager, I don't have the time, money or personnel to train the staff." Well, you had better find the time, money and personnel… or it will come back to bite you in the ass!

2.5 RECOGNITION and discipline

If you notice in the title above, the word "**recognition**" is much larger than the word "discipline". That was done for a purpose; to underscore the fact that the accent in the workplace should be on **recognition** instead of discipline.

Recognition can have several definitions, but the best is probably "attention or favorable notice". It is important that you remember the "favorable" part; that is how you separate **recognition** from discipline.

Recognition…every member of your department wants to feel that if they left, the plant would shut down. As a manager, you can never let one individual control that much power, but you must make them feel that their work skills are that important to the organization.

What does management need to consider in recognizing quality performance from maintenance personnel? First, ask what is the incentive for a maintenance person to do an outstanding job? Often, the answer is zero, zip, none. Why? Management's reward system. You must match the reward system to the activity you want… all members must have the same incentives. Things such as team safety, quality workmanship, cross training, and common goals must be stressed.

Maintenance management must reward people for teaching and taking a proactive team approach to their job. Again, you must reward the activity you want from your people. What does management get from **recognition**? Typically, they will realize a safer work environment, a trained maintenance staff, and an increase in production

It takes no effort to find fault in a person's work. Instead of bird-dogging your people, use a technique described in the book "The One Minute Manager" by Ken Blanchard. He stated that you find activity that you like and praise them. This is how I used the technique to motivate maintenance. When maintenance people were sitting around doing nothing, I said nothing. I waited until they were working, interrupted their work and then thanked them for their effort. They knew that they were screwing off for 30 minutes but they didn't get any negative feedback. They also appreciated the pat on the back... after this I sat back and started to think "what a novel idea…." Instead of bitching and bird-dogging people, you tell them they are doing a good job and they will actually work harder and smarter.

One more thing…when it comes to recognition, don't forget the employee file. So many times, only mistakes go into the employee file. If an employee does something he should be positively recognized for, put it in their file.

discipline…

Managers often have their hands tied in the way they can handle a problem employee. That's why it is important to do a complete evaluation on all new employees.

Discipline in industry is always directed toward the blue-collar worker. Typically, you hear of a mechanic being "written up" for damaging a piece of equipment. How about the manager that doesn't set goals, plan work or asks their people to perform unsafe activities? You never see them being written up for poor performance or negligence…

Discipline should be used as the LAST resort to motivate or correct an employee's performance. I've never seen a technician become motivated after they had their ass chewed. If you have to discipline an employee, follow company policy, do it immediately, listen for personal problems, maintain a paper trail, and keep it private.

Final note:
It takes a lot of time and patience to teach someone…
It takes no time to discipline them.
Or remember a quote by **Napoleon:**

"Recognition… Men will die for a ribbon"

2.6 Evaluation

"Damn, evaluation time again."
This seems to be the consensus. However, evaluations shouldn't be a time of worry for both the employee and supervisor. They should be an accurate measure of the performance shown by the employee during a certain time.

The following is a list of items to consider when evaluating maintenance personnel:

SAFE WORK HABITS

- Multi-skill capabilities
- Supervisory skills
- Special production or process knowledge
- Trouble-shooting skills
- Communication skills
- Teaching/mentoring skills

Construction or fabrication skills

- Work planning skills
- Demonstrated parts purchasing and material acquisition
- Directing or coordinating contractor work
- Knowledge of maintenance tools and equipment
- Knowledge of specialized tools and test equipment
- Cost reducing suggestions
- Engineering skills, ability to update documentation

Using the list above, give your maintenance people goals and the opportunity to achieve them. Above all, make sure goals are written and understood!

In reference to the first evaluation (usually after a short period like 90 days), the performance of the employee should be judged mainly by his fellow employees. Since the peers spend the bulk of the time working directly with the new employee, they should have the best idea of his progress. Remember, an evaluation of progress, not popularity!

What is the evaluation for? Normally, it is tied to money in the form of a wage adjustment. For the newer, less experienced employees, it can also be a stepping-stone to a higher level, or classification. Do the maintenance personnel in your plant know what they need to do to progress from one level to the next? Depending on your system, there could be a number of things that factor into a change in level. For instance, an entry or third class job is considered a learning position. As such, the employee must be learning safety, the proper use of tools, a general overview of the process, etc. A second-class maintenance person should have a good understanding of safety, be able to repair most plant equipment, use most tools properly, be able to work without supervision, and be able to teach the third class. Finally, a first class technician should have a good understanding of the plant process, understand drawings, be able to order parts, be able to plan large projects, show leadership, and be able to teach the other classes. Of course, you will want to add more plant specific performance measures as well, but these general ideas should serve as a guideline to things that your employees should master before moving to a higher grade.

Wrench Time Story… "maintenance pay"
One goal I've always had as a manager is to teach people. Not saying I was smarter, I just knew something different. With that in mind, one day I told a lead mechanic working for me that my goal was to teach him everything I knew about PLC. I told him once you know all this stuff, I hope that one day you can walk into my office and tell me to shove it because you got a better job. Well, a year and half later he walked into my office (before I had even had any coffee) and said "Fred, you asked for it. Shove it!" It seems he had gotten a new job paying $3.00 more per hour. Personally, I was glad for him, but as a manager, I knew it would hard to replace him. The loss of good people and spending most of the day talking to the people that give you problems is the reason why I say " Managing maintenance isn't rocket science, <u>it's harder</u>."

3 RPM method

"The RPM method…
Repair, prevent and then modify"
Fred J. Weber

3.1 The RPM method

It's 7:30 a.m. Monday morning. You are looking down at your desk and you see 800 open work orders. While you drink your first cup of coffee, you have to decide on how to prioritize the work. Of course, Monday morning also brings out each department's agenda. The maintenance shop wants to change a machine program, operations has a rush job to relocate a conveyor system, engineering wants to try a new idea on a pump seal, purchasing held up your bearing order ordered because you left out a period on your request, and the warehouse is looking for the compressor belts shipped two days ago. Welcome to Monday!

To prevent the usual chaos, organizations have tried various work order priority systems. One style is the "Ten-code Priority", so complicated that no one uses it. Another method is "First In — First Out", where the date of the work order is determines date of repair. However, the most commonly used priority system today is based solely on who screams the loudest!

Obviously, you need some form of work priority method. It should be comprehensive and effective while protecting personnel and equipment (remember your earlier goals?). Through the years, I have devised a program that I call the *RPM method.*

The RPM method is a simple way to assign a work order priority based on the "TYPE" of work. The RPM method uses a letter code to define type and priority of work.

"R" - Repair work orders

"P" - Preventive work orders

"M" - Modification work orders

The RPM method is easy. A work request is submitted to maintenance. The request is reviewed by the supervisor or the maintenance planning department and becomes a work order. At this time, a priority of R, P, or M is placed on the work order based on the type of work required. If the work requires maintenance to repair, rebuild, or put something into a safe condition, it becomes an "R" work order. If the work is preventive maintenance such as adjusting or testing, then it is a "P" work order. Finally, if the work type is not "R" (repair) or "P" (preventive) then it must be an "M' type work order. It generally covers everything else, such as modifications, changes, wish list items, and… maintenance folks doing something besides maintenance!

With each work order now identified by R, P or M, which work order does maintenance start first? "R" and "P" types are work orders that are ready for maintenance. The equipment is clean and safe with access to parts and information. The "M" work orders are handed to management to be prioritized and sent back to maintenance. The "M" work orders are *not* started until the "R" and "P" work orders are complete or can't be started due to parts or equipment availability. Not only does this method prioritize your work, but it also provides a means to track repair, preventive or modification work of any piece of equipment.

Remember the RPM method is a mindset, not a high tech software program; it's how your plant approaches equipment problems. The RPM method requires changes in maintenance, but also in every other department. For instance:

- Maintenance - should understand that there will be no changes on equipment until all repairs and PMs are completed
- Management – like maintenance, realize that NO plant changes will be made until the existing equipment and back-up systems are operational.
- Operations – help maintenance locate safety & equipment performance problems
- Engineering – focus on long-term solutions to equipment problems (repeated "R")
- Purchasing – should order parts immediately for "R" and "P" work orders
- Warehousing – expedite materials for "R" and "P" work orders
- Training – train personnel in equipment safety, operation and maintenance

The plant focus is now in one direction; in short, the RPM method supports the true meaning of maintenance. Make no mistake, maintenance usually understands urgent work orders without any type of special code. For instance, the extrusion press is down. No product is going out the door. The plant manger is screaming to get the press operational. Typically, no priority code is required, most likely a work order wasn't even written. The RPM method was developed to set maintenance priorities once the extrusion press *is* running. Let us look at the three elements of the RPM method a little closely.

3.2 Elements of the RPM method

Repair Work Order…"R"

The first element of the RPM method is "R"…an abbreviation for a repair work order. This is used to initiate repair of an *existing* piece of equipment in the plant. This includes back – up equipment and rebuilding spare equipment parts for future use. The "R" type work order is our top priority and is related to equipment issues or safety / environmental problems. Equipment work orders are those that effect the operation of your facility, written to repair an *existing* piece of equipment. The "R" work order will use words like: bad, broken, bypass, failed, fault, fix, jamming, leaking, loose, noisy, overheated, problem, repair, replace, rebuild, tripped, trouble, vibrating, worn, etc. In addition, look for "not" words, such as won't, didn't, doesn't, can't, or wouldn't.

Here are a few sample "R" type work orders:

W O #	Equipment ID	Work Description
R0112233	1-WW-PMP-001	*Repair* pump
R0112234	1-WW-VLB-023	*Leaking* valve
R0112235	1-AS-MTR-007	Motor *overheating*
R0112236	1-AS-PRS-013	Bad switch…*bypassed*
R0112237	1-AS-CNV-002	*Worn* idlers
R0112238	1-WW-PMP-003	*Rebuild* spare pump

Table 3.2 "R" type work orders

If equipment is not working per manufacturer specifications (such as a safety relief valve gagged, electrical limit switch bypassed or computer program modified), this represents a legitimate reason to note a potential safety problem. Reviewing industrial accidents you will usually find equipment problems involved, so repairing existing equipment to a safe operating status becomes a top priority for maintenance.

In most plants, safety and environmental work orders have the highest priority, and they should. Normally, these work orders are written if any part of the plant is not meeting county, state and federal standards (OSHA, EPA, etc.). However, there is often an abuse of the safety work order in industry. Sometimes a person writes safety work order for maintenance on work they want done immediately. To eliminate some of the abuse of a safety work order, a reference to a regulation or policy should be required. In other words, if it's a safety issue, document why. The information can be found in company safety policy, OSHA or EPA regulations, or other safety or environmental information. Another tool is the support of the safety and environmental departments; it wouldn't hurt them to spend 20 minutes a day with maintenance to review and approve safety and environmental issues.

Remember, potentially every work order submitted to maintenance could be considered a safety work order if you look close enough. How about this one… *"Add cup holder to operator's desk. The potential of spilling a hot cup of coffee exists - could hurt the operator".* Maybe an extreme case, but you get the idea. Safety and environmental work orders should take high priority, but they should be used only for the intended purpose.

Preventive / Predictive Work Order…"P"

The second element of the RPM method is "P"…an abbreviation for a preventive work order. It could be considered as any activity that *plans, prevents, or predicts* maintenance work.

The "P" work order will use words like: adjust, monitor, inspect, lubricate, calibrate, plan, preventive, predictive or test.

Plan it - every "P" type work order should be detailed, including safety procedures (lockout, draining, MSDS sheet, etc.) and any other information required (drawings, photos, service manuals, calibration sheet, test sheet, etc.). Don't forget the tools and supplies required, including lubrication specs, rags, and wrench size.

Schedule it - the "P" type work order is a *known event*, so it can be scheduled. In scheduling this type of work order, schedule the PM to benefit maintenance personnel as well as for plant requirements. For instance, schedule outside PMs during spring and fall, not on the coldest days of winter or the hottest days of summer.

Any predictive maintenance work orders (such as vibration or thermography) should be taken with equipment operating at same load; in fact, they need to be taken with the equipment running!

A "P" type work order is based on the minimum amount of work required to maintain safe operation of equipment. The abuse of this work order comes when maintenance uses it for equipment failure. Assume a "P" type work order to lube a fan's bearings monthly is established by maintenance and engineering. Before the PM, the mechanic hears a bearing noise. The mechanic fixes the bearing immediately, but needs to write a separate "R" type work order for the time to change out the fan bearing. Remember anything outside the scope of a scheduled "P" type work order is "R" work.

Modification Work Order…"M"

The third element of the RPM method is "M", or an abbreviation for a modify work order. It covers ANY activity that modifies the basic responsibility of maintenance. Remember, you hired maintenance to Repair or Prevent. Therefore, if a work order is submitted and isn't an "R" (repair) type or a "P" (prevent) type, then it must be an "M" (modify) type work order.
Typical words used in "M" work orders are: change, fabricate, install, move, relocate, modify, update documentation, find root cause of problem, resolve, improve, develop, training, operate, purchase, or design.

The "M" work order is your last priority. Why? No changes, modifications or wish list items should be made until existing plant equipment is under control. All outstanding "R" and "P" type work orders should be either completed or waiting for parts. To quote my mom "No dessert until you finish what is on your plate!"

The "M" type work order becomes a catch all of various maintenance activities. For this reason an "M" work order should be *approved and prioritized by management.* Maintenance knows the operation of the plant well enough to be able to prioritize "R" or "P" type work without management's assistance. What maintenance needs is someone to prioritize the Modification work orders. Examples of "M" type work include updating electrical prints, implementing a CMMS system, or even a wish list item, such as building a tool shed, installing a phone in the restroom, or refinishing the VP's table! The priority of these "M" type work orders will play a key role in a plant's reliability.

3.3 Using the RPM method

Remember when you walked into the "Monday from Hell" in the beginning of this module? Let's start that Monday morning over again, only using the RPM method.

On the first day, thumb though those 800 work orders and find some "R" (Repair) work orders for your maintenance guys to do for a few days. Next, let everybody know about maintenance's new priority system…the RPM method. Then, locate five empty boxes. Label and place the three boxes "R", "P" and "M" together with "NEW" and "CLOSED" box at each end as shown below.

These boxes will be used to organize your work orders.

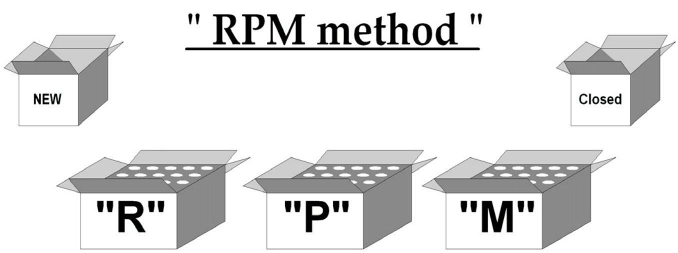


Figure 3.3 RPM method

Use the:
"R" box for repair work on existing systems
"P" box for preventive work orders
"M" box for open work orders that are not an "R" or "P"
"NEW" box for new work order requests or if unable to determine R, P or M type
"CLOSED" for completed, deleted, canceled or duplicated work orders.

Well its time to start…

Call your supervisor and lead mechanic into your office. Grab another cup of coffee and get one for them too. Go through the stack of 800 work orders one by one and determine the work order type: "R", "P", "M", NEW, or CLOSED.

Here are three of the 800 work orders that may be in the pile:

Example #1

WO# 012134 1-WW-PMP-003 Hot inboard bearing
Problem… Pump inboard bearing running 15 degrees hotter than normal.

"R" type work order …Problem with an existing piece of equipment.

Example 2

WO# 012256 1-AS-LTR-001 PM…Calibrate transmitter
Calibrate level transmitter, blow instrument lines and complete calibration sheet.

"P" type work order … preventive maintenance / calibration.

Example 3

WO# 012199 1-BG-ALL-001 Install phone in restroom
Operations need a telephone installed in the restroom.

"M" type work order… work is a modification to facility.

We've completed the 800 work orders. What's in the boxes? The "CLOSED" box - the first thing you notice is that 150 of the 800 work orders are in this box. Remember, *YOU TOLD* the maintenance supervisor to keep work order "BACKLOG" at 800. He did by not closing out 100 completed work orders. The other 50 were duplicates from other work orders.

The "NEW" box - work orders missing problem description or equipment identification. These work orders need to go back to the person that wrote the work order for clarification.

The "R" and "P" boxes - top priority for maintenance. Remove the R and P work orders from the boxes and determine if maintenance can work on them. If they can, hand the work order to the Maintenance supervisor to be distributed to your maintenance team. Try to have two people working together in the same area. Instruct the teams that if they're unable to do work for any reason, return the work request. Work orders in the "R" and "P" boxes requiring safety, parts, information, or tools before work can start need immediate attention by planning, purchasing and operations. These work orders need to be everybody's top priority.

The "M" box - hand the "M" work orders to management for approval and to prioritize by asking for the top ten. Remember, this work doesn't start until the "R" and "P" type work orders are down to a manageable size and manpower is available.

By the third day, the 800 work orders are sorted and the RPM method is up and running. The first thing you notice is that any new work request entering maintenance generally has only two choices: "R" (repair or safety problem with an *existing* piece of equipment) or "M" (modification to plant equipment or maintenance's original job function!). What happened to the "P" type? In reality, most "P" type work orders are generated by the maintenance department itself, primarily for things such as needing to PM a piece of equipment.

Three months later, and you can take the RPM method to the next level. It's time for maintenance to write "M" work orders. Maintenance people are typically the most knowledgeable about the equipment design. Therefore, maintenance needs to generate work orders to solve equipment problems, update documentation or redesign equipment to be maintenance friendly. In other words, this lets maintenance personnel take an active role in solving problems.

Let's review an example of "M" type work order generated by maintenance. After three months of using the RPM method, collect all the completed "R" work orders from the "CLOSED" box. Looking for repeated failures or high cost repairs, you find three "R" work orders due to bearing failure associated to pump 1-WW-PMP-003. The costs from these work orders totaled $8300 in parts and labor. Time for maintenance or engineering to generate an "M" type work order to resolve the bearing problem, as well as a place to charge their material and labor.

Here's what it might look like:

WO#: M012331 **Equipment ID**: 1-WW-PMP-003
Description: Resolve bearing problem, modify pump or process to increase pump reliability

Now maintenance, operations, and engineering can brainstorm together to find the root cause of pump bearing failure by reviewing all data associated with pump such as:

- pump PM procedure (correct lubrication and coupling alignment being used)
- operating parameters (flows, pressures, motor current)
- predictive analysis (bearing vibration and temperature readings)
- repair procedure (tolerances of bearing housing and shaft)
- the cost of the pump ($26,000 new)
- the application used for the pump (designed for wastewater)

Results: After $1200 to research the problem, and the cost of a new bearing housing, the bearing problem was resolved. What was achieved? In the next three months, there were three less “R” work orders + $8300.00 saving + increase production + ability to reduce spare parts.

As maintenance, operations and engineering generate more “M” type work orders to help improve equipment performance, it is still up to management to prioritize these work orders. The right selections by management will produce a reduction in repeat “R” work orders and a result in a better prepared maintenance department. As an example, imagine the relative importance of updating electrical prints when compared to building a tool shed. Both projects have value, but management must decide on where the biggest bang for the buck lies.

One year later - The backlog is expanding but each work order is a suggestion on how to make the plant run better.

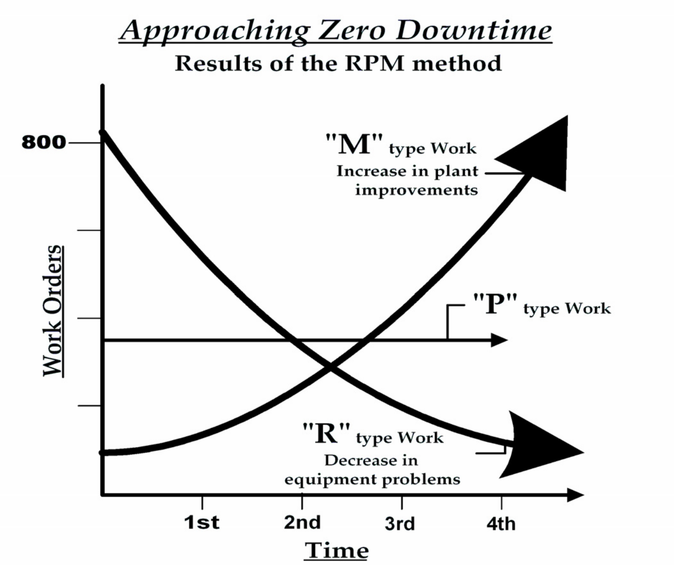


Figure 3.3a Approaching Zero Downtime

What impact did the RPM method have at your plant…observe the graph.

- Same number of work orders? Yes
- Equipment downtime higher or lower? Lower
- Maintenance doing a better job and focused on long-term solutions? Yes

Sounds like this system can work. However, just like with any method, there are always exceptions. For instance, if the Plant Manager's secretary asks maintenance to do something, forget all of what you've read here, just do it!

3.4 History of the RPM method

Well, it all started for me as the manufacturing manager responsible for maintenance and manufacturing engineering in a small production plant. After several months on the job, I was constantly putting out fires and trying to please my "customers" (production, warehousing, product design engineering, management, etc.). I was also in the same place I started…no improvement.

One morning I came out of my office, coffee in hand, and decided to just WATCH… nothing else. Armed with a pen and 3x5 cards, here are a few of the things I noticed:

- The same people working on the same problem they had two days ago
- A maintenance person jumping between two pieces of equipment, trying to keep them running
- Maintenance people carrying spare parts in their toolboxes due to repeated problems
- Equipment randomly stopping
- Equipment jamming and operators having to pull damaged product from equipment
- Maintenance working on equipment without documentation
- Maintenance modifying equipment because it won't operate
- Even Maintenance people operating equipment

After walking and watching for two days, I knew we needed major changes. To improve maintenance, I asked for help from the other departments.

From Management: stop all changes of products and equipment (which was like pulling teeth).

From Product Design Engineering: work with quality control to identify product problems.

From Production: monitor all downtime on each major piece of equipment, and to reduce the number of product changeovers (change equipment set-up for a new product).

From Purchasing: order parts for broken equipment within two hours after request, and have parts sent the next day.

So how about the maintenance department itself? I was surprised by the support of the maintenance personnel now that someone was actually concerned with their problems, and trying to find ways to solve the problems. It's amazing the buy in you can get…

The first thing I did was to support production. Two technicians were assigned to each production line to assist in production and resolving minor equipment problems. The rest of the technicians were assigned to identify, inspect, and generate a repair punch list with parts required for each piece of equipment. This list also included equipment laying on the shop floor to be rebuilt. The focus was to define all the repair ("R") work and PM ("P") equipment to prevent any future problems. As the maintenance team was working on the repairs and PM in the plant, the lead technician and I were focused on solving problems. The goal was simply to make the equipment act and look like new.

Remember earlier, I saw a mechanic spending 8 hours each day between two machines. To free up that maintenance time, we had to get the machines operating properly. To do that, we had to find the root cause problem for these two pieces of equipment. We collected every piece of information about this equipment. Data and documentation included quality reports, service manuals, drawings, instrumentation calibration sheets, programmable logic controller program, and anything else we could get our hands on. We wanted to know everything about our machine. In addition, we located all spare parts in house and placed them in one location, reviewed the spare parts lists, and ordered all necessary spares.

Once we felt we knew the machine as well as its' problems, we went to work. We verified all mechanical connections for tightness and correct adjustments, electrical connections and updated electrical drawings. We confirmed all PLC inputs and outputs were wired per the electrical drawings. During our work, we found an erratic input card, a pressure switch not calibrated, two neutral connections loose, two limit switches that had been bypassed, and five PLC errors in the program. After talking to the equipment manufacturer, we modified the PLC program logic by extending two sequence timers.

So what did we achieve? After a couple of weeks, both pieces of equipment were operating per design and we gained over seven maintenance hours of per day. We had managed to update documentation for future troubleshooting, including electrical drawings and PLC annotated programs. We even organized all the spare parts for future repairs and PM in one location. This process was used throughout the plant, with improvements in product quality and a reduction in equipment downtime and maintenance overtime hours.

The problem was how to maintain and improve this level of performance? That is how the RPM method was born. Again, this method was based on the word "*M*aintain" (to keep in a certain condition or position, especially of efficiency, good *R*epair, etc; *P*reserve). During the next several weeks, I had to get everybody on board and set up the "RPM mindset". All departments were informed that maintenance's work priority was determined by operational status of the *existing* equipment, not maintenance or management agenda.

The maintenance department jumped on any "R" type work of any production or back up equipment that was down. Later, we used the same approach on everything in the plant, including a leaking faucet or anything that needed repair. The focus was to not only repair equipment, but to prevent it from happening in the first place. So while we repaired it, maintenance performed PM on all the equipment ("P" type work) by inspecting, testing and greasing everything in sight. Last, when time permitted, we addressed “M” type work; we solved equipment problems, started designing our own equipment and eventually had time for some wish list items.

Don't think maintenance did this alone. Manufacturing engineering addressed safety and environmental issues by reviewing OSHA and EPA standards pertaining to the plant. Also, they supplied technical assistance to maintenance on “R” type work orders and later helped in resolving repeated problems. Product engineering and Quality Control established tests for all materials supplied by outside vendors. We noticed that sometimes it wasn’t the fault of the equipment, but what we were feeding it. This group developed simple tests to monitor product through each piece of equipment. Also, Purchasing was ordering parts associated to “R” and “P” work order ASAP (as soon as possible).

Management was thrilled with the extra maintenance time available. In fact, they were so thrilled they suggested that we lay off part of the maintenance work force! My answer was NO, NO and NO! Instead, we addressed safety, environmental and production issues, developed a PM program, rebuilt equipment for future use and organized the equipment parts warehouse in one location. With the extra time, we started to change the design of some existing equipment, and even designed our own equipment. For instance, one piece of equipment we changed was the bottleneck of production. This machine had a cycle time of 45 seconds, so we changed the design slightly, and the cycle time went to four seconds, which increased the product output dramatically.

It may sound simple, but it's not; there is a constant struggle to focus maintenance on taking care of *existing* equipment first. No "M" until the "R" and "P" were completed. With the support from all the different departments and maintenance, we were able to achieve great changes in safety, performance, and product quality.

Make no mistake; people made this happen, not a computer software program. The main problem was that maintenance people lost on the average about $8000 per year in overtime, and some almost their job!

One hell of a reward system for turning a plant around.

4 Equipment Identification

4.1 Purpose of an Equipment Number
4.2 Elements of the Equipment ID
4.3 The Equipment ID
4.4 Equipment Hierarchy
4.5 Maintenance ID

"The main reason for Equipment identification… safety. If operations opens valve "XX" or maintenance works on valve "XX" everyone in the plant knows it.

Fred J. Weber

4.1 Purpose of the Equipment Identification

The Equipment Identification goes by many names such as equipment tag, equipment name, equipment label, equipment number or asset number. In industry, the equipment identification structure can be associated with the plant's Cost Center, Plant Area, or Equipment Class. The problem is that an equipment identification is generated by the engineering, computer/software or accounting departments, with little involvement from maintenance.

Equipment identification is the common label used by all plant personnel to identify a particular piece of equipment in the plant. In a small plant, the label could be something as simple as "compressor", "Big press" or "That @%&# conveyor". As an organization grows, the need for an Equipment Identification system becomes a requirement.

The equipment identification can be used as the common link to everything:

- Safety procedures (tagging and lockout procedures)
- OSHA, EPA or other regulatory agency reporting requirements
- Engineering (piping and instrumentation, electrical, mechanical drawings)
- Maintenance (work order, preventive / predictive maintenance, equipment history)
- Material management (inventory, warehouse, purchasing)
- Operations SOP (standard operating procedures)
- Accounting (equipment depreciation and budgets)

However, the main reason for Equipment identification is for the safety of operations and maintenance personnel. If operations opens Valve "XX", everyone in the plant knows where Valve "XX" is, and its function. If maintenance is asked to repair pump "YY", calibrate pressure switch "ZZ" or test motor "ABC", everyone in the plant is speaking the same equipment language.

What equipment should be identified? It would be impossible to identify each piece of equipment in your plant but a good starting point is equipment that requires:

- repair, rebuilding or replacement (Fix pump #2)
- preventive / predictive maintenance
  (Lube conveyor #001)
- any tagging and lock-out procedures
  (Close valve #45? Open breaker #XYZ?)
- maintaining records for OSHA, EPA or regulatory agency
  (Inspection report for hoist #99?)
- inventory/warehouse/purchasing of equipment parts
  (Need parts for pump #ZYX)
- operation by plant personnel
  (Start press #21B)
- an equipment history
  (Maintenance cost for conveyor #001)

While an infinite number of methods exist, one approach to developing an equipment identification system is using the company asset hierarchy. Start from the top down, largest part (the entire company) to the smallest component (inboard bearing to wastewater pump #1). Four elements are required to build equipment identification (Equipment ID):

- Plant / Unit number
- System abbreviation
- Equipment type
- Equipment number and/or letter

The rest of this module is a discussion on how to build an equipment database. While a computer is NOT required to construct an equipment / maintenance database (and I prefer using the maintenance foreman's filing cabinet), it *is* the 21st century. So, CMMS screens were constructed to explain some of points throughout the rest of this book.

4.2 Elements of the Equipment ID

Using "**Plant** - System- Type - Number/letter" format, the Plant ID is the first part of our equipment identification. The Plant ID should be a number from 1 - 99 representing the different plants, units or other major complexes in your organization. Let's say your company has two plants, one plant in Chicago and the second in Orlando. The second plant would have a Plant ID of "2".

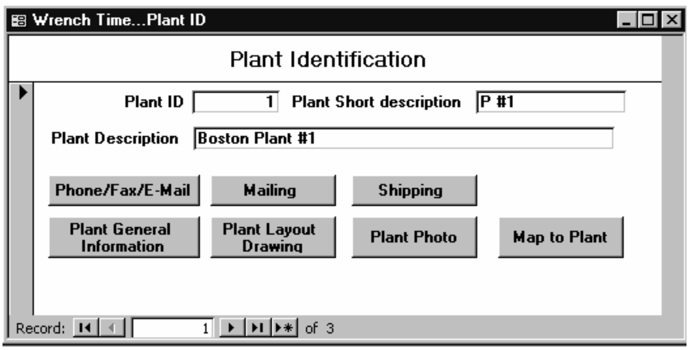


Figure 4.2a Plant ID

We used "Plant" for our first ID but depending on your industry, it could be:

Unit or station… used in the power industry
Factory…used in manufacturing
Facility…used in government or service industry

System ID

The next part of our equipment ID is the System ID (Plant – **System** - Type - Number/letter). For the System ID we will use a two-letter abbreviation. To define a system, we will use Webster again: "a set or arrangement of things so related or connected as to a unity."

Now, a *System* as defined by *Weber*: A group of devices connected together that is:

- designed under the same engineering codes (i.e. fire protection, service water, etc.)
- taking a product from one location to another (i.e. chilled water, compressed air)
- modifying a product and moving it to another storage location (i.e. paint system, widget assembly line, etc.)
- transferring or modifying a media from one location to another (air, water or solid to turbine, boiler, water treatment, ball mill, etc.)

A system can be considered one piece of equipment such as an extrusion press, grinding mill, or boiler feed pump. Some equipment is so large or complicated that it requires being separated into several systems, such as a boiler, turbine, or printing press. See the examples below…

Wrench Time...System Identification

System Identification

Systen	Short Description	Long Description	System Vendor
CA	Control Air	Control air system	Kaeser
CF	Chemical (Acid)	Chemical feed system	Nalco
FP	Fire protect	Fire protecton system	First Alert
HV	AC control	Air condition & heating controls	Honeywell
SW	Service water	Service water system	Orange County Construction
WW	Waste water	Waste water treatment system	US Filter

Record: 1 of 6

Figure 4.2b System ID

Equipment Type

The third element of the equipment ID is the equipment Type (Plant – System - **TYPE**-Number/Letter”). The equipment type is a three-letter abbreviation representing the type of equipment. For example:

Wrench Time ...Type Identification

Equipment Type ID

Type ID	Type Short Des.	Type Description
ALL	All eq'pt	All equipment
AVB	Air btfy valve	Air operated butterfly valve
BRK	Breaker	Electric breaker
CPL	Coupling	Rotating coupling
FLS	Flow sw.	Flow switch
HMR	Hyd. Motor	Hydraulic motor
LVT	Level Trnsmit	Level Transmitter
MTR	Motor	Electric motor
MVG	Mtr gate valve	Motor operated gate valve
PIP	Piping	Piping
PLC	Prog. Cntrller	Programmable Logic Controller
PMP	Pump	Pump
PRS	Pressure sw.	Pressure switch
SOL	Solenoid	Electric solenoid
SWG	Switch gear	Switch gear
TNK	Tank	Tank
VLB	Btfy valve	Manual operated butterfly valve
VLG	Gate valve	Manual operated gate valve

Record: 1 of 18

Figure 4.2c Equipment Type ID

So, what equipment should be in our type list? Remember what we said earlier, any equipment that is to undergo repair, preventive maintenance, operation, etc.

Equipment Number and Letter

Lastly (Plant – System - Type- **NUMBER/LETTER**), the Equipment Number & Letter is the numerical / alphabetic identifier is used to distinguish between two identical parts in the same system. The Equipment Number should be three-digit number, between 001 and 999. The three-digit number is used to allow a maximum of 999 of the same types for a particular system.

Example… 1-WW-PMP-001 to 1-WW-PMP-999

Equipment Letter should be from A to Z. The letter used in conjunction with a number can sometimes be used to disguise equipment relative to plant direction. For instance, with pumps 1-WW-PMP-003A and 1-WW-PMP-003B, the "A" may be used for the north pump and "B" used for the south pump.

4.3 The Equipment ID

We have established that the equipment ID is a unique identifier used to label a particular piece of equipment in your plant. In fact, the equipment ID becomes focal point of any information associated with a particular piece of equipment. If maintenance is working on pump 2-WW-PMP-001, they require "EASY" access to all information related to the pump. Whether the information is found in the maintenance foreman's filing cabinet or imbedded in fancy computer software, it must be accessible and complete. Everything about the Unit 2 wastewater pump should be in one folder (drawings, old purchase orders, work orders and service manuals). In short, any information associated with a piece of equipment.

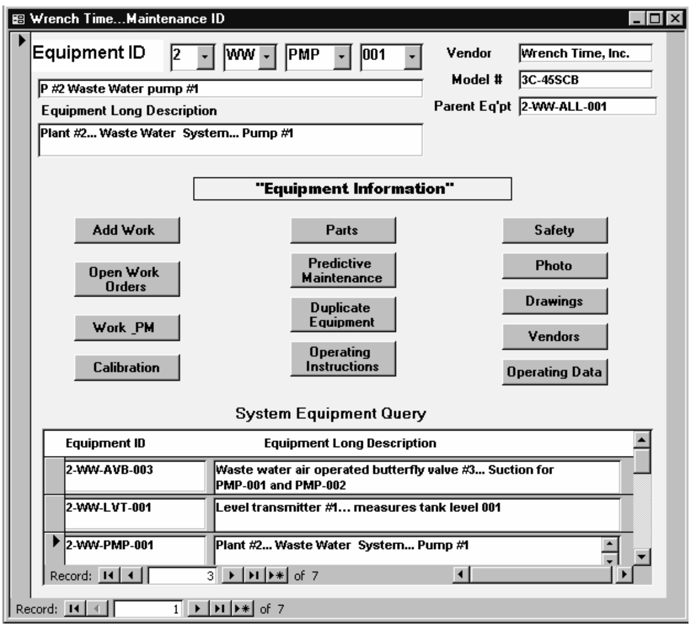


Figure 4.3 Equipment ID

Examples of some information may include:

- Parts (list of parts with inventory number and manufacturing number)
- Add / Review Open Work Order (ability to add work order)
- PM Tasks (list of all tasks associated with equipment)
- Calibration (testing procedures and settings)
- Manufacture's Equipment Data (all information required to purchase a new one)
- Predictive Maintenance (review all vibration, oil analysis)
- Duplicate Equipment (display of identical equipment)
- Operating Instructions (standard operating procedures)
- Operating Data (records of operating parameters, pressures, temperatures, etc.)
- Safety (information about lockout, welding, MSDS, inspection reports, etc.)
- Equipment History (work orders labor and material cost)
- Photos (pictures of equipment and location)
- Drawings (all drawings related to the equipment)
- Vendors (list of equipment parts suppliers)
- Purchase Orders (any POs associated with equipment)

When identifying equipment, keep the ID number as short as possible. If you maintain a small plant, you may not have to use the unit number or system code. Therefore, our example above (2-WW-PMP-001) could be reduced to P-01, but just be sure the numbering system is big enough for plant expansion. Also, use an ID that has some meaning. In our example, we used PMP for pump, PRT for pressure transmitter and WW for the wastewater system. The equipment identification system should be designed for maintenance and operations, so make sure your system doesn't require a special equipment decoder ring to figure out the plant equipment! Finally, be consistent. If you start building your database with the System ID as two letters, then keep it two letters. Reference equipment abbreviations can be obtained from your engineering department or books on process design.

4.4 Equipment Hierarchy

The equipment hierarchy is the "parent - child relationship" used to show how a particular piece of equipment is associated to other equipment in your organization. The building blocks used to develop the equipment relationship? It's the Equipment ID.

Start to build an equipment hierarchy by building your Equipment ID. First, identify a Plant ID for each plant in your company. Again, assume you have two plants, one in Chicago and the other in Orlando.

Next, define the different systems (System ID) in your Orlando plant. Assume your Orlando Plant has three systems to define: Wastewater, Control Air, and Heating & Ventilation. Use a Plant ID #2 for the Orlando plant, and then develop three Equipment IDs for each system:

- Wastewater system will be 2-WW-ALL-001
- Control air system will be 2-CA-ALL-001
- Heating & Ventilation will be 2-HV-ALL-001

Review the equipment ID for the Wastewater System. The "2" is the plant ID, "WW" is the system ID, "ALL" is the type ID representing all the equipment associated in the system and "001" the system number. Therefore, "2-WW-ALL-001" is the parent equipment ID for all equipment associated with the Wastewater System.

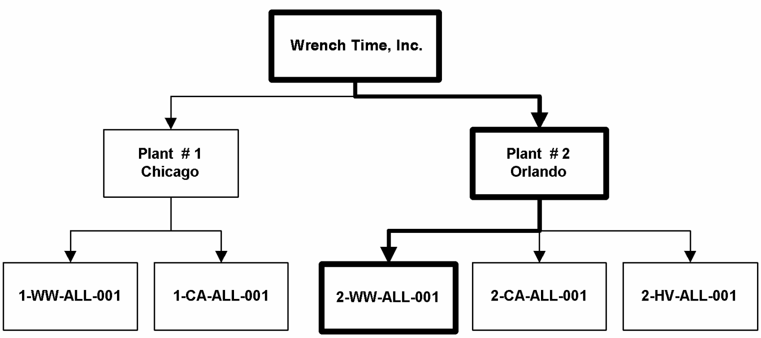


Figure 4.4a System Hierarchy

The next step is to show the parent - child relationship of equipment in each system. Start by selecting one system in your plant. Next develop an updated drawing of the system process (i.e. piping and instrument drawing (P&ID) or process drawing). This drawing or drawings should show all plant equipment and instrumentation. Label all equipment on the drawing:

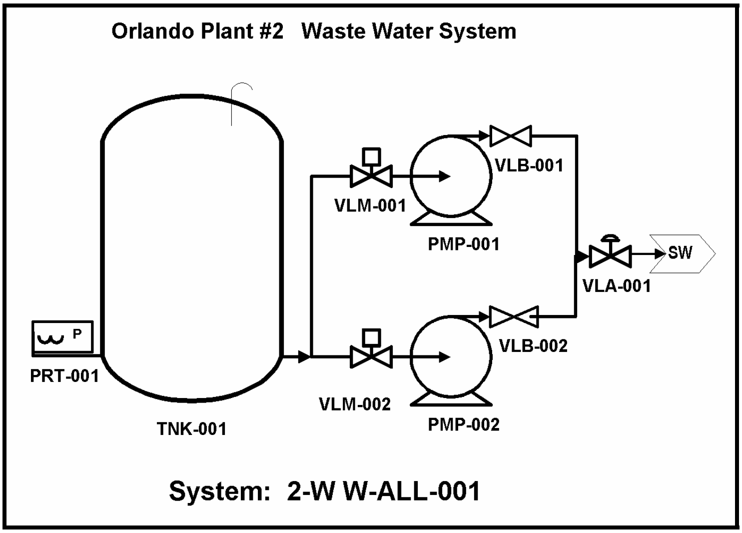


Figure 4.4b Process Diagram…P&ID

Build an equipment ID for each item defined on the drawing. For an example, we'll build the equipment ID for pump #1. Assume we are looking at the Orlando plant's waste water system. The Plant ID for this example is number "2", the System ID for our pump is located in the waste water system "WW". The Type ID represents the equipment type for a pump ("PMP" in our example). Notice, we have two pumps in the system, with one pump number "001' and the other "002". The first pump has an Equipment ID of 2-WW-PMP-001, while the second is 2-WW-PMP-002. Other numbers include those for the tank (2-WW-TNK-001) and the pressure transmitter (2-WW-PRT-001).

One problem you may encounter is that it's virtually impossible to build an equipment ID for every piece of equipment in your plant. Also, it probably wouldn't make any sense to have an equipment ID on something that was fixed once in twenty years. Therefore, "2-WW-ALL-001" can be used when work is done on the Wastewater System's equipment *without* an Equipment ID. Let's say you have an "R" type work order for a damaged drain pipe in the waste water system, and no equipment ID is defined for the piping. You could use 2-WW-ALL-001, and all repair costs will be charged to the Wastewater System. With the new changes, the Equipment Hierarchy starts to grow:

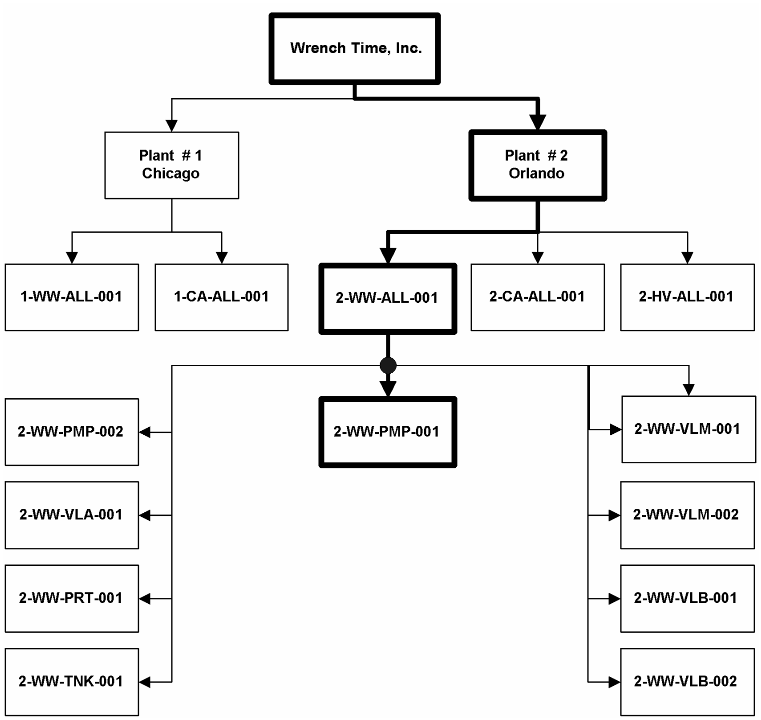


Figure 4.4c Equipment Hierarchy

Developing the Equipment ID for New Equipment

Common questions that sometimes arise in this system are “How do we identify new equipment in the plant?”, and “How do we label equipment common to more than one plant?” Two approaches can be used, but select one method and be consistent. Assume your Plant #1 was built in seven years ago, and at the time required two waste water pumps (1-WW-PMP-001 and 1-WW-PMP-002). In August of 1998 a second facility, Plant #2, was constructed adjacent to Plant #1. The design of Plant #2 required one additional wastewater pump to be installed next to pumps 1-WW-PMP-001 and 1-WW-PMP-002. The question is "What is the new waste water pump Equipment ID?"

The first numbering approach you may use is to identify the new pump using the installation date for labeling equipment. Equipment designed and built for Plant #1 would have a Plant ID = 1, while equipment designed and built for Plant #2 would have a Plant ID = 2. Contractors typically do this to prevent confusion between the two Plants for design and construction purposes. Therefore, with the first two pumps for Plant #1 labeled 1-WW-PMP-001 and 002, the new pump installed could be labeled 2-WW-PMP-001 or 2-WW-PMP-003. The three pumps sitting next to each other would be labeled 1-WW-PMP-001, 1-WW-PMP-002, and 2-WW-PMP-001.

The second possible approach is based on… location, location, location. With all three pumps physically next to each other, the additional third pump would be labeled 1-WW-PMP-003. Even though the third pump was installed at a different time, the three pumps would be labeled **1**-WW-PMP-001, **1**-WW-PMP-002, and **1**-WW-PMP-003. Again, the choice is yours.

4.5 Maintenance ID

One purpose of the Equipment ID was to provide a maintenance accounting system to track costs (i.e. parts and labor) associated with a piece of equipment, a system and/or a plant. The problem is that maintenance just doesn't maintain *equipment*. Due to maintenance flexibility, a lot of their time is spent on supporting functions not associated to equipment ID. For instance, planning, purchasing parts, operating equipment, engineering, or construction are all functions performed by some maintenance departments. There are also other non-maintenance activities to deal with, such as sick time, vacation, safety and training. To understand maintenance performance, you need to establish ONE type of maintenance accounting center:

"Maintenance ID"

The Maintenance ID is an expansion of the Equipment ID format to cover ALL maintenance activities. This is accomplished by simply using different System IDs (such as "AD" for "Administration, "SF" for "Safety Classes or "TR" for Training).

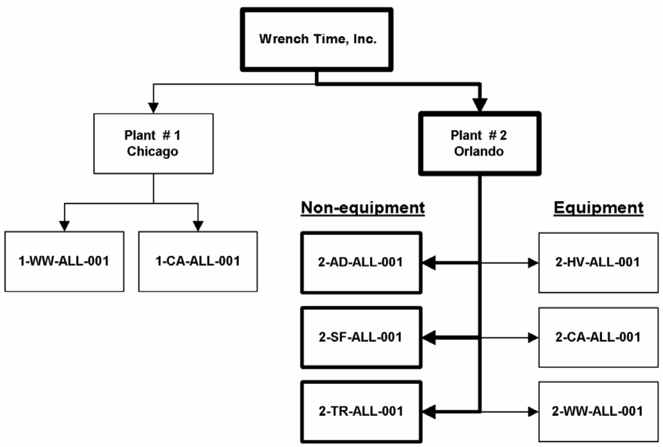


Figure 4.5 Maintenance ID Hierarchy

The Maintenance ID is also the "catch all" for any maintenance activities (i.e. equipment repair, training, operating or etc.). Here are some suggestions using the Maintenance ID. When performing various Administrative Duties, use 2-AD-ALL-001 (all administrative time), use 2-AD-ALL-002 for Sick Time, and 2-AD-ALL-003 for Vacation Time. While training time can be 2-TR-ALL-001 (for all training time), you may choose to use 2-TR-ALL-002 for forklift training and 2-TR-ALL-003 for HVAC training. Finally, all safety related training classes could be 2-SF-ALL-001, with 2-SF-ALL-002 for respiratory training and 2-SF-ALL-003 used for job hazard awareness.

An applied example using the Maintenance ID would be if your maintenance staff is required to take a respiratory training class. Simply write a work order for annual respiratory training (WO #012345) using the Maintenance ID: 2-SF-ALL-002…Respiratory training. Anyone taking this safety class will charge their time to this work order number and Maintenance ID. At the end of the year, you can answer questions like "Who went to the respiratory safety training?" and "What did this safety class cost?"

Maintenance now has a user-friendly accounting number system that allows easy tracking of labor and material. Simply using a work order number and the Maintenance ID allows you to track all maintenance activities in *ONE* type of accounting format. Using the Maintenance ID removes the line items like "Other" or "Misc." in your maintenance budget and expenses.

NOTE: At this point, one final step you may consider is to sit down with your accounting department to tie the Maintenance ID to the correct accounting cost center for tax benefits!

5 Parts

"Maintenance department's goal…
To build a spare plant in your warehouse, one piece at a time!"
Fred J. Weber

5.1 Equipment Part ID

The Equipment Part ID is a unique maintenance part number on a particular piece of equipment. Simply defined, the Equipment Part ID is the Maintenance ID *plus* a Part Number. The Equipment Part ID gives the maintenance personnel a tool that will easily:

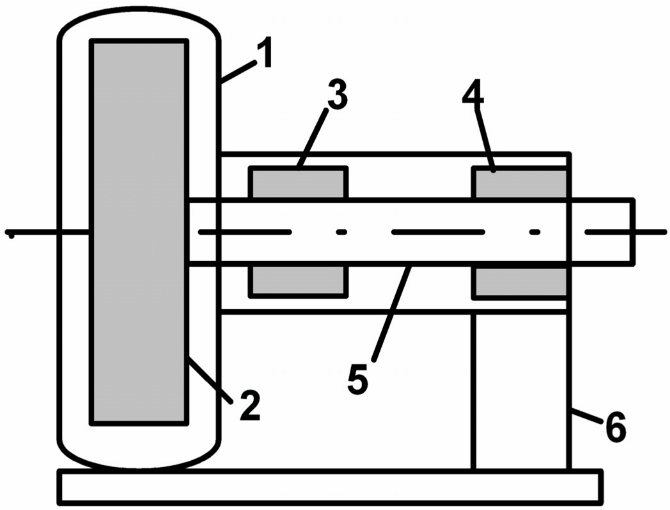
- identify a part for a piece of equipment.
- build a BOM (bill of material).
- separate maintenance parts from general and production inventory.
- analyze the equipment component history.

If you remember the numbering system “plant-system-type-number/letter-PART”, you see that the Equipment Part ID is constructed by adding " PART", a 4-digit number (0000 to 9999), to the Maintenance ID (or any equipment number). The purpose of the Equipment Part ID is to link the equipment’s number to a manufacturer and inventory part numbers. For example, a pump in your plant could be labeled "2-WW-PMP-001". Looking at the manufacturer cross sectional drawing for this pump may show item 3 as the inboard bearing. By applying our system, the Equipment Part ID for that particular inboard bearing becomes "2-WW-PMP-001-1003".

Let’s assume you are not using the Maintenance ID format, and have a pump labeled “Pump 1” in your plant. Identifying item 3 as the inboard bearing for this pump, the Equipment Part ID for the pump's bearing is “Pump 1-1003”.

The best way to show how the Equipment Part ID ties to a manufacturer’s cross-sectional drawing and parts list is with an example.

Below is an example of a pump cross-sectional drawing, detailed parts list and related Equipment Part ID.



Quantity	Part Description	Manufacturer #	Equipment Part ID
1	Pump Housing	WT-230-1	2-WW-PMP-001-1001
1	Impeller	WT-230-2	2-WW-PMP-001-1002
1	Inboard bearing	WT-230-3	2-WW-PMP-001-1003
1	Outboard bearing	WT-230-4	2-WW-PMP-001-1004
1	Shaft	WT-230-5	2-WW-PMP-001-1005
1	Pump frame	WT-230-6	2-WW-PMP-001-1006

Figure 5.1a Equipment Part ID

As mentioned earlier the Equipment Part ID is an extension of the Maintenance ID that simply expands the Equipment Hierarchy.

The equipment relationship is:

- Grandparent (Waste Water system… 2-WW-ALL-001)
- Parent (Pump… 2-WW-PMP-001)
- Children (All the Equipment Part IDs associated to the pump)

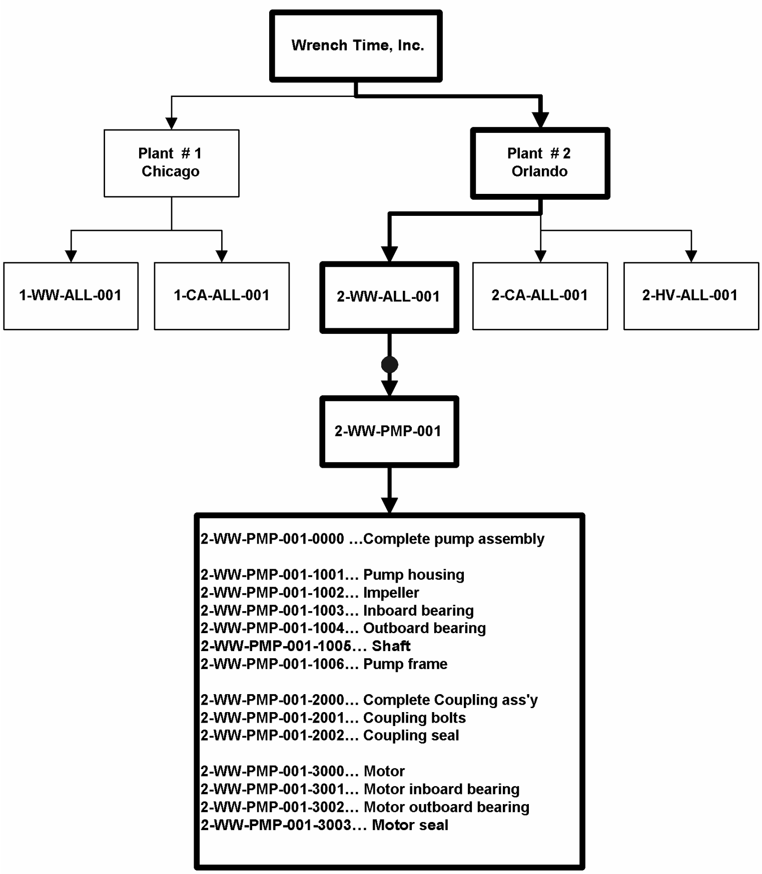


Figure 5.1b Equipment Part ID Hierarchy

Notice the "pump parts" contain coupling and motor parts because the coupling and motor don't have their own Maintenance ID.

If you elect to separate the pump, coupling, and motor, with individual Maintenance IDs, the equipment relationship would be:

- Grandparent (Waste water system… 2-WW-ALL-001)
- Parent (Pump… 2-WW-PMP-001), (Coupling… 2-WW-CLP-015)
- (Motor… 2-WW-MTR-015)
- Children (Associated Equipment Part ID)

With the motor and coupling as subassemblies of the pump, the hierarchy becomes:

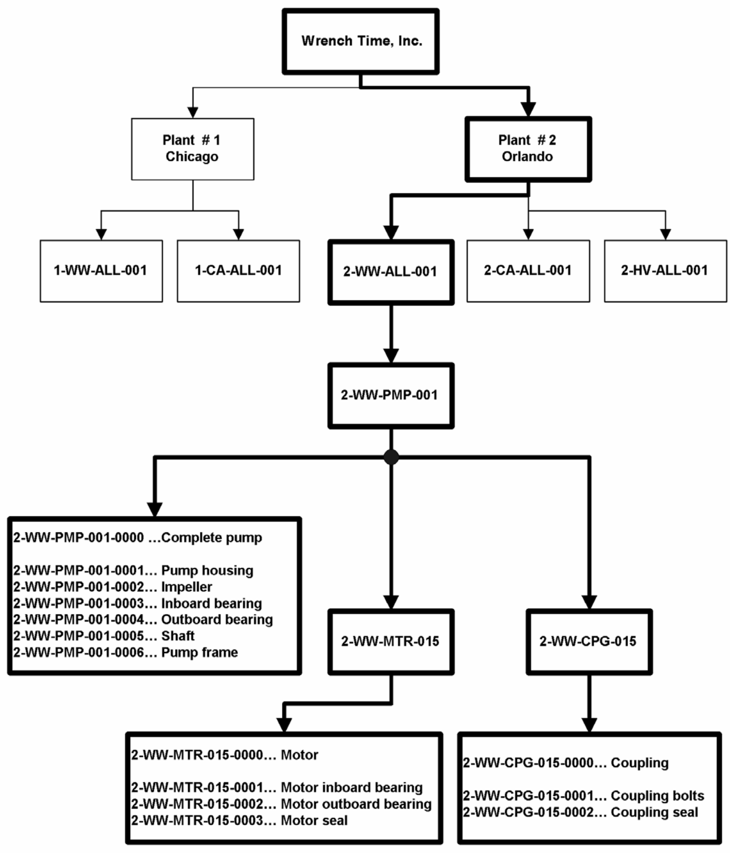


Figure 5.1c Equipment Part ID Hierarchy

Just as the Maintenance ID acts as the equipment "phone number", the Equipment Part ID plays the role of the phone number extension. While a phone extension can direct you to the person you are seeking, an Equipment Part ID connects maintenance to the parts they are seeking. A good place to start is to build equipment BOM (Bill of Materials) using Equipment Part ID, looking at both spare parts in the warehouse and past purchase orders for the equipment. It is impossible to have an Equipment Part ID on every nut and bolt in the plant. Your goal is to have an Equipment Part ID on every equipment part stored, used by maintenance, and referenced to an equipment cross-section drawing.

While it may seem that building Equipment Part ID is just more work for maintenance, in fact it may be the tool you need to organize equipment parts. Throughout the rest of the book we will be discussing the benefits of the Equipment Part ID.

5.2 Part Identification

Managing equipment parts plays a key role in the success of maintenance performance. One of the main functions of material management (Warehouse, Purchasing, & Inventory Control) is to order, label, and store parts for maintenance. The Equipment Part ID becomes the catalyst that ties maintenance and material management together. Therefore, any equipment part stored or purchased should have three numbers associated with it: the Equipment Part ID, the Inventory ID, and the Manufacturer ID.

Why another number? Because the Equipment Part ID gives maintenance the one thing it requires from a part number… uniqueness! The table below shows the some characteristics of each ID.

	Equipment Part ID	Inventory ID	Manufacturer ID
Owner	Owner…Maintenance	Material Management	Bearing Manufacturer
Typical Part number	2-WW-PMP-002-1003	BRGB0389	Wrench Time Inc. #569-334
Number of parts	UNIQUE…one of a kind	Used in several locations in the company	Used worldwide
Operating parameters	Bearing temp = 155°F Vibration = .12 mils Current = 35 amps Use in wastewater	Sitting on warehouse shelf collecting dust	Sitting in the manufacturer's warehouse collecting dust
Maintenance parameters	Lubrication…EP2 PM every 4 weeks	Supplied by three vendors	Depends on application
Bearing history	Replaced 4/7/99 By D. Stevens Replaced 3/5/97 By J. Rollins	Eight used last year	Shipped 200 yesterday

Table 5.2a Equipment Part ID Comparison

From the table above, we can see that a bearing has a different meaning to different people.

The following is a brief discussion on each group's numbering system and how they can change to help maintenance.

The Equipment Part ID was developed for one purpose, to be unique and one of a kind. There is only one inboard bearing on wastewater pump #2 located at your Orlando Plant #2 in the world. This inboard bearing maybe used in 25 pumps and 4 fans throughout the plant, but there is only one "2-WW-PMP-002-1003." Another example of how the Equipment Part ID shows uniqueness is the comparison of the Equipment Part ID to the Inventory ID for a level transmitter used in the wastewater system. Equipment Part ID 2-WW-LTR-002-0000 is located in the wastewater system. It has an operating history and a detailed calibration sheet. On the other hand, Inventory ID # TRMT0345 is located in the warehouse. Same piece, different meanings.

The Inventory ID is a number assigned by Material management to identify parts in the warehouse. This number may have more than one application in your plant, and may also have multiple suppliers. Material management typically bases their parts numbering system by location, cost center, or area. The problem is that the Inventory ID doesn't assist Maintenance personnel in identifying parts. The Inventory ID should be another tool for maintenance to identify parts. Try to remember that a good Inventory ID is made up of the part type (such as SEAL, PUMP, BRGR, etc.) plus a unique number (0000 – 9999). A good example of a helpful Inventory ID would be a roller bearing with an ID of *BRGR0023.*

Further benefit can be seen by looking at the part numbers for the pump's inboard bearing: Equipment Part ID…2-WW-PMP-002-1003 and Inventory ID…BRGR0023. With this information, we have identified a bearing for wastewater pump #2, which is located in Plant 2. Also, remember that this method can be used for other parts as well. For instance, if a mechanic needs a 1/2" x 1" stainless bolt, he would get BOLT5355.

The Manufacturer ID is the number Purchasing must use to be able to order the part from a manufacturer or distributor. Just like the Inventory ID, the Manufacturing ID should use some equipment type in their part number, such as BRG for a bearing.

With all the time wasted by maintenance looking for parts and the inexpensive technology available today, there is no excuse for not supplying maintenance an easy method to search for parts based on the Equipment Part ID, Inventory ID, and Manufacturer ID:

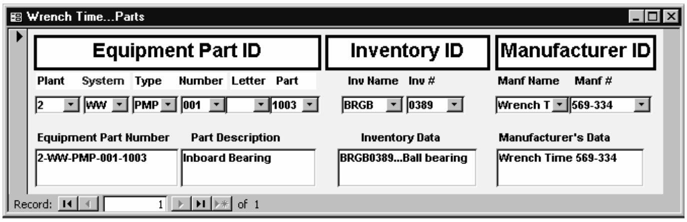


Figure 5.2b Equipment Part ID Display

The benefits in using an Equipment Part ID and an Inventory ID for the equipment Bill of Material, parts search, and storing parts in inventory are obvious. Just keep in mind the scenario when one Inventory ID part is used on more than one piece of equipment. Assume that we have a bearing for Assembly conveyor #2 and it is used on conveyor # 3, 4, 5 and 6. Would you store parts for each conveyor? No. Store all parts in the lowest Maintenance ID number. For example, the bearing labeled "1-AS-CNV-002-0012" and "BRGB0212" would be stored at the 1-AS-CVN-002 location. Reference would be documented for use on conveyor 3, 4, 5 and 6. The bearing "BRGB0212" is the same for all five conveyors. If you are replacing the bearing on conveyor #5 during maintenance, then use the correct Equipment Part ID 1-AS-CVN-005-0012 to track equipment history. Sometimes parts are used in different systems. If the cost is minimal, stock one for each system. If the cost cannot be justified, make sure you cross reference to the other system and Equipment Part ID.

5.3 Warehouse Layout

Consider this…do you remember the first time you walked down the aisles at your local home improvement store (Home Depot, Lowe's, etc.)? Chances are you were amazed at how huge the signs were in the well-marked aisles. You probably marveled at the enormous amount of material contained in each aisle, and the ease of accessibility. You thought that anyone could find parts in a place like this. In fact, you wished your warehouse at work looked like this place. Good news… IT CAN!

First, material management must realize that they are storing the parts for maintenance. So why not make it maintenance friendly? First, test your existing warehouse system. Have a maintenance person ask the warehouse clerk for a bearing on any piece of equipment. Warehouse response: "Do you have the inventory number?" Maintenance response: "NO". Who does the leg work to find the inventory number? Maintenance. Who cares? Just more reasons why work is not getting done.

Now, using the Maintenance ID and the Equipment Part ID to label equipment and parts, establish a common link between maintenance and the warehouse. Imagine a mechanic needs parts on Plant # 2's wastewater pump he goes to one location in the warehouse with an illuminated sign.

"WW"…Wastewater System

One of the shelves has a sign labeled:

"2-WW-PMP-001"

Sitting on the shelf is a pump bearing labeled

"2-WW-PMP-001-1003" and "BRGR0023"

Arrange the warehouse so that anybody walking through Equipment Parts Area can pick up any part and know what equipment uses it. Material management must remind themselves that "I'm storing the parts for maintenance".

The easiest way to organize the warehouse is to establish a team responsible for the warehouse layout. This group should include maintenance and warehousing personnel. Next, take a sheet of paper and define a warehouse area just for equipment parts. Divide the area to represent each system in your plant. Here are a few things to consider in your layout:

- Keep similar systems together (for instance, the coal and limestone equipment have similar conveyor parts, so they would be placed adjacent to each other)
- Layout area size should be based on approximate spare mechanical parts requirement for each system (mechanical components take most of the warehouse space)
- Obtain a cross-sectional drawing for each piece of equipment, and locate the drawing near the equipment parts (here's a tip - make it look like the filter books in an auto parts store)

You may not be using the Maintenance ID to label your equipment, but that's no excuse not to organize your warehouse based on the plant system ID. The plant I managed had no Maintenance ID, but we still stored ALL the parts for each system in ONE location. Within that system, we stored the parts for each piece of equipment. You may decide to store all of the compress air system's parts under your desk. That's fine. At least maintenance now knows where to go to look for compressor parts!

Example of a warehouse layout for a small manufacturing plant with three systems:

- Packaging (PK)
- Assembly (AS)
- Facility (FC)
- Tool Room
- Consumables
- Chemical Storage
- Electronic and instrumentation

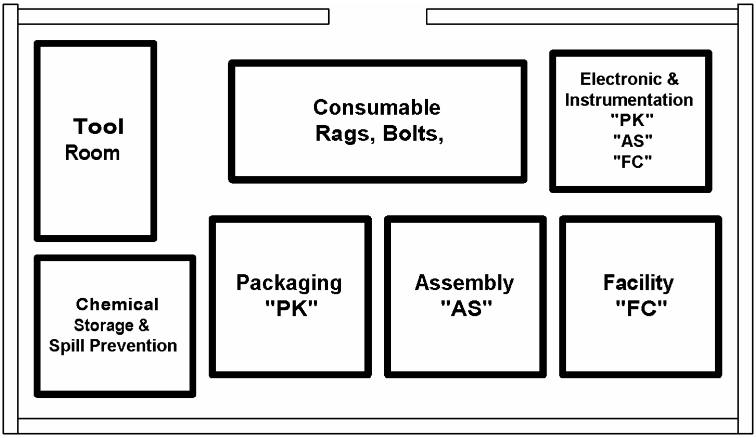


Figure 5.3a Warehouse layout

Next, place BIG signs down each aisle to represent each system. Label each rack (Packaging - PK, Assembly – AS, and Facility – FC), label shelves and/or cabinets with Maintenance ID, and label each part with the Equipment Part ID and Inventory ID.

To recap the process, a bearing for Conveyor #2 on the Assembly line would be located as follows:

- Down the system aisle labeled "ASSEMBLY"
- On the shelf labeled "1-AS-CNV-002"
- As reference, a drawing of the conveyor is located on the cabinet door
- Laying on the shelf, two bearings labeled "1-AS-CNV-002-0012" and "BRGR00123"

The benefit to this type of warehouse layout is that maintenance personnel responsible for the Assembly system can view all of the parts in a matter of seconds. In addition, maintenance would stop hiding parts if they knew the parts would be in one area of the warehouse.

As you layout your warehouse, consider the type of parts in the layout:

Safety Information area: This area should include equipment to handle chemicals and other hazardous materials. Post the MSDS sheet, emergency response procedure, and spill prevention information nearby for easy access in case of emergency. Lubrication and solvent containers should have warning labels and be stored in an area with spill containment. Add lighting with a motion sensor to increase visibility in low traffic areas.

Electronic Cards and Instrumentation area: Usually, this area needs the appropriate temperature, humidity and a dust free controlled environment. Protect the electronic components with static free packaging. Divide the area into specified equipment system locations ("WW", "CA", etc.). Store general electronic parts for plant wide usage by vendor name (i.e. Rosemount). Consider a separate Maintenance ID for DCS or PLC control system. A distributed control system (DCS) card could be labeled 1-DC-CRD-001-0112.

Consumables area: Nuts, bolts, gloves, batteries, rags, etc. need to be located near the front for easy access. Have a local vendor replenish the supply to prevent excess inventory.

Office Supplies area: Various supplies need to be located in a controlled area cabinet in an administration office. As with consumables, use a local vendor to replenish supply cabinets weekly to prevent excessive inventory.

Bone yard ("Discarded Equipment") area: Discarded equipment or scrap material should be stored in the *Bone Yard*, located outside the controlled warehouse environment. Just be careful when using equipment and parts from this area. Defective parts in this area may cause problems due to incorrect storage procedure or wear.

Rebuilt Parts area: Repaired equipment parts need to be stored in the warehouse. Establish a rebuild staging area near the warehouse. This area is setup for equipment that needs rebuilding but is waiting for manpower or parts to become available.

Satellite Storage areas: Maintenance storage areas are those little areas in the plant that maintenance keeps equipment parts and general supplies for the sake of convenience. Consumables like rags or sand paper at these various locations should be no problem. However, the parts I'm concerned with are the equipment parts, because they need to be stored in the warehouse.

Lastly, identify a **New Warehouse Goal…**
Separate Equipment parts from all other parts
Locate all equipment parts *without* a computer
Be able to go to one location, and only one, to find spare parts for your plant equipment.

Wrench Time Story…"A warehouse story!"

It started early one morning with only a half of cup of coffee in me, when one of the compressors failed and reduced plant capacity in half. Working on the problem with Bob and Dwayne (two technicians), we were able to identify the problem as a bad solenoid. Now the hunt for the solenoid began.

First, I turned to Bob (the lead technician) and asked him if we had a solenoid. His reply was "I think there is one in the tool room". We went to the tool room, but no solenoid. Dwayne turned to me and said "I think there was one on top of the compressor room." We went there and started sorting though all the junk and found two solenoids covered with 1" of dust. After testing the solenoids with an ohmmeter, we found both were bad. Bob then turn to me and said "I know I ordered one two months ago." One of the other technicians overheard us and said "Oh, I've got it in my toolbox. It came in last month when Bob was on vacation, so I threw it in my toolbox so it wouldn't get lost." The technician replaced the solenoid within minutes and we were back at full capacity. I turned to Bob and said, "This %&@# is coming to an end." I'm sure Bob understood that I only had a half of cup of coffee in me…

Later one afternoon I went to a local hardware store to pick-up some parts for the house. Standing there looking at the big signs and all the lights, I thought "why can't all the maintenance parts and tools be stored like this at our plant?" The first thing WE did was to find a small lay down area, which we borrowed from production near our shop. We laid down empty skids and containers. Next, we labeled and broke up the area into the following six sections: Facility, Shell, Assembly, Electronic, Rebuild and General Supplies.

Housecleaning was next. Over the next four weeks we sorted, threw out, labeled and located parts. We checked toolboxes, office file cabinets, under every desk, on the roof, and on top of the compressor room. Working on and off a couple hours a day, we had equipment parts, general supplies, and tools all sitting in ONE LOCATION.

When any piece of equipment went down, we went to one location to check for parts. If it wasn't there, it was ordered immediately. In the Rebuild area we determined what parts were required, ordered them, and then rebuilt the equipment. Once rebuilt, the equipment was placed in its correct area for future use. Later we purchased a mezzanine and some cabinets to free up some production space.

We had created the "House of Parts", which was now a one-stop parts shopping area for the maintenance folks!

5.4 Inventory and Spare Parts

Remember the Maintenance goal… to build a spare plant in the warehouse, one piece at a time. Maintenance is trying to stock every equipment part they may need until the day they retire. Excessive inventory is a major financial problem in companies today, but maintenance still finds ways to add parts to inventory one piece at a time. Earlier in this module we discussed how maintenance and material management could team up to play an active role in organizing and labeling maintenance parts. Well, their job is not done yet. First, we need to understand why maintenance stockpiles parts like a squirrel preparing for the winter. Here is a list of reasons:

Pressure from managers to keep equipment running. Every time a piece of equipment shuts down, management expects the equipment to be repaired immediately. If the part is not in the warehouse, maintenance will add the item to inventory to prevent future ass chewing.

Inventory cost is typically not a goal for maintenance, but keeping equipment running is. Here is an example of how maintenance inventory continues to grow, grow and grow. A piece of equipment has been running for 8 years. The oil seal starts to leak. Maintenance goes to the warehouse to find that there is no seal in inventory. They tell the warehouse to order two seals with a shelf life of three years. When the seals arrive, the mechanic uses one and places the other one in inventory. Multiply this times 1000 and you have a million dollar inventory of parts, with a few that are probably no good by the time you need them.

Using the inventory key indicators to manage equipment parts. Material management uses the term "inventory turn ratio" to monitor their inventory performance (remember that the inventory turn ratio is approximately equal to the number of parts used in a year *divided by* the number of parts in stock at the end of the year). According to material management, a higher inventory turn ratio, the better materials are managed in the warehouse.

Here is an example: Assume you are using 200,000 earplugs each year. At the end of 2001 the plant had 100,000 earplugs left in inventory, therefore, the inventory turn ratio equal to 2. Assume next year you only had 20,000 earplugs in inventory, the ratio equal to 10. The higher the inventory ratio, the less warehouse space and better cash flow.

The confusion begins when using the inventory turn ratio to monitor equipment parts performance. Here is an example of two inboard bearings used on different pumps.

Pump #1… 1-WW-PMP-001;
Bearing Equipment Part ID…1-WW-PMP-001-0123
Maintenance replaced 4 bearings last year and one is in stock (inventory ratio= 4).
Pump #2…1-WW-PMP-002:
Bearing Equipment Part ID…1-WW-PMP-002-0111
Used 0 bearings last year and has one in stock (inventory ratio= zero).

It's the opposite of stocked items; a high inventory ratio means equipment downtime, lost of production and high maintenance cost. Notice the conflict using the inventory turn ratio to monitor ALL inventory materials. Simply stated, any equipment part (Equipment Part ID) with an inventory ratio greater than zero should alarm management to ask, "What is it that caused that part failure?" It is fine to use a high inventory ratio to monitor earplugs, but for equipment parts (Equipment Part ID) it should be zero.

So, we have identified the reasons why parts are stockpiled, but what are the solutions to control material and reduce inventory?

I have a list of solutions (I know, another list. Stick with me…)

Hire a manager that doesn't over-react to equipment failure. Every time any manager complains about equipment failure, maintenance orders EVERY part possible part so they are prepared for the next failure. If management complains about a leaky faucet, there will be a purchase order for a new sink and faucet on the desk within the hour. Later that day you will also see a max/min form for two faucets to be placed in inventory.

Create a team goal. Use equipment inventory as the performance indicator. Tie the equipment inventory cost to maintenance performance by separating equipment parts from the rest of the inventory. Also, consider asking maintenance to remove something of equal value when they add a part to stock.

Develop a parts priority system. The RPM method should be utilized for maximum efficiency. Maintenance and material management must be in agreement about the same parts priority: repair, prevent and modify.

Reset the max / min on all equipment parts if needed. When the equipment is removed from the plant process, the associated equipment inventory should be removed and adjustments should be made to zero all max / min immediately. Example: Remove Pump 1-WW-PMP-001 from service.

Check cross-reference for a duplicate of the equipment. Remove parts 1-WW-PMP-001-0001 thru 1-WW-PMP-001-9999 from inventory. Sell the equipment to someone who still finds value in it. Note: Keep an eye on slow moving parts as maintenance solves equipment problems and resets min / max appropriately. Don't remove a part from the stock; instead, set the min/max to 0/0 because maintenance may need the part information in the future.

Establish the max/min with an annual limit. In addition to setting max / min of a stock part, establish an annual limit on the number of items purchased per year. For example: Management approves 6-ft. ladders to be a stock item, with a maximum of three and a minimum of one. When the ladder inventory drops to one, purchasing reorders two ladders. Of course, the problem comes at the end of the year when you realize that "someone" needed $10,000 worth of six-foot ladders in one year. Set annual limits such as eight ladders, or maybe an annual cost limit to $1000.

Require a signature to remove parts from warehouse. Consider when ANY part is removed from the warehouse, it must be signed for with a signature. It is amazing that people don't need as much inventory when they have to sign their name for it. They may need only one can of "Wrench Time Oil" instead of the entire case.

Create a material management system for the warehouse. You should create a material management system that separates equipment parts (by Equipment Part ID) from all other parts in the warehouse. The system should allow rebuilt equipment parts to be placed back into the warehouse as stock items. Material management has a hard time determining the value of rebuilt equipment, so the only thing they want to store are new parts. By separating rebuilds, you won't confuse your inventory….or your materials management folks!

Establish partnerships with local equipment vendors. Develop a working relationship with equipment and general supply distributors. I can't tell you the number of times equipment vendors have worked through holidays or hand carried parts to the plant to help me out. There is one requirement to establishing a good relationship with vendor, and that is your word. If you say it, then do it.

Get maintenance involved. Maintenance can help material management by developing a "Thinking of Tomorrow" mind set by reducing the number of ININ ("I need it now") type material requests. The maintenance department can take steps for controlling material and reducing inventory, such as:

- Finding problems early by using inspection and predictive maintenance techniques.

- Set high priority to rebuilding equipment using "R" type work order.
- Develop a planning department that can order parts when you need them, instead of having the parts in stock.
- Develop a root cause analysis to eliminate the main reason for parts being reordered, which is that they're failing.

Stock equipment parts that effect safety, environment and production of plant. From the earlier discussion on inventory control, it may sound like no parts are required to be kept in stock. Well that's not true. Spares are your insurance policy to ensure a safe and reliable operation. The problem is which equipment spares *do you* put into stock? I remember an ex-boss telling me "your equipment budget is $X dollar next year, so purchase only the equipment that is going to fail". My response was "I have a better chance of picking the winning lottery number than knowing what is was going to fail next year." In theory, you don't need any parts in the warehouse; planning and predictive maintenance is supposed to warn before you need them (*just-in-time* parts!). But the reality is that equipment fails, so spare equipment parts are required.
So the question becomes "What do we want to protect against? Maybe the question should be "If the equipment fails, what will happen?"

Personal injury - equipment failure becomes a potential personal health hazard. Example of this would be a dust collector failing and operators being exposed to contaminated air.

Violates Safety or Environmental Regulation - equipment failure causes a violation in a state or federal regulation. Example: you are required by the state to monitor and record gas emission every hour. Gas analyzer fails so you are unable to record emissions.

Loss of Production - equipment failure stops production. Example: if the plant equipment operates on air, when the compressor fails the plant shuts down. Along with each potential failure, management needs to know what is the overall effect or cost of the failure. With this guideline, look at each piece of equipment in the plant and identify the effect from a failure.

One method to do this with is a table as shown below.

Equipment	Personal Injury	Violates Safety or Env. Reg.	Loss of Production	Cost to Plant
1-WW-PMP-001		X	X	$200/hr
1-WW-MBV-012				Stops PMP-027
1-WW-PTR-002	X	X	X	**Priceless**

Table 5.4a Equipment Impact

It is obvious that any equipment marked in the first two columns "Personal Injury" or "Violates Safety or Environmental Regulation" needs to be on the top of your list of spare parts required. Next, locate the equipment that will stop production.

Stock only critical equipment parts. To determine what spare parts are required, maintenance should review equipment supplier recommendation, maintenance equipment history, system maintenance personnel, predictive maintenance data, and parts interface. The benefits for each source are listed below:

- Equipment supplier recommendation – most equipment suppliers will send a recommended spare parts list upon request. This list is generated by the vendor's history of a particular piece of equipment.
- Maintenance equipment history - review all work orders to locate parts purchase or removed from stock.
- Maintenance personnel – ask maintenance people who are assigned to the system because they know what and when they need it.
- Predictive maintenance – use equipment operating data to determine part life.
- Part Interface - Most wear occurs at the interface between moving and stationary components, such as the contact point between a seal and shaft. In addition, look for changes in direction, such as flow though a 90-degree pipefitting.

- Using this feedback from the different sources, review the BOM (bill of material) on the critical equipment and determine the spare parts required. Keep in mind in the total cost of spare parts on a piece of equipment. It may be more cost effective to just purchase the complete piece of equipment rather than the individual components. Also, consider the shelf life of items because you don't want to repair equipment with bad parts. Oh yeah - after buying all the spare parts you require, and if there is money left over from your maintenance budget, buy some tools that make life easier for your maintenance team!

5.5 Purchasing & Material Request

Any maintenance person's nightmare: purchasing parts. Purchasing parts is another big reason for maintenance to stockpile spare parts in the warehouse. Material management needs to realize that maintenance is not concerned about shipping, back orders, purchase orders, inventory numbers, etc. All they want is the part and they need it NOW.

To understand why maintenance would rather have parts in the warehouse is to look at the two ways maintenance can obtain parts.

If the parts are sitting in the warehouse:

- Mechanic / supervisor request parts
- Warehouse pulls parts
- Planning stages parts
- Mechanic installs parts

If the parts are NOT in the warehouse:

- Supervisor or planning generates a purchase request
- Management approves the purchase request
- Purchasing places the request at bottom of pile
- Purchasing request goes out for bid
- A purchase order is generated
- "Someone" (typically maintenance) expedites the part
- Warehouse receives the part
- Planning stages the part
- Mechanic installs the part

Now you can understand why Maintenance's goal is to build a spare plant in your warehouse, one piece at a time!

Storing every equipment spare part in the warehouse is not realistic or cost effective. Most problems are due to the lack of teamwork between purchasing and maintenance management. Purchasing a part will never be easier than having it in the warehouse, but several things can be changed to reduce the desire of maintenance to keep every part in stock.

Four things purchasing can do to reduce the pain:

- Purchasing Priority System
- Purchase Approval System
- "Thinking of Maintenance" Purchasing
- Purchasing/Maintenance Staff Requirement

Purchasing Priority System…Typically, maintenance and purchasing have two different priorities. Purchasing is using FIFO (first in first out) and maintenance uses ININ (I need it now). Maintenance needs to understand that purchasing has 1000 purchase requests with no priority, just as maintenance has 1000 work orders. Both departments end up going in different directions chasing the squeaky wheel. The reason for developing the RPM method was to focus maintenance on problem equipment. This same method should be used to put purchasing and warehouse on the same page. The material request supporting an "R" type work order needs to be on the top of purchasing pile. By adding the Equipment Part ID to the "R" request tells purchasing that this equipment part is critical and is required immediately by maintenance. Don't forget, we are asking maintenance to jump on problem equipment. Therefore, it is important that Purchasing orders these equipment parts with the same urgency as maintenance addresses them.

Purchase Approval System…. Most plants have upper management approve every purchase request due to company policy or internal audit. It's puzzling that you would allow a technician to work on a million-dollar piece of equipment, but you will not let him buy a $50.00 oil seal.

Test this in your plant: Give any work order number or cost center number to a third class mechanic. Ask him to go to the warehouse and remove a $3,000 item. No problem. Ask your best mechanic to get a purchase order for a $50 oil seal. Nope, no approval. One approach to help this is to develop a maintenance-planning department with the authorization to purchase parts using the RPM method, Equipment Part ID and a limiting maximum dollar approval. If the part has an Equipment Part ID, it's for a piece of existing equipment in the plant. Planning personnel would be able to order any Equipment Part ID part or material for:

- "R" type work order (up to $XXXX)
- "P" type work order (up to $XXXX)
- Management approved "M" type work order (up to $XXX)

Management approval should only be involved in:

- Major ("R" & "P") repairs and overhauls (above $ZZZZZ)
- "M" type work orders…modifications to equipment or wish list items

Once the priorities and approvals have been established, develop a material flow path in writing. A simple flow path teaches responsibilities and defines a procedure for any material request.

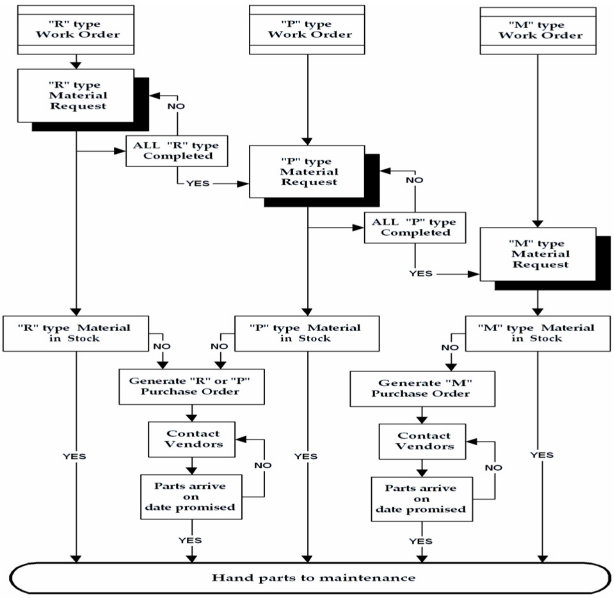


Figure 5.5 Material Request Flow Path

"Thinking of Maintenance" Purchasing…Design a purchase order and request form that is useful to maintenance, warehouse and purchasing. Remember that an equipment part you order today could be reordered by maintenance in the near future.
To make life easier the next time, the following items could be added to a typical purchase order:
Owner Information:

- Inventory ID number and description
- Equipment Part ID and description
- Requested by / approved by
- Requested Receive date (the date maintenance needs it in their hands)
- Work order type (RPM method) & Work order number
- Maintenance information (see info on purchasing new equipment below)

Vendor Information:

- Manufacturer ID number and part description
- Unit and total cost (include shipping to plant)
- Safety information (MSDS)
- Contract conditions (warranty, performance, etc.)
- Maintenance information (see info on purchasing new equipment below)

Think of maintenance when purchasing new equipment. Maintenance requires several things to be able to service this equipment in the future. Make sure the vendor supplies:

- Contacts for service and parts (name, phone, e-mail)
- Complete service manual
- List of recommended spare parts
- Cross-sectional drawing of assembly with parts lists
- Special tools to service equipment
- Detailed Drawings (electronics schematic, electrical wiring, hydraulic, pneumatic, piping and instrument, etc.)
- List of end users of equipment (minimum of 3)
- Software upgrades and new revisions for "X" years with back-up system

- Vendor supplied training classes (generic and on the specific to the particular piece of equipment you purchased)
- Computer information that includes logic drawings, I/O lay out, program with documentation and a back-up copy
- Warranty with parts and labor outlined
- Performance testing because most design problems are located by sound start-up practices. All I/O, logic and rated capacities are verified before releasing vendor responsibility. Two days of testing can solve thousands of hours of maintenance
- Field Service time for performance testing and owner training
- Maintenance agreements

This is the time to ask for it, not after you bought it. The vendor will sometimes supply some of these items at no charge.

Today we ask maintenance to work on equipment with very little information. You probably had more information to assemble your daughter's bicycle than a maintenance person has to troubleshoot your $3 million dollar extrusion press. However, as a manager, we still have the nerve to ask maintenance "What's taking so long?" Imagine some day you purchase a piece of equipment. In the mail arrives a CD, and on the CD are all the cross-sectional drawings with a complete parts reference, all the technical drawings, and a complete service manual. The parts list is compatible with your CMMS system and all you do is download and enter your Equipment ID data. Sorry, I was dreaming again….

One more…T*hink of maintenance when purchasing replacement parts and equipment.* Purchasing needs to be careful in adding the famous line "or equivalent" or using low bid price on the maintenance or engineering material request. There are several reasons why engineering and maintenance "sole source" a purchase request besides getting a free lunch or a calendar:

- Existing spare parts in your warehouse can be used on replacement equipment.

- Additional maintenance training maybe required if different vendor is selected.
- Maintenance and engineering usually pick reliable equipment that allows them to go home at night and to prevent phone calls at 2:00 am! Trust them.

Of course, it is possible that if engineering & maintenance approve a design change, an “equivalent” item could be used. However, unless it has previously been checked, don’t just assume its okay!

Purchasing/Maintenance staff requirement… Most companies use a centralized purchasing department to save money. If possible, one purchasing person should be located at each plant site to help expedite any parts required by maintenance. Centralized purchasing often doesn’t understand the urgency of a part, where a local purchasing agent would understand the urgency and the equipment. Most material requests created by maintenance have the legwork completed. They’ve talked to the vendor, identified the part required, and obtained pricing. All they need is a PO number.

Expediting Purchase Orders… Using the RPM method, we have management, maintenance and purchasing jumping through hoops to get a purchase order. Somewhere in your system, you need to have a person following up on this purchase order. In most plants, there is void between the time a purchase order is generated and the parts are received. Who in your organization contacts the vendor to insure the “parts receive” date is met? Typically, after a few weeks you hear, “where are the 2” bearings I ordered last week?” Management must assign this responsibility to one department and / or person.

This person should be on the same page as everyone else following the RPM method. If we are telling maintenance it’s important to repair equipment, then you had better be supporting them with the parts to do the job.

6 Work Order

"The only *Emergency* work order number is 911…
place *People* before equipment."
Fred J. Weber

6.1 Work Order System

A <u>*Work Order System*</u> is the flow path of a Work Order's information though your organization. This system is the communication tool between maintenance and the rest of the plant. Managing a work order system can be as simple as using a telephone and a pad of paper, or as complex as using a multi-million dollar Computer Maintenance Management System (CMMS).

No matter what system you select, every work order will go through the following four stages:

- Work Request (report equipment problem or ask for maintenance assistance)
- Work Plan (organizes and schedules work)
- Work Task (wrench time; actual labor and parts used)
- Work Summary (accumulation of information collected)

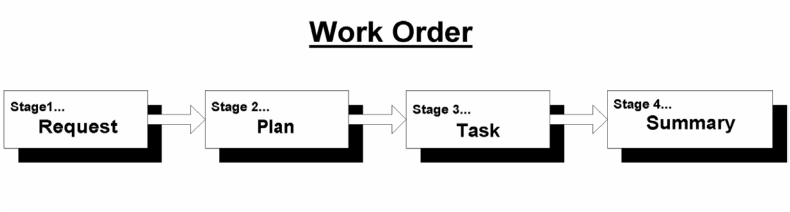


Figure 6.1a Work Order Stages

The first step in creating a work order system is to identify critical information required for the four stages of a work order. The work order information is the data your company requires from each maintenance job; what information is *required* in a work request before it's submitted to maintenance?

This data is collected during the Request, Plan, and Task stages of a work order. The Summary stage is the work order's information storage location to be used by maintenance or transferred to other departments. Technology has allowed us the capability to collect everything. Below is a list of information you could add to your work order.

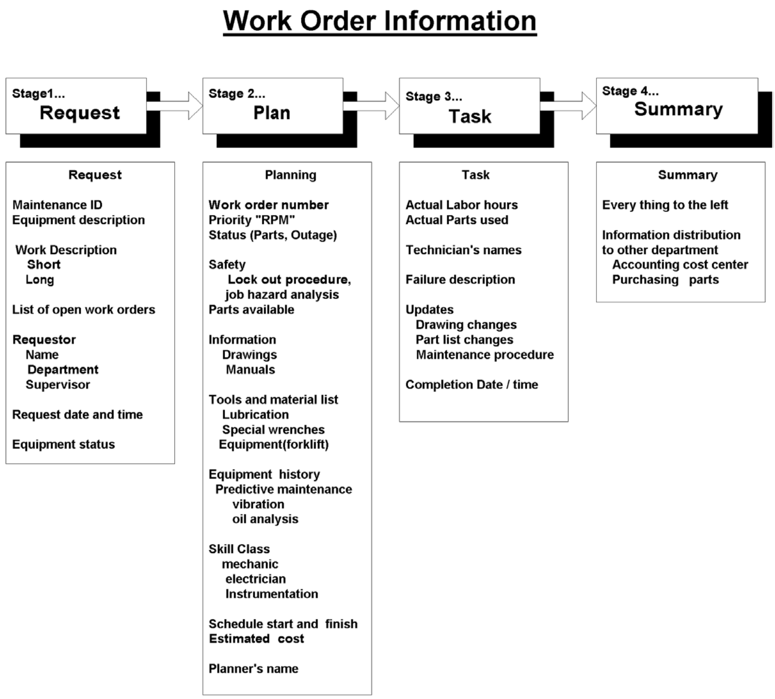


Figure 6.1b Work Order Information

Maintenance isn't the only one that needs information from a work order. Next check with each department and determine what information they require from a work order such as:

- Accounting… cost center
- Engineering… failure and repair description
- Operations…Lockout / tag out list, date entered, request name
- Safety… job hazard analysis, safety permits, OSHA reporting
- Environmental…EPA reports
- Purchasing / Warehouse…Equipment Part ID, manufacturer's name and number
- Maintenance… technician's name, equipment location
- Management…cost, cost and cost

With everybody's input, you've established a list of information required for your work order system. Before you finalize it, check for an information overload. One way to prevent an information overload is to define "Who enters the data?" and "Who needs the data?" from your work order Summary.

SUMMARY The information	**"Who needs the data?"**	**"Who enters the data?"**
Work order number	Everybody link to the job	System…sequential number
Description of work	Planning / Maintenance	Person requesting
Work priority "RPM"	Maintenance	Planning and Management
Work Status	Operation and Purchasing	Planning
Maintenance ID	Planning and Maintenance	Requestor and Planning
List of parts used	Warehouse	Maintenance and Planning
List of labor hours	Accounting	Maintenance and Planning
Cost	Management	Maintenance System
Failure description	Engineering???	Maintenance

Table 6.1c Work Order Data

Looking at the last item on the table above, we see that Engineering requests that each work order have a "Failure description". Who enters failure description? Maintenance does, which takes about 20 minutes per work order. With a 1000 work orders per year times 20 minutes, each work order equals 333 man-hours. How many pumps you can rebuild with an extra 333 man-hours? If Engineering uses the information to prevent say, 500 man-hours of maintenance work, you gain 167 man-hours a year. The question you need to ask, "Are they?" Alternatively, if the information ("failure description") is not on each work order, will someone react? Take the time to review each line item and make sure there is a benefit.

The work order flow path… Once the information for each stage of a work order is established, we need a flow path showing how the information is going to move from point "A" to point "B" though your organization. This work order "road map" describes who is responsible for entering the data and the method that the information is entered in a work order.

The flow path answers questions like:

How is a work request received? Paper, phone, e-mail or CMMS system

- Who receives the request? Clerk, supervisor, or planner
- Who prioritizes the request (i.e. RPM method)? Planner or supervisor
- Who plans the work, i.e. make the job safe and easy? Planner or supervisor
- Who enters the parts and labor data? Supervisor, planner, clerk or technician

Once you develop a flow path don't keep it a secret, tell everybody.

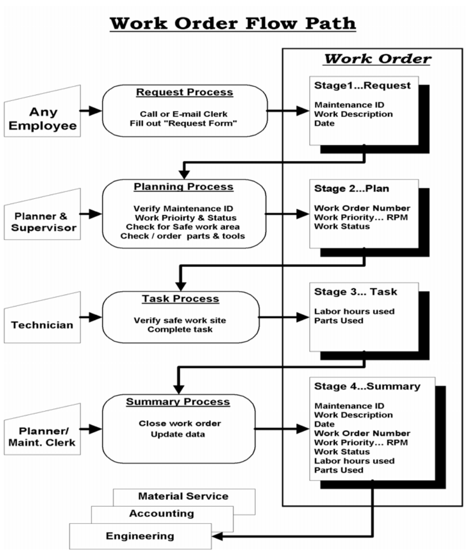


Figure 6.1d Work Order Flow Path

Goal of the Work order system… the time to manage the work order must take less time than the actual work on the equipment.

Wrench Time Story … "paper and pencil work order system." While managing maintenance (and before CMMS was popular), we used a paper and pencil work order system. The main reason we were able to do this was the lack of information required by Upper Management (i.e. my boss). Management's requirement was simple; keep the plant running, and charge all labor and material costs to one account number. The maintenance personnel's time sheets supplied the labor cost, while any purchase order or inventory part used from our division supplied the material cost. I know I was lucky; you don't have to tell me. Therefore, any Work Order System we developed was only used for maintenance. The lack of information required (and my dislike for generating paper work!) allowed our work order system to be simplified. Here is a brief a description of the work order system I used:

The Request process… First, *anyone* can write a work request. How can a work request be submitted to maintenance? Three different ways:

1. Filling out a Work request form or use any piece of paper with the following information: Name of requestor, equipment name and long work description. Place the request in the "IN" box outside of maintenance shop.
2. Call Bob anytime between 7am – 4pm.
3. Talk to line mechanic John "Assembly Line" or Dwayne " Container Line"

The Planning process… How are the work requests sorted? We used the RPM method (of course, I didn't know what it was called at the time!). Bob the lead technician kept three pads of paper marked "Repair", "Parts" and "Wish list" on his desk. Each work request the shop could not repair immediately was recorded as either an "R" type on the pad labeled "Repair" or "M" type on pad of paper labeled "Wish List".

The third pad ("Parts") was used to list all purchase parts required. What happened to the "P" type work request? The preventive maintenance tasks were posted in the shop and handled by a line technician. Any "R" or major "P" type work like an overhaul associated to the Assembly Line, Container line, or General plant facility stayed on the "Repair" pad until completed. Any other work request went to the “Wish list” a place used to collect suggestions to improve the plant or make life easier for everyone. My role was to prioritize the “Wish List” (“M” type work) and remind management we were not moving office furniture until the "R" and "P were completed.

How is the work request planned? Work not handled by the line technicians were planned and organized by Bob. If parts were required, Bob located or ordered them. If repair and PM’s required more people, Bob reassigned them. If any technicians were available, depending on “R and “P” work load, they were assigned to “Wish List” item. These items were handled by engineering and scheduled though Bob.

Task process… Who does the work? The line technicians handle daily equipment problems. The other technicians assisted line mechanics by handling PM’s, safety issues or rebuilding equipment. One to three technicians would work on “Wish List” items ready for installation. What data is collected? Labor cost was collected from the technician’s time sheet. Material cost was a collection of purchase orders and material removed from inventory.

Summary process… Evaluation of data? Management of course looked at cost. For engineering and the maintenance team, it was the equipment. Reviewing Bob’s list of repairs, talk to the line technicians looking for repeated failures and adding new solutions to the “Wish List”.

Final note… Notice I didn’t always practice what I preach. We had no CMMS or Maintenance ID, and we were still able to reduce downtime. However, one day Bob left the company and so did the plant history. Another lesson learned.

6.2 The Work Order

Now that we have all the proper information and path, we can proceed with the work order. A work order is a work request acknowledged by maintenance by placing a number on the request or writing down the request on the supervisor's 8 ½ x 11 pad of paper. The work order is the mechanism used to define the Why, What and When the maintenance parts and labor were required. The Work order is like a phone call, since you have different types (urgent, repeated, or junk!). If you listen to management, they feel every work order is an emergency, but…

The only emergency work order number is 911…

A work order maybe *urgent, critical, or important,* but never an emergency. The only time the word "*Emergency*" should be used is for a health-related problem of an employee.

The purpose of the Work Order is to track maintenance and equipment performance. To have the data to analyze real time and historical performance, a minimum amount of information needs to be *accurately* recorded on each work order. That data is:

- Maintenance ID
- Description of work
- Date
- Work order number
- Work priority method ("RPM")
- Work status
- List of parts used
- List of labor hours used

This information is entered while a work order steps though the four stages.

- Stage 1… Request
- Stage 2… Plan
- Stage 3… Task
- Stage 4… Summary

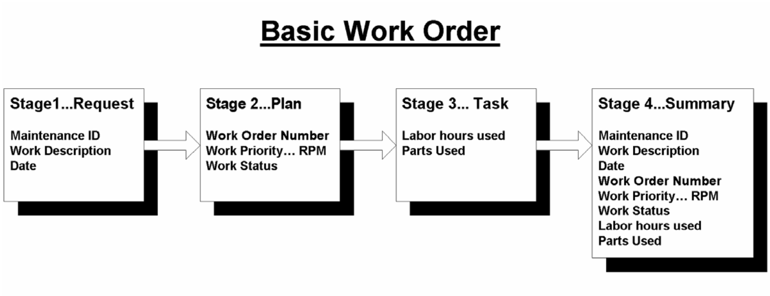


Figure 6.2a Basic Work Order

To understand how to build a work order, we need to describe the format of the information. The following is a look at the information in each stage of the work order and some examples of a various CMMS work order screens.

Work Request

The work order request is the first step required for maintenance to work on any equipment. The work request can come into maintenance in many forms such as phone call, e-mail, scratch paper or enter by CMMS screen. Since maintenance is providing a "service" and the customer is always right (i.e. operations and engineering), maintenance is forced to accept incomplete or duplicate work requests. If you are interested in saving maintenance time without having to turn a wrench, have "the customer" supply a complete and detailed Work Request before it goes to maintenance. An accurate work request is so important to maintenance performance that a training class on "How to enter a Work Request" should be given to all plant personnel.

A simple work request form…

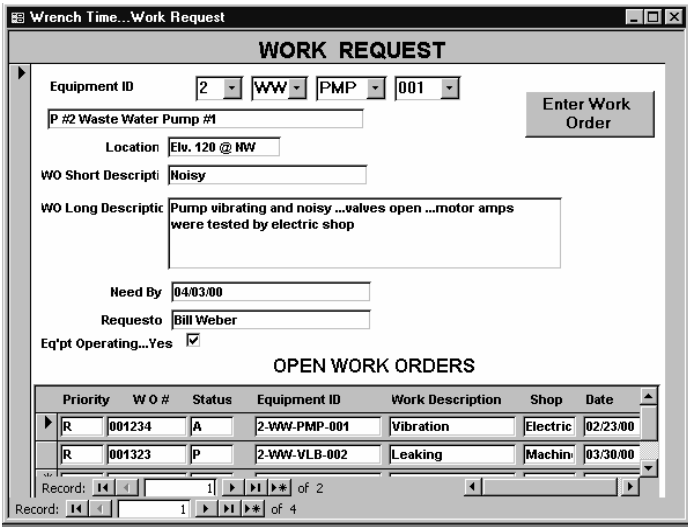


Figure 6.2b Work Request

The elements of any work request:

Maintenance ID… identifies the equipment to be worked on or the maintenance cost center ("1-WW-PMP-002"). If equipment is not identified, use the general system code such as 1-WW-ALL-001 to charge maintenance labor and parts to. Sometimes the equipment problem can't be determined initially, and it becomes the responsibility of maintenance to update the work order to the correct Maintenance ID.

Long description… with the Maintenance ID, the long description is the most important element of a work request. Maybe you have seen this before - "Pump won't run". With this information, maintenance is required to send a person to this pump just to identify the problem. From the work order description, maintenance is trying to determine:

- What is the real problem?
- What are the safety requirements?
- What type of craft personnel is required? (mechanic, electrician or instrument)

- When the equipment is available?
- What is the work type? (R, P or M)
- What parts are required?

So the example "Pump won't start" needs more detail. The description should be informative to maintenance, such as: What was tried or tested… i.e. reset overloads, operated back up pump, etc. Any noises, vibration, temperature or smells noticed?

Describe operating conditions before and after problem was noticed. For instance, a better description from our example could be written: "Pump won't start -seal water flow permissive not met. Seal water solenoid is buzzing, but valve did not open." With this information, maintenance planning can easily determine the work order needs to go to the instrument shop after checking availability of solenoid.

Note: Questionable work requests on equipment problems need to be sent to an electrical or instrument shop first, since their knowledge of control systems may help determine the real problem.

Helpful supplemental information on a work request…

Equipment description - a brief description of the equipment, such as P #1 Wastewater Pump #2.

Short description - a predetermined list of words to assist planning in determining the type of request.

- "R" type words like repair, safety, rebuild.
- "P" type words... PM, Predictive
- "M" type words…modify, change, and move

Equipment operating - yes or no. Operations need to inform maintenance if the equipment is still operational.

Date written - date work is requested. Use (XXYYZZ) format. Can be used in searching old and new work orders

Requested by - person requesting the maintenance. Use full name (FRED WEBER) to make it easier to call and talk to the individual who is making the request.

Query of Open Work Orders - Has a work order already been written? Maintenance personnel get annoyed with duplicate work orders. Operations think that if they write 10 work orders on the same problem, it will be done quicker. To maintenance, this is like an annoying phone call at dinner time. One way would be to display or post all OPEN work orders in that system. It is the requestor's responsibility to review the open work orders to prevent any duplication. This is one of the reasons why maintenance people still like the old pad of paper to list their work orders, so that they can easily see duplicate work orders.

"Enter Work Order" - at this time, maintenance logs the request as a Work Order or it's entered on the supervisor's work order pad of paper.

After all this is entered and completed…*it's a Work Order*!

6.3 Simple and Compound Work Orders

Since we have established what should be contained in a work order, we should also discuss different types of common work orders. Our discussion will focus on the information contained in two styles of work orders… *Simple Work Orders* and *Compound Work Orders*

The Simple Work Order is designed to handle one task. Below is the flow path for a typical simple work order.

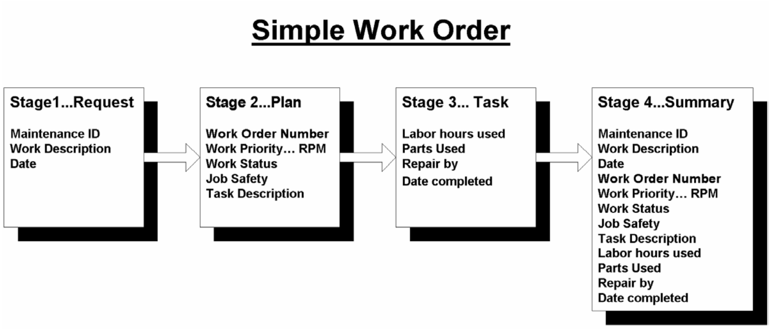


Figure 6.3a Simple Work Order

Components of a Simple Work Order

Work Request… information from the work request is transferred to the work order, and will include the Maintenance ID, a Long Work Description, and any supplemental information supplied by the Requestor.

Work Plan…the request becomes a maintenance job. It is assigned a:

- Job Safety - all safety requirements for individual to work on equipment, including vent and drain, MSDS sheet available, Lockout-tag out, JHA required etc.)
- Work Order Number (several accepted ways, but we will use the year (YY) and Sequential Numbering (XXXX) system
- Work Order Type / Priority (remember the RPM method?)

- Task description (long) - Complete detail of work required by maintenance. It includes safety procedures, drawings, photos or any other information required to do a safe and efficient job.
- Work Order Status (the status of the work order in your maintenance department). From the maintenance standpoint, they would like just a two-word status code… YES, we can work on it or NO, we can't. Of course, we all know that's too simple!

Here are a few suggested additional status abbreviations:

"A" for approval…Work is waiting for approval by someone. Every work request should default to an approval status.

"C" for closed… Work order is completed. This means done, done and done. Equipment is ready and been tested. All purchase orders and parts charged to this work order have been received, used or placed back in stock. Job site is clean. All documentation and drawing are updated.

"O" for Outage…Equipment needs to be down to service. Equipment needs to be scheduled for servicing, such as a plant or system outage or end of a production run. Closely review these work orders…delaying repairs or PM tasks on a piece of equipment may be more costly in the long run.

"P" for parts or planning…Missing parts, tools or anything required to service equipment.

"W" for wrench time…Equipment is ready to service. Safety, parts, information and tools are in place for work to start. Maintenance is responsible for status "W" work order. Any other status means that the work order belongs to someone else, such as "P"…parts (purchasing or planning), "O"…outage (operations) or "A"…approval (management or planning).

Work Order Task

- Actual parts costs (Equipment Part ID required to complete the work)
- Labor costs (all labor charged to a work order)
- Repair by (person responsible for work done)
- Date completed (date task completed)

Work Order Summary

All of the above! Simply an update and storage of work order information, as well as the transfer of information to other programs and departments, such as the Equipment Part ID changed to an inventory part number and sent to purchasing for reorder, labor and part cost charged to an accounting cost center, drawing updates sent to Engineering, and any test data sent to the Predictive Maintenance folks.

If you are using computer software to generate your work orders, below is an example of what your Simple Work Order might look like.

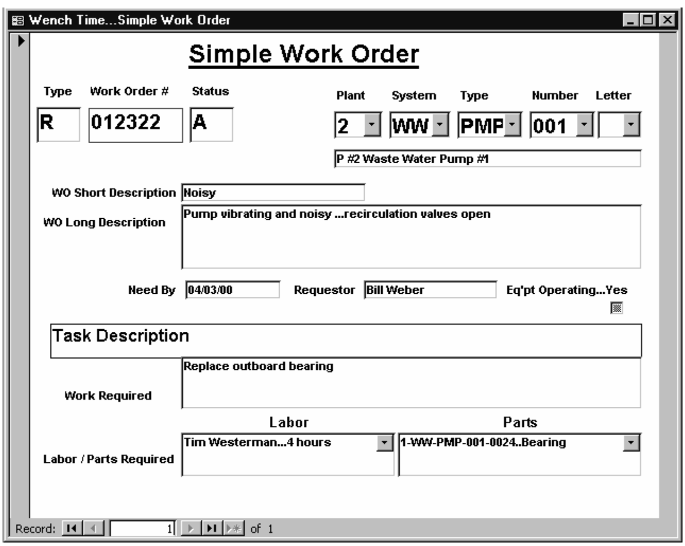


Figure 6.3b Simple Work Order Display

Compound Work Order

The simple work order was designed to handle only one task. Anybody that has managed work orders knows maintenance has a tendency to repair/work on other equipment while under the old work order number. It becomes impossible to separate costs (parts and labor) to a specific Maintenance ID. One tool used to do this is the Compound Work Order. A Compound Work Order is like a simple work order on steroids! This type of work order allows multiple tasks, Maintenance ID and personnel under the same work order number. It is a work order that contains one or more tasks; it's like a multiple work order, but each task has the same work order number.

Below is the flow path for a compound work order:

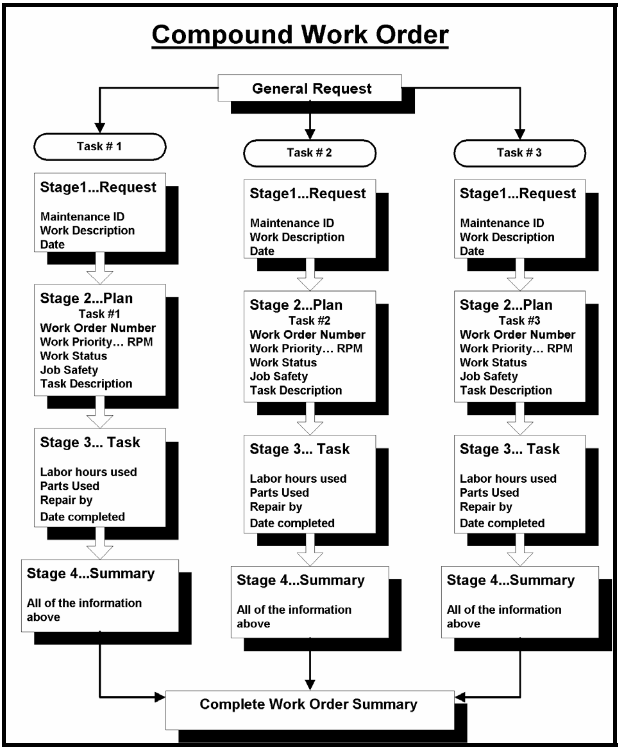


Figure 6.3c Compound Work Order Flow Path

How about an application example for the compound work order? Assume fan 1-WW-FAN-002 needs to have a PM every month. Using a simple work order, separate work orders would be written for each monthly PM. With the compound work order, one PM work order would be written at the beginning of your fiscal year for fan 1-WW-FAN-002 and a separate task would be used to track the parts and labor of each PM.

Another benefit of the compound work order is covering multiple equipment repairs while under the same Maintenance ID. For instance:

“WO# 023333… Pump 1-WW-PMP-001 won’t start.”

Using the simple work order, an Instrument Tech added a new suction valve actuator 1-WW-ABV-003, an electrician changed out a PLC card 1-WW-PLC-004, and the mechanic reset the impeller clearance to pump 1-WW-PMP-001. The simple work order system would charge all labor and parts to the same Maintenance ID (1-WW-PMP-001). However, a compound work order system would allow each task to be charged to the correct Maintenance ID. (Task #1 - 1-WW-PMP-001, Task #2 - 1-WW-ABV-003, and Task #3 - 1-WW-PLC-004). Of course, later this prevents questions like “Did we replace the suction valve actuator 1-WW-ABV-003 last spring?”

A sample screen for a Compound Work Order is shown below.

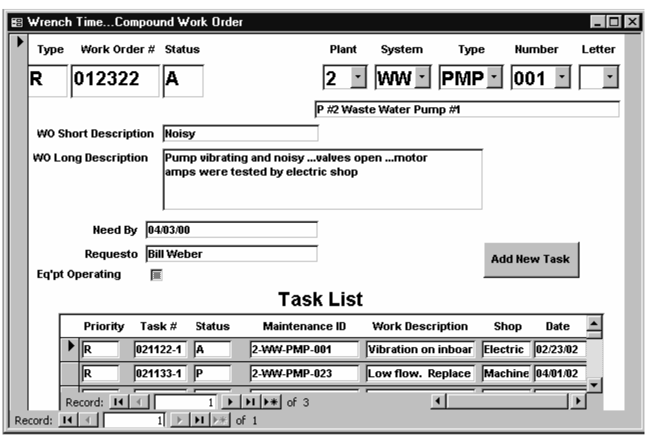


Figure 6.3d Compound Work Order Display

Work order search

A little side note here. The ability to perform a work order search is a big time saver. The purpose of a work order search is twofold. One reason is to allow someone to search existing work orders to prevent writing a duplicate. The other reason is to allow maintenance to sort though the pile of work orders based on various parameters. Before computers (*BC*), Maintenance's typical work order search was thumbing though stacks of work orders and jotting each work order on a pad of paper, which then became maintenance's punch list. Technology took over, but often forgotten about is the simple requirement of maintenance – the Maintenance ID (what is broken?) and the Full Work Description (What is the problem?). If you use a CMMS, be sure that you get a good fit! (More on CMMS in Chapter 10). Remember, when performing functions such as a Work Order search, a CMMS allows you to easily search by parameters, such as by Shop (Electric, Machine, Labor, or Instrument), Work Priority (The RPM method), or Work Status (Approval, Parts/Planning, or Outage). A computer version of a Work Order Search may look like the screen below:

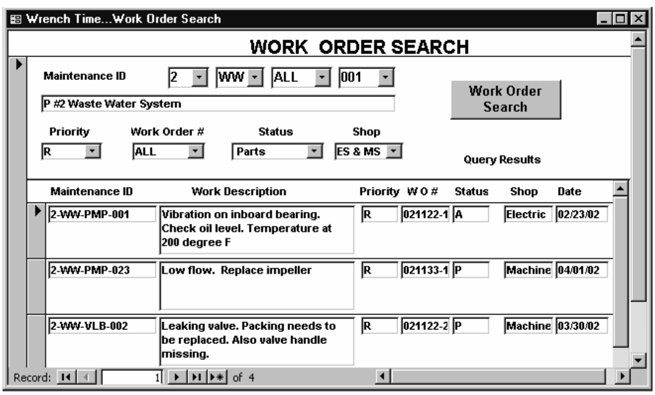


Figure 6.3e Work Order Search Display

If you justify a computer, get the proper system, software, and training. And yes, even I use computers all the time!

6.4 Blanket Work

The blanket work order number (sometimes called *the standing work order number*) is used to charge parts and labor from miscellaneous or repetitive tasks. This number is generated at the beginning of the fiscal year to ensure that all maintenance time is charged to some work order. Even though some problems may exist with using a blanket number, the benefits of its use still outweigh the problems. Here are some uses of the blanket work order to consider:

Idle time

Let's assume that a maintenance person has completed her work order in 5 hours and no other work is assigned. How will she account for her day? She has two options. The first option is to charge 8 hours to the existing work order. The problem is that 3 extra hours of labor was charged to the equipment. Now the data charged to the equipment is bogus and it becomes hard to determine equipment performance. The other option is to charge the 5 hours to the original work order and 3 hours to a generic blanket order. This is a much better choice, since the true labor cost of repair can be determined.

Repetitive Task

The original thought behind the blanket work order was to prevent writing several work orders for the same job. As we discussed earlier, one approach to handle a repetitive task was the use of the compound work order. Another method is to generate a blanket work order for the task. An example of this would be:

WO# 0211357 1-WW-PMP-001 Adjust pump packing

This example shows that a mechanic could charge his time to this work order (#0211357) to adjust packing to the pump through out the year. The problem with this type of work order is control. Only time and material for PM should be charged, not repair work. Repair work should be charged to a separate "R" work order.

General System Maintenance

As we mentioned earlier, every piece of equipment doesn't have a Maintenance ID. So if maintenance was asked to fix equipment (lets say in the limestone system) without a work order there would be a way to track their time. One method to monitor maintenance time is the use of blanket work orders to cover the "R", "P" and "M" work for each system. An example of this is to generate three generic work orders to collect miscellaneous work on the Limestone system.

Maintenance ID …1-LS-ALL-001

WO# **R** 012233 Misc. repairs on Limestone System

WO# **P** 012234 Misc. PM on Limestone System

WO# **M** 012235 Misc. Modifications / Wish list on Limestone System

You can see that with these three work orders we can track any miscellaneous repair, preventive and modification costs associated to the limestone system.

Work Outside of Maintaining Equipment

After supervising maintenance for a few weeks, you realize that maintenance's time is spent doing more than maintaining equipment. One method to track costs is to associate a Maintenance ID and work order number to ANY maintenance activity. One of the main functions of the Maintenance ID was to develop a maintenance accounting cost center. Here are a few examples of the use of a blanket work order and a Maintenance ID to store these non –maintenance activities such as:

- Administration time… generate a Maintenance ID to cover Personal time (Sick, Vacation, Workers Compensation, Family Leave, etc.) such as
  1-AT-ALL-001 Administration time.

- Next, write a blanket work for each activity:

  WO # M024444 Sick Time
  WO # M024445 Vacation Time
  WO # M024446 Holiday Time

- Safety and Training time… another area of administration time is safety and training. One approach is to generate a separate blanket work order and Maintenance ID for each safety and training activity:

  WO # M020011 1-AT-SAF-001
  Safety training… chemical hazards
  WO # M020023 1-AT-TRN-001
  Equipment training… forklift training
  WO # M020045 1-AT-SAF-001
  Safety training… protective equipment

- Working for other departments…believe it or not, maintenance does more than work for maintenance. Task such as operate equipment, train personnel, purchase parts, engineering or work for contractor. Again, to track these costs we need to generate a Maintenance ID and a blanket work order to track the time and material associated with these types of jobs. An example of this is to build a Maintenance ID such as 1-OJ-ALL-001 for *Odd Jobs* in other departments. You could charge out jobs such as:

  WO # M021122 …Purchase parts (purchasing parts)
  WO # M021123… Warehouse (organizing warehouse)
  WO # M021124… Engineering (update of drawings)
  WO # M021125… Water Department (rebuilding pumps)

This is confusing, so why would I write a blanket order for this stuff? Mainly so that Maintenance management can determine the costs and time associated with any activity (such as forklift training). Now we have support data to approach management for an increase in manpower. You may be spending the time of 2 people just to meet safety and training requirements. Or you have a maintenance person purchasing parts for equipment and another updating drawings for the engineering department. This example shows the time spent by four maintenance people, and not one of them has turned a wrench.

While the blanket order has many positives, it can also have drawbacks. The blanket work order is considered the "gold card" of maintenance because it is too often used by maintenance as a "catch all." Maintenance will use a blanket work order to account for "idle" time, to justify buying nearly anything, to remove items from stock, etc. Much like any other credit card, you need to control the use of the blanket order. For example, do you have an open purchase order with a local vendor? Of course you do. Do you look at the charges at the end of the month? Again, of course you do. So in the same way you control your purchasing costs, you need to control blanket work order. Control blanket work order use by limiting the dollar amount, shop assignment, and type of material that can be charged.

REMEMBER that all maintenance time and parts should be associated to the maintenance accounting system by using the MAINTENANCE ID & WORK ORDER NUMBER! It's up to accounting and maintenance management to tie the information to the correct accounting cost center. Finally, you can think of a Work Order System like a Telephone System. The work order is like a phone call, since it initiates action. Using the Maintenance ID is like using the correct phone number. Last, the RPM method is similar to the boss's secretary, since it prioritizes work the same way she prioritizes phone calls!

7 Thinking of Tomorrow

7.1 Planning
7.2 Scheduling
7.3 Preventive Maintenance
7.4 Predictive Maintenance

Planning is the "fire prevention" for maintenance
Fred J. Weber

7.1 Planning

It's the "P" part of the RPM method….Planning, Preventive and Predictive Maintenance. These three activities change the focus of maintenance from "Thinking of Today" to an organization that is "Thinking of Tomorrow". The table below shows the differences of these two approaches in running maintenance department:

Thinking of Today	Thinking of Tomorrow
Repair broken equipment	PM equipment before it fails
Wait until it breaks	Predict when equipment needs repair
Repair repeated equipment problems	Use the RPM method to track equipment problems and solve them
Locate parts, tools, and information A*FTER* equipment shuts down.	Plan the job…review information, clean work area, move tools, place parts *BEFORE* is equipment shut down
Layoff people AFTER equipment is running	Use maintenance staff to prepare for future equipment problems: Develop bill of material and store parts based on Maintenance ID. Build equipment library.

Table 7.1 Thinking of Tomorrow

One element of Thinking of Tomorrow is *Planning*. Planning is considered to be:

- knowing what you need, before you need it.
- a tool to remove any obstacle that might stop a job.
- a system used to keep the work in front of your people.

Basically, planning is the work before the work starts! However, despite all the benefits of planning, maintenance still has millions of reasons for *not* planning. To this day, many maintenance supervisors still think that handing a work order to a technician is considered planning. So, to avoid planning, maintenance people will usually say something like "Well, we won't know what we need until we tear into it." That means no one has checked for parts, drawings, or tools. The tendency of maintenance becomes "wait until I need it". An example of this Thinking of Today approach could be "I'll look for the fan service manual when I need it."

Another reason for not using a planner is that maintenance supervision assumes they can plan the work *and* supervise the work force. However, if they're doing their job right, they are just too busy with all the daily problems, such as:

- making sure your workforce as well as plant equipment are safe and meeting environmental standards
- organizing and scheduling the work force to make work easier
- performing quality control for maintenance work
- reviewing design changes
- training personnel
- working with different departments and contractors
- handling personnel problems
- answering phones, reading memos/reports, and going to meetings

And the list doesn't end here…

This is just a brief list of the reasons why a maintenance supervisor can only handle dealing with TODAY. There is no time in the day to think about tomorrow, and definitely not next week. Test to see if you need a planner in your maintenance department. Ask your maintenance supervisor the question "Can you show me in writing what maintenance is working on next week?" Typical supervisor answers without a planning team will say, "I don't know what will be broken next week", or "Ah, um, we'll be rebuilding the fan". Rebuilding the fan is good for three people, but what is the supervisor doing with the other 18 people? The real obstacle for not developing a maintenance planning team is management. It starts at the top. If upper management does not have a plan showing the direction of the organization, most likely maintenance won't have one either. Bad habits start from the top and roll down hill. In addition, *management rewards panic*. The only time upper management thinks maintenance is working is when they see them overreacting to a piece of equipment that just failed. It's when maintenance jumps through hoops by air freighting parts, working a ton of overtime, and generally doing what ever it takes to get the equipment back on line (i.e. putting out fires) that management takes notice.

REMEMBER - **Planning is the fire prevention of maintenance**…

Let's face it, maintenance planning is not nuclear physics. It is a common sense approach to organizing all aspects of a job. Planning work will have *immediate* impact in your plant. With more people reviewing the job before any work is started, you should see a safer work environment. The work is easier because the jobs are prepared with correct safety, parts, information, and tools. For management's benefit, you'll see an increase in production and maintenance efficiency because the work is right the first time.

One of my best experiences for understanding the benefits of planning was managing a construction project with several subcontractors. Here you quickly understand the cost of not planning. What happens?

- If material or equipment is not on site as scheduled, you pay.
- If parts don't assemble, you pay.
- No drawings or documentation, you pay.
- Even if you just change your mind, you pay!

Back charge, after back charge, after back charge.
Planning is critical to bring the job in on time and within budget.

In maintenance, these same experiences happen, but they are easily hidden in the system.

- Material not on site? The mechanic calls supervisor and goes to break.
- Parts don't assemble? The mechanic looks for supervisor, who looks for the engineer, who calls the distributor, who calls the factory. By the way, the mechanic went to break.
- Change your mind after mechanic started a job? All that does is tick off the mechanic, who now *very slowly* moves their toolbox to the next job, then locks out equipment and repairs the new problem.
- You don't supply enough information to repair equipment? The mechanic assembles the pump with the wrong impeller clearance, and then reworks the pump on overtime (which includes more breaks!).

The results of poor planning are obvious; you will have to hire more people, increase overtime, or stop PM's on equipment.

To understand the effects of planning, simply follow two work orders for a simple pump repair though your plant. **Without planning**, the path often looks like this…

- Mechanic is given the work order, goes to operations and asks, "What is the problem?" Operations states the motor overload is tripping. Mechanic states "you need an electrician, not a mechanic"
- Electrician goes to the pump and finds no problems with the motor or overload settings and says " you need a mechanic to disassemble pump and find the problem"
- Mechanic goes back to operations to tag out the pump and associated valves. While disassembling the pump, the mechanic finds the bearings are damaged and goes to the warehouse to see if there are any parts in stock for the pump. After discovering the warehouse has no bearings, the mechanic tells the supervisor to order bearings for the pump.
- Two weeks later bearings arrive. The original mechanic is on vacation, so a different mechanic is sent to reassemble the pump. An Operator starts the pump and observes a

rubbing noise. Mechanic asks operations to tag out the pump again. This time the mechanic locates the service manual and discovers that the impeller clearance was set wrong. The mechanic adjusts impeller clearance and turns pump over to operations again.

- Finally, the pump is running…
- If this sounds all too familiar, you should probably start thinking about a planning department.

Now let's look at a planned job…

- Planner talks to operations and changes the work order description from "Pump problem" to "pump starts but trips on overloads". Next, the planner reviews all associated work in the system that interfaces with the pump and its system.
- Electrician is given three work orders in the system, with the pump problem being one of them. Electrician confirms high motor current at normal pump flow. Electrician tags out the pump and tests motor and overload settings. Pump problem is determined to be a mechanical bind and the work order is returned to planning. The two other work orders are completed and closed.
- Planning reviews past history and notices a bearing problem with pump; also, there is a work order for a leaking valve near the pump on the same system. Planning collects the necessary information and parts to do the work by:

  -requesting that the warehouse order bearings immediately and to send all pump parts and valves to the job site.

  -requesting laborers to clean work area.

  -requesting operations tag out pump and associated valves.

  -supplying the mechanic a copy of a pump cross-section view and the necessary assembly information from the service manual.

- Mechanic is sent to job site with two work orders, one for the pump and the other for a leaking valve. After verifying lockout of system, the mechanic with parts and information in hand repairs both work orders that day.
- Operations releases tags and operate the pump (and without the nearby valve leaking on their feet!).

That's what planning can do in your plant…

Setting up a Planning Team

Assume you are convinced to develop a planning team. The first thing you need to establish is a goal for the planning team. How about "Make maintenance's work as safe and easy as possible?" Notice that the goal of the planning team is the same as the goal of the supervisor. If you are not physically repairing equipment, you had better be making it safer and easier for people who are doing the work.

A planning team consists of Planners, individuals who organize work for maintenance today, tomorrow and next year. These multi-tasking and flexible individuals could be planning activities from changing the toilet seat in the men's locker room to a major overhaul of a steam turbine. Any successful planning team requires a leader. A good candidate for a lead planner is a person with a supervision background in construction or maintenance. This type of individual understands the effect a lack of planning has on a job; they know someone could get hurt or the work could stop. A lead planner should be a permanent position in your maintenance department and have a good grasp of the plant operation, skills of the craft trades, tools, equipment and parts. One of the main responsibilities of this individual is to teach each technician in your shop planning and work organizational skills. One method to do this is to rotate maintenance people into the planning department for a month at a time.

One of the first questions a manager will ask is how many planners are required. Start small but select enough planners to keep maintenance busy. If you need two planners to keep five people safe and busy, do it. However, before you send those two people into planning you need to define their responsibility.

The planner's function is any activity that prepares any maintenance job for Tomorrow. To do that, a planner needs to *"S.P.I.T."* on each work order before it goes to maintenance. No, not *that* kind of spit! *"S.P.I.T."* is an anagram for Safety, Parts, Information, and Tools.

So, before a job is handed to a maintenance person, a planner should review the following:

- **Safety requirements**

Plan a safe work environment (tagged out, locked out, flushed, drained, vented, permits reviewed, environmentally safe, completed job hazard analysis, etc.)

Define the work. Check the details of the work order. Confirm a description of what failed with operations and maintenance, which will enable the proper craftsperson (electrician, mechanic, or instrumentation technician) to be sent to the job. It will also help to determine the proper number of people needed for the job as well

- **Parts requirements**

Material - supply all generic supplies to make the job easier (i.e. rags, buckets, etc.)

Parts - stage parts required for the job at the work area and supply a list of all available parts in the warehouse

- **Information requirements**

Set a work priority based on the RPM method and the effect on plant reliability

Coordinate work with all departments. Group work orders together to prevent excessive travel time and interruption of operation. Monitor work and parts status

Documentation should include drawings, service manuals, inspection reports, photos, PM reports, or anything else to support the job

Record labor time, material, and support data for the purpose of equipment history

- **Tools and equipment requirements**

Check on the availability and requirements of special tools and equipment to do the job (such as a crane, forklift, welding machine, or special rigging). Of course, this is not meant to be a comprehensive list: add anything that I missed to make the job safe and easy for the technician.

One purpose for *"S.P.I.T."* is for the planning team do the legwork an each work order. It includes anything that benefits the technician working on the equipment. A big part of that is having the information in a format that any maintenance person can easily access. Take a proactive approach and find the information before you need it! Below is a list of information a planner can start to collect today:

- Safety information
- List of MSDS sheet for each material in plant
- List of Job Hazard Analysis, sorted by plant systems
- Lock out and tag out procedure for each piece of equipment
- Parts information
- Build a BOM (bill of material) for each piece of equipment
- Develop a detailed procedure for each PM including a list of tools and supplies
- Organize the warehouse based on equipment and plant system
- Documentation requirements
- Build an Equipment Library based on the plant system. It would include drawings, service manuals, operating parameters, testing data, and equipment history.
- Build a drawing system with a means to control changes
- Develop a vendor contact list, referenced to equipment
- Tools and equipment information
- List of equipment and tools in the plant (welding machines, forklifts, etc.)
- Record and file equipment inspections and PM reports (cranes, hoists, etc.)

Besides organizing each maintenance job, the planner needs to determine the work order priority and monitor the work status. Remember the RPM method (how could you forget?).

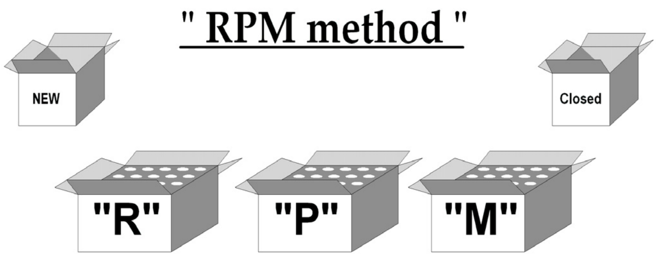


Figure 7.1a RPM method

Using a planning team, we can extend the RPM method. Start by getting three more boxes and labeling them “R”…Planning, “P”…Planning, and “M’…Planning. Next, re-label the old "R", "P" and "M" boxes with “R”… Maintenance, “P”… Maintenance and “M’… Maintenance. Keep the "NEW" and "CLOSED" boxes on opposite sides of R, P and M boxes.

The RPM method with planning added looks like this:

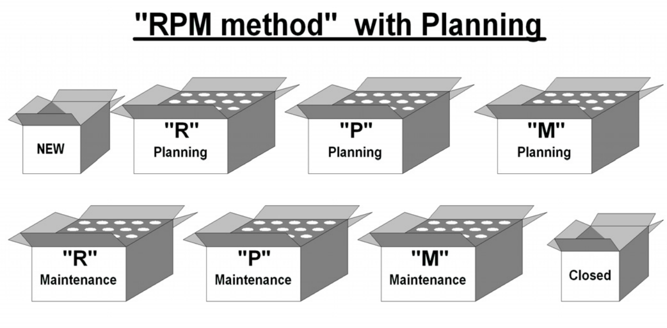


Figure 7.1b RPM method with Planning

To start we need to define what each box represents. The "NEW" box is where all the new work orders entering the system would be placed. The three boxes labeled "R", "P" and "M" (maintenance) are defined as R, P, or M type work that maintenance can do NOW. NOW means the equipment is clean and safe to work on. Information and parts for the repair are in maintenance's hands. "In maintenance hands" means you can touch it, not laying in warehouse or being shipped tomorrow. Simply speaking, the only thing missing to do these work orders is manpower.

Next, the three boxes labeled "R", "P" and "M" (planning) together are for R, P or M type work that is waiting for something besides maintenance, such as safety, parts, information or tools. The planner prioritizes and defines the work requirements BEFORE placing the work order in the "R" and "P" Maintenance boxes. Again, remember that management is responsible for setting the priority of the work orders in the "M" (planning) box.

The last box labeled "CLOSED" is for completed work orders. This is the time the planner reviews the information on the work order for accuracy before placing it in the equipment filing cabinet.

So how does all this fit together? Here is a brief description of how the system works. First work order is entered in the "New Work Order" box. A planner reviews the work order description and Maintenance ID. Next, the planner determines the status and priority, and places work order in the appropriate box. If equipment is ready to be worked or requires maintenance to look at it to determine the problem, it goes in "R", "P", or "M" Maintenance box. If something stops maintenance from working on the equipment, it goes into the planner's "R", "P", or M" Planning box to be resolved (such as with parts, an outage required, or vendor information). Maintenance and planners have the same priority on work orders…

"R" type…NOW

"P" type…as soon as possible

"M" type…when the "R" and "P" are completed

The best way to understand the RPM method with planning is to show how to handle some work order examples. Here are seven work orders sitting in your "NEW" box:

WO #	Equipment ID	Work Description
012134	1-WW-PMP-003	Hot inboard bearing
012167	1-AS-VLB-023	Valve won't open
012189	1-WW-FAN-001	PM.Vibration readings
012199	1-BG-ALL-001	Install phone in restroom
012256	1-AS-LTR-001	Calibrate level transmitter
012312	1-AS-TNK-001	Tank leaking
012331	1-WW-PMP-003	Resolve bearing failures

Table 7.1d Work Order List

Example #1

<table>
<tr><td>Work order #</td><td>Maintenance ID</td><td>Short Description</td></tr>
<tr><td>012134</td><td>1-WW-PMP-003</td><td>Hot inboard bearing</td></tr>
<tr><td colspan="3">Long Description: Pump inboard bearing is running 15 degrees hotter than normal. Verified correct valve position. Pressures and pump flow normal. Bearing temperature reading at 205 degrees F and observed high vibration in pump.</td></tr>
</table>

Operations has identified a problem with an EXISTING piece of plant equipment. Notice operations did an excellent job by reviewing the pump's operating parameters, recording the bearing temperature, and writing a detailed work order description. Maintenance can easily determine the type of craft from the details of the problem. Work order becomes an "R" type is placed in "R" (maintenance) box. Maintenance reviews the pump operation by taking temperature, motor current and vibration readings and determine inboard bearing problem. The work order is returned to planning and placed in the "R" (planning) Box. Planning prepares the equipment and associated valves for maintenance to work on by tagging out equipment, placing parts in hand, collecting pump information and getting the work area clean. The work order is then placed back into the "R" (maintenance) Box.

Maintenance repairs the pump and verifies pump performance. The work order is placed in the "CLOSED" box and reviewed for the correct time and parts use to repair pump before placing it into equipment filing cabinet.

Example #2

<table>
<tr><td>Work order #</td><td>Maintenance ID</td><td>Short Description</td></tr>
<tr><td>012167</td><td>1-AS-VLB-023</td><td>Valve won't open</td></tr>
<tr><td colspan="3">Long Description: Inlet valve to Tank 1-AS-TNK-012 will not open. Annunciator alarm "Tank High-level" alarm is in. Visual inspection shows the level in tank is normal.</td></tr>
</table>

Again, operations did an excellent job by supplying maintenance with technical information to troubleshoot the problem by verifying tank level. The work order becomes an "R" type, or a problem with an existing piece of equipment. Work order is placed in the "R" (maintenance) box. The instrument shop picks up the work order and determines the level switch 1-AS-LVS-002 is bad. Operations manager requests the switch to be bypassed to keep the process running. (Note: This is a not only an operational problem with a piece of equipment, but a Safety problem as well. Bypassing equipment or not having reliable back up for the equipment jeopardizes the plant safety). The work order is placed in the "R" (planning) Box. Planning first changes the Maintenance ID to "1-AS-LVS-002" and adds "Bad level switch" to the work description. Time and materials will now be charged to the right piece of equipment. Planning immediately orders a switch. Once the switch is in hand and the area is safe to work in, the Work order is placed in the "R" (maintenance) Box for maintenance to install switch and remove the jumper.

Example #3

Work order #	Maintenance ID	Short Description
012189	1-WW-FAN-001	(PM) Vibration readings
Long Description: Take vibration readings on inboard and outboard fan bearings. Record bearing vibration, motor current, bearing temperature and guide vane position. Verify oil level.		

The work order becomes a "P" type, since it's a preventive task with an existing piece of equipment. This type of work order is typically generated and detailed by maintenance and is placed in "P" (maintenance) Box when the equipment is ready for PM. If a "P" type work order needs parts or need the equipment not running to do the PM, then the work order goes to the "P" (planning) box until everything is ready for maintenance.

Example #4

Work order #	Maintenance ID	Short Description
012199	1-BG-ALL-001	Install phone in restroom
Long Description: Need to install phone restroom. Operators get phone calls when in the bathroom.		

Adding a phone is considered a modification to the existing facility, so this work order is placed in the "M" (planning) Box. This work order (and all other "M" type work) is reviewed and prioritized by management.

Example #5

Work order #	Maintenance ID	Short Description
012256	1-AS-LTR-001	(PM) Calibrate level transmitter
Long Description: Calibrate transmitter, blow down instrument lines and complete calibration sheet for 1-AS-LTR-001.		

The work order placed in the "P" (planning) box. This transmitter can only be calibrated when the AS system is down. Once this system is secured, this work order is moved to the "P" (maintenance) box.

Example #6

Work order #	Maintenance ID	Short Description
012312	1-AS-TNK-001	Tank leaking
Long Description: Observed a leak at the bottom of the tank near the drain valve 1-AS-VLB-002.		

Again, an "R" type work order because we are repairing an existing piece of equipment. The work order is placed in the "R" (maintenance) box. It's obvious that maintenance can't work on a full tank, but they are usually required to determine the problem. Working together, Maintenance and Planning go out and inspect the leak, identify the problem, build a material request sheet, and place the work order back into the "R" (planning) Box. In addition, during the inspection of the tank leak, maintenance observed the valve 1-AS-VLB-002 with a packing leaking. Notice that maintenance's job is to not only fix the problems, but also find them! So, Maintenance generates a new work order to repair leaking valve 1-AS-VLB-002.

Work order #	Maintenance ID	Work Description
012313	1-AS-VLB-002	Packing leaking
Long Description: Replace packing on valve #2. Looks like half-inch packing, but should verify with service manual.		

This new work order placed in the "R" (planning) Box waiting on parts and availability. When the tank is drained and parts are available, both work orders are placed back into the "R" (maintenance) box.

Example #7

Work order #	Maintenance ID	Work Description
012331	1-WW-PMP-003	Resolve bearing problem
Long Description: Maintenance has spent $8300.00 in parts and labor last year on bearing failures. Develop root cause analysis of pump bearing problem and make recommendation.		

This work order is not an "R" or "P" type, so it must be an "M". The "M" type Work order is generated by maintenance and is placed in "M" (planning) Box. Because it is an "M" type work order, it needs to be prioritized by management. They should compare it to our earlier work order (# 012199 1-BG-ALL-001…Install telephone in restroom). Both are "M" types, but completing which work order would increase plant safety, reliability and profit?

Once either work order is approved by management, the work is ready for maintenance, and the "R" and "P" work order are at a manageable level, it's moved to the "M" (maintenance) Box.

Test yourself; list all the "M" type work orders in your plant like this:

Priority	WO #	Maintenance ID	Work Description
4	M010034	1-WW-ALL-001	Install hose brackets
1	M010134	1-WW-PMP-002	Resolve bearing failure
2	M010256	1-AS-FAN-023	Add speed controller
3	M010398	1-WW-VLB-001	Redesign valve handle
5	M010709	1-BD-ALL-001	Relocate VP filing cabinet

Table 7.1e Priority of "M" type Work Orders

How would you prioritize the list?

Remember, for any work order system to be useful, the planner needs to accurately collect a minimum amount of information from each work order: Work order number, Description of work, Work priority method ("RPM"), Work status, Maintenance ID, List of parts used and List of labor hours used. Hold on, the planner's job is not done yet. The planning team has prepared and prioritized the work for maintenance, but there is more work for them to do. Another activity the planning team is required to be involved in is Scheduling.

7.2 Scheduling

Scheduling is another "Thinking of Tomorrow" activity for that the planning team is required to do. Scheduling is “time stamping” a plan. The Plan describes “what, who, and how” the work is to be done, while the Schedule defines “when”, which is the start, finish and critical dates of a plan. Three elements are required for any schedule to work.

It has to be in writing - use a computer, chalkboard or a table with 3x5 cards.

Let EVERYBODY see it - a schedule plan is a map for maintenance and the rest of the plant. It defines the direction of maintenance is going next week, next month and next year. Without this map, you’ll be lost.

Consider the Human Side - typical scheduling of plant events is based on what’s best for the plant. Don’t stop there; keep in mind the events and work conditions that affect the people working for you. Remember holidays, even consider the ones the company doesn’t observe. Some holidays may not be important to the company, but are very important to some workers. Also, be cognizant of vacations, school breaks, company events, or special events (hunting season, farming season, Bike Week, etc.). Another lesson I had to learn – never start a project on the first day of hunting season; it was amazing the number of people who called in sick on that day! Of course, you always should think about the actual work environment as well, including ambient temperature, visibility, dust, rainy season, noise level, etc. If possible, consider moving work to non-production time such as an outage or off shift, or schedule classroom training to avoid bad conditions.

In previous modules, the planning team organized the what, who, and how of a work order. The next step is to define "when" the work is to be done. The member of the planning team who defines “when” is called a *scheduler*. Their function is to display an overview of the maintenance work and plant activities for Tomorrow. One method to display this information is called a Gantt chart (named after one of the legends of scientific management). The Gantt chart is a calendar that shows the timeline and date of plant activities.

To visualize the plant's activity in the future we need to build and combine two schedules: the Plant Schedule and the System Schedule.

Plant Schedule

A Plant Schedule is a timetable showing plant activities such as projects, outages, peak production or major activities from the System schedule. The plant schedule is a view of the "Big Picture" showing the time of major activities in the plant. This collection of events and their timelines from each department gives everyone the "heads up" on future activities in the plant, including:

- Operations - plant outages, high production season
- Purchasing - delivery time of major parts and equipment
- Engineering-capital projects, equipment modification
- Training - safety classes

With the feedback from each department construct the plant's "year at a glance" schedule. First, find a large table and lay out the months of the year on top of the table with 3x5 cards (or build a simple spreadsheet). To the left of the calendar, list all the plant events. Items like high plant production seasons, outages, holidays, etc.

A simple Plant Schedule may look like this:

				2003											
	Event	Start Date	End Date	October				November				December			
1	WT run	10-3	12-4	x	x	x	x	x	x		x	x			
2	Holiday	11-23	11-27							x					
3	KP run	12-5	12-19									x	x		
4	Holiday	12-20	01-03											x	x

System Schedule

A System Schedule is a timetable of daily and future maintenance activities within a system such as PM, equipment outages or design changes. The System Schedule is a maintenance driven schedule that uses the Plant Schedule as a reference. The purpose of the system schedule is to group all activities associated to one system together and fit them into the jigsaw puzzle called the Plant Schedule. To find out what maintenance activities can be scheduled, let's look at the three types of work orders - "R", "P", and "M". At first glance, it looks like the "P" and "M" could easily be considered scheduled work. The "P" type work is typically PM work generated by maintenance and the "M" work orders are projects and wish list items. The "R" type work orders on the other hand are associated to a repair, so how can you schedule a repair? Most repairs or rebuilt work that can't be done immediately are due to lack of parts, or may require an equipment outage. Therefore, some of the "R" type work orders can be scheduled based on when the parts or equipment become available. The system schedule becomes a list of work orders stapled together before they handed to maintenance. Simply speaking, the work orders are placed in the RPM Maintenance boxes at a time that best fits the Plant Schedule and when maintenance personnel can do them safely and efficiently.

One method the scheduler can use to get a picture of Tomorrow is to fit the System Schedule into the Plant Schedule's Gantt chart. The schedule lets everyone know that someone plans to work on something within the system. With this notice, each department needs to review how they can support the work. For operations, it may be tagging out a pump, while purchasing may need to have a part shipped before a certain date. Simply, the purpose of the schedule is to group maintenance work associated to one plant system with other plant activities.

An example of this could be the PM of the air compressor in the second week of October, and a compressor overhaul in December for the control air system. To get a picture of this is to add these to activities to the Plant Schedule.

				2003											
	Event	Start Date	End Date	October				November				December			
1	WT run	10-3	12-4	x	x	x	x	x	x		x	x			
2	Holiday	11-23	11-27							x					
3	KP run	12-5	12-19									x	x		
4	Holiday	12-20	01-03											x	x
5	CA System PM	10-8	10-12		x										
6	Overhaul Compressor	12-8	12-22										x	x	

Scheduling defines when the control air system needs to be down (start and finish time). At this time, other departments can review the schedule to see if it will affect them. Also, maintenance needs to review repair work, PM tasks and engineering changes ("R", "P" and "M" work) associated to the control air system that could be addressed while the system is down. Now move events around to best fit the plant and people. The schedule time stamps the requirements for manpower, tools and equipment. For example, the plan may require a forklift to be used for one week during the overhaul. Have it there!

Take a glance at the schedule above. What potential problems do see? With the Control Air system down, will it affect the WT production run? If the compressor overhaul is not completed as scheduled, do you want maintenance to work through the holiday? These are examples of issues to address when scheduling for "Tomorrow."

Scheduling determines "when" it can be done. Whatever methods you use, just make sure you make a hard copy of the year at a glance. It may help to keep management from changing their mind every day!

7.3 Preventive Maintenance

Preventive maintenance is the minimum amount of scheduled work required to keep the equipment running safely and efficiently. A preventive maintenance task can vary from greasing a bearing to inspecting a crane or backing up computer software. To establish a Preventive Maintenance Program, you need to look at ALL your plant equipment and answer three simple questions:

- What to PM?
- How to PM?
- When to PM?

What to PM?

One method to determine what equipment to PM is to simply ask what happens when equipment stops or fails. Without a PM, are you subject to personal injury, violation of a safety or environmental regulation, or loss of production? Lay out a spreadsheet with a list of equipment as shown below.

Equipment	Personal Injury	Violate Safety / Env.	Loss of Product	Cost to Plant
1-WW-PMP-001		X	X	$200/hr
1-WW-MBV-012			X	Stops PMP-027
1-WW-PTR-002	X	X	X	Price less

Table 7.3a Effect of Equipment Failure

Without a doubt, any equipment marked in the first two columns "Personal Injury" or "Violate Safety or Environmental Regulation" needs to be on the top of your list of preventive maintenance tasks. Next, locate the equipment that will stop production and define the effect it will have on the plant. Once equipment associated with safety, environmental, and production has been addressed, it's time to PM the other equipment.

Usually, most PM tasks are defined by the recommendation in the equipment's service manual, but there are other factors to consider. For instance:

- Keep it safe or remove it - if a hoist costs $200.00, are you going to spend $500.00 annually to PM it to keep it safe? If not, remove it.
- Equipment application - most equipment manufacturers are not aware of the service of the equipment. Using the example of two cranes, one could be located in dust-free warehouse, while another one is used in a 200-degree corrosive environment. Obviously, with the second crane needs more aggressive PM attention.
- Effect on other equipment - assume you have a $200 dollar pump in your plant, would you spend 500 dollars annually to PM it? Probably not, but take look how the pump is associated with other equipment. If the pump that costs more to maintain than to buy new fails and stops a $1,000,000 process, your $500 PM costs really don't sound so bad! You should also consider using predictive maintenance tools to track pump performance, or at least install a back up pump or keep a spare pump in inventory.
- Equipment history - one reason for the RPM method was to make equipment history user friendly to locate equipment problems. Every time maintenance completes "R" type work orders, you need to ask if a five minute PM could have prevented the problem.
- Equipment Type - consider the different type of equipment. When looking at:

  - Mechanical equipment, look at the interface between the moving and stationary parts.

  - Computer and electronic equipment, you are often concerned with memory. If the equipment fails, do you have the software and initial settings to reload it?

  - Instrumentation, think of things like sensing lines. Instruments can't read what they can't sense.

  - Electrical parts, think "moisture", and keep it out!

To summarize "What to PM", consider everything with an equipment label, even if it's just to see if it's being used or still on site.

HOW TO PM?

A preventive maintenance task is a planned, scheduled and detailed event. Any PM should go through three stages: Pre- PM, the PM, and Post-PM

- Pre-PM… The Pre-PM is observing the equipment while it is operating. One benefit of having a technician responsible for a system is that they are aware of the normal equipment performance. Safely monitor the equipment by looking, smelling, feeling, and listening to equipment run at different loads. Technicians should review and record the equipment's operating parameters such as flow, pressure, or motor current. Look at the process, such as the product going in and out of the equipment by reviewing the product QC reports. Use all the tools available to you to monitor equipment, such as vibration, oil sampling, or thermography. Identify the equipment performance before the PM starts.
- The "PM"… Any PM is a known maintenance function, therefore you have NO excuse not to have a detailed PM procedure. To achieve a detailed PM we need to S.P.I.T. (safety, parts, information and tools) on each PM before it's handed to maintenance.

Safety - equipment must be safe and clean to work on.

Parts - material required for PM.

Information - details, details and more details. Describe how to inspect or PM equipment using drawings, manuals, and equipment history. Use photos and videos because a picture is worth a thousand man-hours. Use predictive maintenance tools to review past and present vibration, oil sampling and thermograph status.

Tools - supply a list of tools and equipment required for the PM to prevent technicians from dragging their toolbox around the plant. Use tolerance-checking tools like go and no-go gages for component replacement status.

How much detail on a PM is required? Enough that a technician not familiar with the equipment does have to ask the supervisor "How do I __?" The equipment's service manual is probably the first place to look for a PM procedure and recommended PM schedule. However, it is up to the maintenance team to detail and develop a PM procedure for your particular application.

Another consideration in building a PM procedure is to review inherited weak points of each particular type of equipment. Here are some PM tips to consider:

- Mechanical equipment - again, it's the friction areas (stationary and moving interface) that are typically your weak spots. Any place where parts are exposed to turning, rotation, sealing, sliding, rubbing, rolling, flowing, or impact are subject to earlier failure, and should get extra attention.

- Computer and Electronic back up -Back up all programs for computers and PLC with all annotations. Use two different mediums to store programs, such as tape, CD, or floppy disk. Store your copies in different air-conditioned locations. Verify your program copy is correct. Most software allows you to make sure that what you copied is in the computer. Use it. For an EPROM, get a spare copy from the vendor if you are unable to copy it. Finally, print out a hard copy of the program with documentation (because backups seem to disappear!).

- Instrumentation components- Develop a hard copy of instrumentation calibration procedures and initial set-up parameters. During any PM calibration, make sure the sensing lines are clean. Sensing line plugging is a particularly common problem on powders or slurry applications.

- Electrical components- Suggested PMs on your electrical equipment might include motor testing (including meggering, DC high potential testing, surge testing, rotor impedance, DC brush wear, etc.) Your motor heaters keep moisture out, so don't forget to use an amp probe on them. In addition to motors, test your breakers and verify / record overloads and trip settings. While you're testing, remember to inspect your termination connections, and ensure the electrical cabinets are clean and sealed. Finally, perform operational tests (such as verifying inputs and outputs match the electrical drawings, testing equipment safety devices, and testing "run" and "stop" permissive logic).

- Structural supports and piping- Inspect coatings and general painting using a thickness gauge or spark testing. Check critical welds for cracks using visual inspection or ultrasonic testing. Inspect tanks and vessels for required standards and codes. Look for loose connections or movement at connections.

- Post PM… The final stage of the PM is for maintenance to review equipment performance after the PM is complete to ensure no operating problems. One method is to record operating and predictive maintenance readings (vibration, thermographpy, etc.) after the equipment is released to operations.

WHEN TO PM?

So how do you decide when to PM a piece of equipment? A typical PM program uses a computer or someone from maintenance is designated to add equipment PMs. A PM is added to the system, and then once a month the computer cranks out a PM work order. The System Schedule we discussed earlier should be used to coordinate all the PM's for a particular system and group them together. The System Schedule is used to focus maintenance and the rest of the plant on one system at a time. Maintenance can (and should) review system performance before and after the PM. Engineering, operations and purchasing are also aware of maintenance activates relating to a particular system. Using a simple Gantt chart like the one below tells everybody in the plant that maintenance is planning to work on HV system in October.

These maintenance activities are transferred to the overall Plant Schedule.

PM System Schedule				2003											
	System PM	Start Date	End Date	October				November				December			
1	Heat and Vent	10-3	10-17	x	x	x									
2	Service Water	11-23	11-27							x					
3	Control Air	12-5	12-19									x	x		
4	Limestone	12-20	01-03											x	x

To organize the PM schedule, take all your PMs and display them for a calendar year. Example of a weekly PM would be System "A" - 1st week March; System "B" - 2nd week March; System "C" - 3rd week March. The point is to keep PM's associated with one system group together which will limit interruptions in operations and reduce excessive travel time for maintenance.

The next item to consider is a reduction in the number of PM periods. Typically, maintenance PM's equipment are based on the manufacturer's recommendation, and vary any where from hourly to annually. Try to limit the number of PM periods to: Daily, Weekly, Bi-weekly, Monthly, Semi-annually, or Annually. An example of this could be a PM on a pump and coupling. You could have a PM on the pump every three weeks and the coupling every five weeks. While maintenance is at the pump, the pump is locked out, so why not do the coupling at the same time? If the pump showed no performance problems, you may want to shift the pump and coupling to every four weeks. If there is problem, then shift pump or coupling PM to every two weeks, but keep them together. Better yet, while the system is down, look at other associated equipment you can PM now, such as instrumentation or motor testing.

Another obstacle on "When" to PM is the use of the equipment's operating time (sometimes call the equipment run time). Assume we have a PM to change the gearbox oil every 160 hours. The reason equipment run time is difficult is that the computer puts out a PM exactly after 160 hours. If a PM were required, would you shut it down the equipment at the 160-hour mark in the middle of production run? No, you are more likely wait until the end of the day or even next week. Run time should be used as a warning for scheduling equipment overhauls and mandatory equipment lubrication and adjustments. So whenever possible, try to change an equipment run time PM to a calendar based schedule. Using the example of the 160-hour gearbox PM, if the gearbox operates only 40 hours per week, we could change the 160 hours PM to once a month. In addition to the gearbox PM every month, planning can now group other PM's associated to this system.

Failure of the PM program

So far we have discussed "What to PM", "How to PM" and "When to PM" equipment, but some equipment continues to fail. If equipment is failing, then the PM program is failing. The following is a list of items that may cause a PM program to fail.

PM activity causes failures instead of preventing them. Most equipment failures happen just after start-up or at the end of the equipment life cycle. By doing the PM, you are forcing the equipment to go through the start-up phase again. A PM is like equipment surgery; you need to definitely understand the benefit from it.

PM description is missing detail. Test all your PM's for details. Have a third class technician who is not familiar with the equipment walk through the PM with the person who wrote the PM and the maintenance supervisor. Update the PM before releasing it to maintenance. Make sure to fill in all the blanks.

Missing Pre or Post PM. In this hurry up and get it done now world, we sometimes forget to give maintenance the time to monitor the equipment, both before and after a pm. During my career, if faced with troubleshooting a problem, the first question that came out of everyone's mouth was "didn't maintenance just work on that?" As I thought about this, I realized that maintenance didn't own this problem, I did. They were often hurrying from one job to the next. I needed to give them the time to do the job correctly the first time, including time before and after a pm to ensure the equipment is operating correctly.

Abuse of the "P" type work order. A preventive maintenance task should not be confused with a repeated equipment failure task. For instance, a pump manufacturer recommends adjusting the pump packing every week. If pump packing is failing every week, you shouldn't use the "P" work order to replace packing. Instead, every time the packing fails write an "R" type work order. The "R" type work order is for replace pump packing and the "P" type work order is for adjusting the pump packing. Even further, if you want to resolve this problem, write an "M" type work to resolve pump packing failure.

No review of PM program. The RPM method is one technique to track PM performance. Assume you are following the manufacturer's PM recommendations and schedule. Also assume you have a monthly PM to lube pump bearings. This should be enough, right? Yet, you're still receiving "R" type work orders on the equipment. A review of the problem should occur. Is the PM wrong? Is there an incorrect application? Is the mechanic doing something wrong? Don't hesitate to examine your program if it is not performing the way it should.

PM is not convenient. Most equipment PM's are a scheduled function, so you decide when is the best time for your plant, equipment, and people. As we discussed early in "Scheduling", you need to consider work environment, holidays and other company activities. Example of this is doing a 3000 miles PM on your own car. Assume the weather outside is raining with a cold breeze from the north. Would you lie on the cold wet driveway to change the oil? No; then why do you ask your people to do so. What would you do? Delay it until next weekend when it will be in the mid 70's. Heck, it's such a nice day you'll probably change the oil, check all the fluid, change the wiper blades and vacuum the inside of the car while listening to the oldies! I know some PM tasks are critical, but most can be delayed a little bit, so make it convenient for the person doing the PM.

Final Note: To fine tune any PM program, you need to have a dedicated maintenance person assigned to each system. This person is responsible for detailing information on each PM, by using photos, videos or drawings and supply detailed description on, how to do the PM. Remember, their purpose is to make it easier for the next person and increase equipment reliability.

7.4 Predictive Maintenance

Predictive maintenance is an early warning tool to identify any equipment or system problems. What is the best tool to do this? You're right - your people are the best predictive maintenance tool that you have! Any time a person writes an "R" work order on a piece of equipment that is either operating or undergoing an inspection, it is predictive maintenance. Examples of feedback from your employees could include an operator noticing a noise from a pump bearing, or when a mechanic rebuilding a fan notices a crack in fan shaft, or an electrician smelling burnt insulation.

Remember that half the battle to solving problems is locating problems before they become PROBLEMS. If I am not mistaken, most operators or technicians don't get any extra money for finding problems. So to keep this predictive maintenance tool (people) plugged in, it will require a manager that listens and acts on the information. Listening to problem means supplying positive feedback for locating a problem and making it easy to get the problem into the work order system. Acting on information means that you are using a priority system that solves problems first, such as the RPM method. The day a manager stops listening is the day you unplug the best predictive maintenance tool you own. Stop acting on these problems and you may not see another work order for a long time. However, if you use this tool correctly, it becomes an early warning signal that allows the plant some time before taking action, such as scheduling outage of equipment to fit operation requirements. This allows maintenance time to schedule workforce and locate parts and tools for the repair.

Traditionally, industry associates predictive maintenance with the use of high tech equipment to monitor the performance of equipment. The benefit of using this technology in plant maintenance is significant – but only if used correctly. It allows maintenance to view the vital signs of equipment without "maintenance surgery" (tearing down equipment!). With this data you can increase PM frequency, delay outages and SAVE $$$$$.

Following is a list of some of the technology used in predictive maintenance.

Technology	Tools	Problems Found
Product Monitoring	Quality Control Statistical Analysis	Influent and Effluent quality problems Wear in tooling High Scrap rate
Process Trending	DCIS trending Control tuning Chart Recorder	Control problems Instrumentation problems Incorrect tuning of process loops
Vibration analysis	Digital spectrum analysis	Misalignment & balancing Material build-up Looseness or incorrect tolerance
Fluid analysis	Oil Analysis and Condition Monitoring	Mechanical wear or failure Contaminated oil Lube quality
Leak detection	Gas Detection Ultrasonic Soap and water	Loose connection Worn components
Material testing	X-ray Ultrasonic Hardness testing	Material quality Weld defects Casting defects
Thermography	Infrared camera	Poor connection Insufficient insulation Lack of lubrication
Electrical testing	Megger DC high potential Overload testing	Grounding problem Poor electrical connection Insulation quality
Visual Inspection	Microscope Bore scope Digital camera	Material defect Worn components

Table 7.4 Predictive maintenance techniques

The use of these predictive maintenance tools is regarded as a "P" type work. This scheduled task is designed to monitor the equipment's operating condition to keep the equipment safe and reliable. Industry is spending billions of dollars in high tech instrumentation to locate problems, but does not supply maintenance people the tools, time, and money to fix the problems correctly. Assume you are taking vibration readings on a pump, but you have not been supplied a laser alignment tool to align the pump correctly the *first time*. How about oil testing? You have the time to collect and send oil samples out for testing, but does your maintenance team have a portable filter unit and the time to use it? The point is making sure maintenance is given the time, training, and tools to do it right the first time. Are you spending more money and time in predictive maintenance, or in the preventive maintenance and equipment training?

Speaking of predictive maintenance instrumentation, do you have confidence in the conclusions drawn from the data? Here are some examples of data that can lead you astray.

After installing a new water pump, the vibration analysis showed an excessive bearing vibration. Reviewing the vibration data concluded there was an imbalance in the pump impeller. Just before we were ready to tear down the pump, we saw the recirculation valve was closed. All this time, the pump's excessive vibrating was due to operating the pump below manufacturer's minimum flow limit.

Another example was vibration data from a compressor. This plant had two compressors (physically located next to each other). It was reported to a manager that Compressor #1 had vibration reduction. Further investigation showed Compressor #1 wasn't even running! The vibration was coming from Compressor #2.

A similar situation happened after a rebuilt fan was placed back into service. The fan's initial vibration test showed everything was okay. However, vibration continued to rise. An hour later, an operator discovered the problem: there was no oil in the bearings!

Even though these examples may never happen in your plant, it shows the importance of knowing the equipment and system before you take any predictive maintenance readings. One way to obtain trustworthy data is to record all equipment and system operating data while using predictive instrumentation. Let's say you had a choice between 12 monthly vibration readings with no other support data, compared to four quarterly vibration readings taken at the <u>same</u> operating conditions. Which data would you use to determine it is time to rebuild an expensive pump?

For that reason, instead of just recording bearing vibration for a fan and pump, consider adding fan vibration reading supplement data (including bearing lube oil temperature and level, bearing oil pressure and flow, fan volume output, inlet air temperature, motor current, damper position, etc.). For the pump, you could also add supplemental data such as bearing lube oil temperature and level, suction and discharge pressure, pump flow rate (gpm), motor current, etc. Recording the operating data will help you locate the real problem. For example, a fan's vibration data shows the inboard bearing with high vibration. The support data showed the oil temperature 15 degrees cooler than normal. Conclusion, it was a bad oil temperature controller and not a bad bearing.

As the cost of predictive maintenance instrumentation reduces, it will become more cost effective to mount monitoring systems on the machine. This allows the operating and predictive data to be stored in the same location. This gives maintenance the capability to trend vibration data relative to other operating parameters, as well as the tools to troubleshoot the equipment correctly.

Note: Keep in mind that when adding any "P" type function, your maintenance team should be able to see a benefit, whether it's from a safer work environment or an increase in equipment reliability (reduction in "R" work orders).

8 Maintenance Engineering

"The best equipment design for Maintenance?
The design with the fewest moving parts"
Fred J. Weber

8.1 Equipment History

Equipment history is the collection of maintenance or operating data associated to a particular piece of equipment. Accurately recording parts and labor data by using the RPM method, Maintenance ID, and Equipment Part ID, we are able to easily monitor past equipment and maintenance performance.

If you recall, one purpose of the RPM method is to set the priority of work orders. The other purpose of the "R","P" and "M" stamp on a work order is to define what equipment has had a repair, a PM, or a modification in the past. Using the RPM method with the correct Maintenance ID gives you the capability of generating a simple time between repair analyses. To do this, locate the "R" work orders associated with one piece of equipment. Then, simply look at the time between the "R" type work orders (also known as the TBR, or time between repairs). The list below shows the date of three completed "R" type work orders associated to 1-WW-PMP-001 (Wastewater pump #1).

Work Order #	Date
R021234C	02/13/02
R023456C	05/15/02
R026789C	09/02/02

Table 8.1a Completed Work Order List

We can then set a time between repairs for this pump of approximately 3 months. Taking it one more step, we can add the Equipment Part ID to each work order so that we can determine the life cycle of each component of the pump. Review these three work orders again for 1-WW-PMP-001 with the Equipment Part ID added.

Work Order #	Date	Equipment Part ID
R021234C	02/10/02	1-WW-PMP-001-0005 1-WW-PMP-001-0023 1-WW-PMP-001-0187
R023456C	05/15/02	1-WW-PLC-002-0063
R026789C	09/02/02	1-WW-PMP-001-0005 1-WW-PMP-001-0023

Table 8.1b Completed Work Order and Equipment Part ID List

This example shows the pump components 1-WW-PMP-001-0005 (seal) and 1-WW-PMP-001-0023 (inboard bearing) have an approximate life of seven months for this particular pump. Look at Work Order # R003456C on 05/15/02. Notice that the Equipment Part ID is 1-WW-PLC-002-0063 (PLC input card) was replaced. This Equipment Part ID confirms the pump wasn't the problem. Instead, it was a PLC card failure. The addition of the Equipment Part ID enables you to find the equipment component life, and double checks that the correct equipment is responsible for the problem. The Equipment Part ID data changes the pump repair life from 3 months to 7 months due to the PLC card failure.

Of course, analyzing equipment performance is only as effective as the data collected by maintenance. If the data is faulty, then your analysis will be skewed also. For the data to be useful, it requires someone in your organization to change the Maintenance ID from 1-WW-PMP-001 (pump) to 1-WW-PLC-002 (PLC card). As we saw above, the wrong equipment data leads to a wrong conclusion. However, with accurate data it reveals that the inboard bearing 1-WW-PMP-001-0023 has operating life of seven months. Remember, there is only one 1-WW-PMP-001-0023 in your plant!

8.2 Failure Analysis

Failure Analysis is a step-by-step procedure used to find out why a process or a particular piece of equipment has failed. In addition, it is also used to answer the Plant Manager's question, "Why is this @#&* pump tripping all the time?" Various methods of failure analysis are used to locate the root cause of a problem. The path you take to prevent failures from resurfacing is not important, but be aware that the results on equipment downtime, inventory, and labor costs can be dramatic.

To see if any type of failure analysis would benefit your organization, answer the following questions with either a yes or a no:

- Was the equipment modified to allow easy access to clear plugging or spills?
- Are isolation valves added to any system to allow access to the failed equipment?
- Was a back-up system added due to problem equipment?
- Are mechanics dedicated to any piece of equipment due to problems?
- Has any piece of equipment failed two times in a year?
- Have you increased the spare parts max/min due to repeated failures?
- Is the equipment constantly jumpered out or bypassed?
- Do mechanics carry spare parts for any piece of equipment in their toolbox?
- Is any equipment operating in manual instead of automatic?

If you answered *yes* to any of these questions, you need to develop a way to solve problems. Stop FIXING IT, SOLVE IT!

Before going further into failure analysis, I want to express that no failure analysis technique will work in maintenance until two items are acknowledged: the *Maintenance Paradox* and *Time*.

Typically, the *Maintenance Paradox* can be explained by saying that the employee simply wants to understand what the benefits of problem solving are. In other words, what's in it for me (and my fellow employees)? Often the only reward a maintenance person sees in solving equipment problems in your plant is the loss of their job (or a co - workers), or at least lost overtime. Change the reward and you'll see a change in performance.

The second item is *Time*: maintenance people need time to focus on the problem. Most maintenance teams have time to repair the same piece of equipment fifty times, but not to find a permanent solution. The lack of time is caused by management's demands on maintenance. Typically, the equipment is down and all the boss can say is "FIX IT NOW!" Maintenance folks should be given time to really look at the problem.

Back to failure analysis - any tool you can find to assist maintenance in solving repeated problems should be used immediately. One approach is called *equipment failure analysis*. There are several seminars and books on this subject. For any failure analysis to work, you must:

- develop a team to focus on the problem
- collect the data
- analyze and define the problem
- develop and implement a solution
- monitor the results

Lets talk about each step…

When **developing your focus team**, keep it a small technical group comprised of personnel from Maintenance, Operations, Engineering, as well as an Equipment Manufacturer's representative. Remember, their goal is to focus on the equipment problem.

Your team should **collect data**, then organize and review all information pertaining to the equipment. Include a variety of information in your data, including:

- identifying any failed or problem components.
- listening to and interviewing people associated with the equipment and system.
- reviewing process trends, such as strip charts or quality control reports.

- verifying that operating procedures meet manufacturer's recommendations.
- checking start-up information for signs of design or application problems.
- reviewing any design changes by reviewing all drawings associated to equipment.
- reviewing all purchase orders associated to the equipment.
- reviewing a maintenance procedure which includes repairs, preventive maintenance, and predictive maintenance
- locating any piece of documentation associated with the equipment history

When your team finally gets down to **analyzing and defining the problem**, they should use all information available to them. One pitfall to avoid here is the classic line "It's been like that for X number of years." I've made a career chasing down these very types of problems! Don't settle for lame excuses; look at the data for clues. One analysis technique is to continually ask the question "Why…?" An example of this would be to "Investigate pump bearing failure". Will asking "why" lead us to a potential root cause of the pumps bearing problem?

Why did the pump bearing fail? The pump was operating 120% capacity.

Why was pump operating at 120% capacity? The flow control valve failed open.

Why did the flow control valve fail open? The analog output card failed.

Why did the analog card fail for the fifth time in one year? The repair shop for the analog output card was installing low quality components.

Although only an example, you can see how asking "Why" several times is one method that can lead you to the root cause of problem. The problem is it focus

A slightly different approach is to ask the question "How can?" or " What could cause?" This approach opens the door to

ALL the potential reasons for failure. The benefit to this technique is the ability to find several potential solutions to a problem.

The "How can" Procedure goes like this:

- It simply starts by asking the question "How can" this problem occur?
- Next, list every possible potential cause of this problem.
- Investigate each possibility.
- Finally, rank each cause (1-100%) on the likelihood of happening based on your support data.

Let's revisit the pump bearing failure using the "How can" procedure.

Question… How can the pump's bearing fail?		
Probability	**Potential cause of problem**	**Investigation**
10%	Lack of lubrication	Verified PM completed as scheduled
10%	Vibration problem	All vibration readings have been within tolerance
60%	High flow	Pump received a high current alarm
10%	Low flow	Recirculation orifice controls minimum flow

Now that you have given probabilities to the various failure possibilities, the highest probability is *high pump flow*. Now ask …

Question…How can the pump flow go high?

Question…How can the pump flow go high?		
Probability	**Potential cause of problem**	**Investigation**
10%	Operators bypassed system	Trends show no other valves open on system
95%	Control valve went to 100%	Instrument tech test showed analog card failure
30%	Operator manually operated valve to 100%	Operator stated system was in auto
50%	Orifice in discharge line worn out	No inspection on discharge orifice in 8 years

So, it now appears that we have two potential paths to review. Our analysis has shown that either the analog card *or* the orifice are the prime candidates for failure. Continuing on, ask HOW CAN…

Question… How can the analog card fail?		
Probability	**Potential cause of problem**	**Investigation**
10%	Maintenance installation error	Maintenance installed the card with power off
75%	Failed component on card	Poor workmanship from repair shop

Question… How can the discharge orifice be the wrong size?		
Probability	**Potential cause of problem**	**Investigation**
10%	Installed wrong during construction	Startup data verifies correct orifice
80%	Media has worn the orifice out	Maintenance to inspect next outage

Using the HOW CAN method, you continue to put your figures on the potential problems. Look at the feedback the team generated from using "How Can." In combination with data analysis, you have defined potential problems. You've also just built a troubleshooting procedure for pump 1-WW-PMP-001. Imagine if this information could be stored in a database for future use…the "How can?" technique is used by your top maintenance people every day, but instead of writing it down, they're smart enough to do it in their head!

So far, our team has collected the data, and their analysis has proposed two possible problems. Next, we need to **develop and implement a solution**. Once a potential problem has been identified you need to ask, "How can" the problem be fixed. List the potential solutions to each problem, only this time factor in management's ranking system, _time and money_. The team should supply management with several recommendations to solve the problem and prevent it from occurring again. Using our example, we need to ask how can we stop the analog card from failing and how to address the orifice problem.

Your team should make a list of recommended solutions, showing time and approximate cost. For the card, they may suggest developing further in house training on test equipment at a cost of $23,000 for two months. As another choice, propose using only OEM (original equipment manufacturer) to repair all cards. This change would increase the annual card repair costs approximately 25% to $6,000. As for the orifice problem, the team says inspect or replace orifice at a cost of between $1200 and $1600. Another approach would be to simply review the flow rate specifications with the pump manufacturer.
With the team's recommendations, management takes action by approving the time and money to resolve the problem.

Now, you need to **monitor results** to see if the changes made a difference. Once a solution is implemented, management needs to determine if the solution increased the safety or reliability of the equipment. One tool that can be used to confirm the results is the RPM method. If the changes benefited the plant's performance, there should be a reduction in "R" type work orders.

Despite your best efforts, sometimes it is difficult to find an equipment problem. You could ask a thousand "Why" or "How can" questions and still not find the problem. One approach I discussed earlier in the section titled "History of the RPM" was to look at the problem system and associated equipment as a *new installation*. Test and check every component like its going to be energized for the first time. Before you start, read the service manual, review drawings and understand the basic operation. Now it's wrench time! Verify all connections, test all inputs and outputs, calibrate instrumentation, test system performance compared to design data, verify control logic, check PM and predictive maintenance activities, and call the manufacturer of the equipment and obtain three end users of equipment. You may not be the only one with this problem. If all else fails, get a field engineer on site to review the problem and train your maintenance staff. Finally, it probably goes without saying, but to solve it, you need to identify it. Here are a few places to look for equipment failures.

Human error - during the installation and operation of equipment, people make mistakes. The important thing is what you do to prevent the mistake from happening again. As a manager, you need to change the focus of maintenance from blaming to assisting everyone.

Design change – maintenance folks and plant engineering both love to change equipment. Most of the time, maintenance feels engineering really didn't know what they're doing. The problem is that they make changes without understanding the complete design or process. A hidden design change is when purchasing decides to replace a component with a less expensive one.

Design error - sometimes maintenance is right, and the original manufacturer of equipment or your engineering department is at fault. Some places to look at are application of equipment, deterioration of parts (fatigue or corrosion), or process control logic.

8.3 Equipment Design

Early in my career, I learned to leave my ego at the door and talk to maintenance before any equipment modification. I can't tell you the number of times that maintenance or construction people have made me look smarter than I am with their inventive thinking. The problem is we've built a wall between maintenance and engineering. The Engineering department is like Nikola Tesla, while the Maintenance department is like Thomas Edison. Both men made major contributions to the electrical industry; they just didn't get along with each other. Imagine what they could have done if they had teamed up! Don't make the same mistake these two great inventors did. I can't stress enough the importance of keeping maintenance in your design loop.

The following is a list of Weber's design tips I've learned from maintenance or picked up the hard way. I've broken down the information six categories:

- General Engineering
- Safety and Environmental
- Mechanical Design
- Electrical Design and Documentation
- Instrumentation Design and Documentation
- Computer Control Logic Design

General Engineering

The best equipment design for maintenance is the design with the fewest moving parts.

Don't re-invent the wheel; use equipment that's been successful in industry. Your plant is not the vendor's research and development lab.

Get advice from construction and maintenance people during the project review phase before you place your design into reality. Why? Because changes on paper are easier than ones in steel. Review a similar project. Talk to craft personnel about project activities such as crane lifts with ironworkers, conduit layout with electricians, and start-up problems with instrumentation technicians. One problem is how to ask for suggestions from maintenance. Start with an idea, put in writing, and then approach maintenance and ask "What do you think?" One thing you can count on is that maintenance *always* has an opinion (especially if it's an engineer's idea!).

Supply a process and control description. Maintenance people have "inventor type" personalities who require an understanding of how the system and equipment work. Describe the basic physics, chemistry or logic of your design. You know your design is good if it meets the approval of maintenance.

Consider the cost of spare parts in a design change. Review the cost of the old spare parts in your warehouse, plus the cost of new spares you need to purchase in your design evaluation.

Utilize word of mouth. Talk with other engineers and maintenance people. Even in this competitive world it still seems that people on the front line seem to help each other. Call several end users and discuss performance of equipment similar to your application.

Consider "IRMO" - somebody must Install, Remove, Maintain and Operate it. Design equipment to allow maintenance easy access. Check clearance for installation and removal. Design connections at inlet, outlet, air, hydraulic and power to allow equipment removal. Equipment access for manual operation, inspection or any calibration needs to be considered. Remember, even the Hubbell telescope needed to be repaired.

Document the equipment with photos and videos. Take pictures or a video of the equipment before, during, and after design progress reports. One of the first things I tell young engineers starting a project is to take photos of equipment and the surrounding area of the project site. The engineer is able to get a perspective of real objects relative to the lines on a drafting board (for the younger generation I mean the computer aided drafting screen).

Create a Logbook. Record technical data and vendor information such as contacts, phone numbers, and discussions. This is especially important if your memory is as poor as mine is (memory the first thing to go…or at least one of the first…)

Build Technical library of books and technical manuals. Sort the books by component type such as valves, analyzers, piping, or electronics. Sort drawings and service manuals by system, such as heating and ventilation.

Consider the interface between vendors. This gray area of responsibility is where most equipment design and start-up problems occur. Detailing all interfaces between vendors is your responsibility. One method to reduce your responsibility is to reduce the number of interfaces (vendors). Examples of interface problems might include an electrical interface issue where some field instrumentation device goes to a control panel. To avoid the problem, supply a terminal strip drawing of both pieces of equipment and their wiring. This eliminates any surprises during start up of equipment. Or how about the mechanical interface? Maybe there is a problem with an equipment bolt hole pattern to a structural base. Supply a general arrangement drawing to the equipment supplier and structural designer. If you need to create a separate interface drawing, do it before you lift the equipment in the air.

Purchasing new equipment - try to use a minimum of two vendors for pricing and get it in writing. Build an "equipment information checklist" for all equipment purchased. Maintenance requires service manuals, electrical drawings, and PLC programs to be able to service this equipment in the future. This is the time to ask for it, not after you have paid for it. (This is a repeat from the “Parts” module, but I wanted to make sure to remind you!)

Implement design changes - Develop an information flow path using the Maintenance ID for design changes and list them with the operator of the system, Maintenance and Engineering.

One method is to list "M" type work orders associated to each system as shown below.

Waste Water System (WW) Design Changes

WO #	Maintenance ID	Modification Description	By	Date
M020012	1-WW-PMP-001	Replaced pump packing to a mechanical seal design model M-Seal 23-34	FJW	01/04/02

You can use any method, just make sure the people operating and working on the equipment know about the design change. A final note on design changes; try not to implement a design change on Friday afternoon because most people want to go home on the weekend. Problems due to a last minute design change do not endear you to the operators that are stuck with it all night or all weekend!

Safety and Environmental

Do they know how to do it safely? Maintenance will be required to repair and PM every piece of equipment in your plant. Therefore, every piece of equipment should have a lockout procedure.

Consider a fail safe design - what do you want to happen to your equipment or process if you loose air, water, power, pressure, temperature, or flow? One possible solution could be to open a vent valve, start stand-by equipment, or sound an alarm. Consider the design of a seal water solenoid for a pump. Should you use a N.O. (normally open) or N.C. (normally closed) solenoid? You need to determine if you want seal water flow to the pump if you lose power to the solenoid. If the answer is, "seal water required" then use a N.O. (normally open) solenoid.

Take the time to ask yourself some "What if?" questions - What if the device is disconnected or failed? What do want to happen? Assume a temperature switch fails open, what should happen? Maybe alarm the operator or switch the process control from auto to manual mode. What if your equipment exceeds the operating limits? Maybe printout of an alarm or reduce equipment speed. What if the equipment jams or plugs? Consider breaking a shear pin, tripping an overload, or opening a vent valve. Play devil's advocate. Question your design, and get opinions from other people.

Be careful of equipment modifications - Several accidents have been caused by poor design modification of existing system. Always check with the equipment manufacturer before design changes. Review all failure modes, effects on an existing system, and consider the safety / environmental impact.

Include environmental consideration in your design process - design equipment with reusable and modular components to reduce landfill.

Mechanical Design

Reduce the moving parts - use gravity feed versus pumping, use programmable logic controller versus relay control.

Minimize changes in direction - reduce bends and 90-degree fittings that change the direction of flow of any media. These bends will typically cause higher energy requirements and increase wear points. Use large sweeps or rotate equipment to prevent sharp changes in direction.

Use standard sizes in your design. Use parts that are available today <u>*and*</u> tomorrow. If the design calls for a 5-½ inch standard pipe, use a 6-inch pipe if possible. If the design calls for a small bearing in a conveyor idler design, consider using the same bearing design used for the wheel bearings of an automobile.
Another way to *check parts availability* is to look at the number of units produced each year. Example: Assume 30,000 feet of 5½ standard pipe is produced each year compared to 1,000,000 feet of 6-inch pipe produced annually. A good chance the 6-inch pipe is available in one week while the 5½ standard pipe may have a lead-time of four months.

Material selection should be designed for the worst chemical process media and environment. Operations tendency is to push a process to the limits and keep it there.

Adding tolerances aren't free, you pay extra for every tight tolerance you add to your drawing. Example of this could be changing the surface tolerance on a shaft from 250 microns to 16 microns. Do you know the cost and is it required?

Is it achievable? When adding dimension and using tolerances, consider the person doing the work. Define the important dimensions on drawings with tolerances, but make sure it can be achieved. It's easy to show a centerline dimension on a drawing. Be sure you can measure it when sitting on an I-beam 110 feet in the air!

Prevent using roof penetration on enclosures. If possible, move piping or conduit to the sides of enclosures. Assume that all penetrations will leak, so control what it's going to leak on.

Redundant and isolation paradox - sometimes when a piece of equipment fails to operate correctly, the first thing that engineering or maintenance does is to add more equipment. Let's consider an example. Assume a control valve has a worn valve body and continues to leak by. A typical engineering solution would be to add an isolation valves on either side of the control valve to allow maintenance to isolate the control valve. So, now the results may ultimately be three leaking valves instead of one. Instead of adding valves to the system, ask yourself; if the valve is actually required, is it a bad application for valve, or can the valve be repaired if the system is down? Of course, all equipment must be safe to work on, but adding valves is only hiding the real problem. Also remember that the new equipment requires more spare parts, modifications to the operating procedure, and changes on engineering drawings.

Electrical Design and Documentation

Conduit installation considerations. Keep in mind that maintenance may have to remove the equipment. Imagine what a headache it would be to install equipment with the conduit already in place. Also, consider the consequence if someone stands on the conduit, because they will.

Electricity and water don't mix. In theory, water should not be in any electrical conduit, but somehow it always does. A conduit layout should "assume" that water will get into the conduit by weather, equipment wash downs, loose conduit fittings, or condensation. Therefore control where the water goes by sealing conduit enclosure penetrations, avoiding enclosure top penetrations above electronic and electrical devices, and by orienting conduit fitting covers down to avoid water entry. Also, select a higher quality material as a cheap insurance policy to protect equipment against a corrosive environment and a replacement cost in ten years.

Enclosure design considerations

- Separate incoming power sources (AC, DC, high voltage, low voltage)
- Supply a separate fuse (with indicator) or a disconnect for each power source when possible.
- Enclosure size should allow for field cable / wire size, wire minimum bend radius, raceways, and easy access to internal components. Most of the time *bigger is better* here.
- Design the enclosure with spare I/O and terminals (5-10% spares) for an engineering "oops" or a manager saying, "I changed my mind, can you add a ____?"
- Supply a separate terminal strip and raceways for each field device. Keep in mind each device may have a separate power or neutral, so have room for additional wiring too. Try not to terminate directly on small electronic boards. Large field wire size may causes stress on the I/O card and make it difficult to remove later.

Drawings and Information. The goal of a maintenance electrical drawing is to place all the information on *one* drawing to prevent thumbing through service manuals at 2:00 in the morning. One approach is to simply take the information in the service manual and put it on the drawing by labeling both sides of a terminal point.

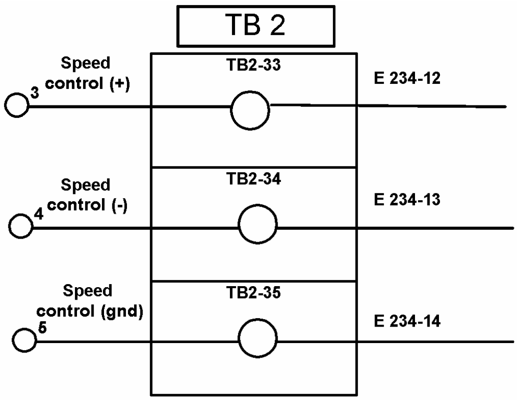


Figure 8.3a Electrical drawing

The terminal strip above shows "speed control (+)" at TB2-33 terminal point with wire E234-12. During installation, an electrician only needs to know that wire E234-12 goes to TB2-33. Maintenance needs to know all the information. If the vendor's information shows the speed control (+) and (-) moves between 0 to 10 volts DC, show it on the drawing.

Detail ground and neutral circuits. Ground loops and floating neutral problems are noted for causing random equipment problems. Supply a detailed wiring drawing of the interconnection of ground and neutral to and from all devices.

Cross-reference wire numbers to a drawing. Mark wiring numbers on electrical drawings where they originated. Example: Wire # E234-12…is wire number 12, originating on drawing # E-234

Document information on the electrical drawings, process drawings, and computer annotations the same way. For example, a process diagram for Plant # 2 Waste Water system labeled a seal water flow switch for FLS-002. To be consistent, the electrical drawings and computer logic should use the same annotation, FLS-002, as shown below.

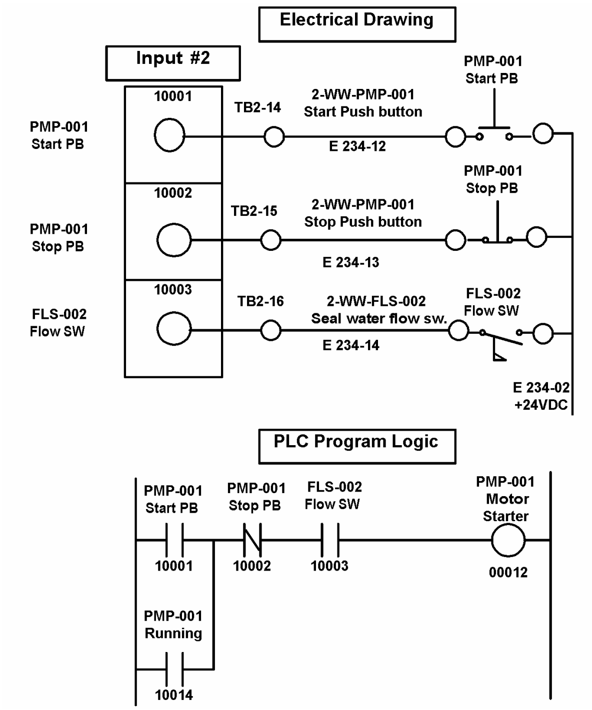


Figure 8.3b Electrical and PLC drawing

(Quick wiring note: try to display field devices on drawings in the deactivated state, the way an electrician would wire the device)

Instrumentation Design and Documentation

On electronic boards, *establish oscilloscope and meter test points* or install permanent metering devices. Describe a set up procedure for an oscilloscope assuming maintenance only tests this device every five years. The oscilloscope set-up should show connections and initial settings. Also, supply examples of correct and faulty waveforms.

Generate a hard copy record of instrumentation calibration and set-up information. Someday you may need to install a new instrument, so this info is vital.

Use the latest proven electronic technology, but look for reliability. Remember electronic technology only has a service life of 10 years before vendors stop supporting it and you are unable to get parts.

Standardize on instrumentation tubing, fittings and instrument connections throughout the plant and on all vendor supplied equipment.

Consider instrumentation isolation and by-pass systems - the design of any instrument should allow a technician safe access to test equipment online if possible. Design and supply a procedure to isolate, vent, clean, drain and test any instrument without disturbing the process. Design instrument lines between the process and instrument for easy blow down of sensing lines to prevent blockage.

Equipment feedback - Technology is too inexpensive (aka *cheap*) not to incorporate it in equipment design. Add the bells and whistles to support operating and troubleshooting any equipment. Warn the operator about an equipment failure by using a minimum of two different methods, such as annunciator alarms, horns, printers or screen displays. Also, supply gauges, displays, lights and switches to give operations information on the equipment performance and process data though computer interfaces. Display what is required to start / stop or switch from manual to automatic. After all, it's all hidden in the control logic, but why keep it a secret? Show operators equipment operating limits, alarm points, and live/historical trends of performance data.

Some real world examples of the importance of missing feedback from my past jobs include soot blower drain valves that use temperature to open and close, but had no limit switches supplied to let operators know if valve is open or close. If the valve was stuck open, operations would not be aware of it, and steam would continue to blow to the drains. Another example is a hydraulic cylinder that wouldn't move. The vendor didn't supply blind and rod cylinder pressure gauges for maintenance to troubleshoot system.

Computer Control Logic Design

As you have probably gathered so far in this book, I am not the biggest computer fan in the world. That's probably because I'm a dinosaur that remembers that we used to get jobs done just fine without them! However, it would be pretty crazy to deny the impact of computers on any industry. Part of the "computer thing" is designing the logic that tells stuff how to operate. I realize that many readers of this book will never design logic, but it is such an integral part of computers, I felt the need to mention it in the book. Remember, the cardinal rule is that if you can't do it, hire someone who can!

Develop an understanding of computer logic. One of the key elements that help operations and maintenance understand how a system or piece of equipment works is to understand its control logic. Once they grasp the logic, they'll know what starts, stops or trips the equipment. History of controls has gone from hard-wired relay logic to PLC (programmable logic controller) and then to DCS (distributed control systems). Before PLC, it was easy for maintenance to trace wires or use a VOM to troubleshoot a problem or understand equipment logic. If a pump won't start, all you did was look for the relay that was supposed to pick up by checking a few terminals for power. Today, it's all done with ones and zeros, and some of them are hidden from maintenance. The vendor's reason for hiding the logic? They're worried about the competition rather than making life easier for maintenance.

Minimize the different number of DCS or PLC systems. Design a plant control system that reduces the number of different Distribute Control Systems or programmable logic controllers. Some vendors have a standard control system package, but you should make sure it matches yours. One plant I worked at had seven different PLC controllers. This required seven specific equipment and logic training classes, seven programmable software packages and devices to view the program, seven styles of annotation and documentation, and seven techniques to save and back-up the system. What a headache! Choose the control system that allows maintenance to troubleshoot the equipment, even if it's only three times a year.

Back up and restore failed systems. Most programs will to be modified once the system is up and running. When changes are made, keep a separate backup of the old and the new program. Maintenance and engineering require a basic step-by-step procedure to backup systems using two different mediums (tape drive, optical drive, floppy disk or CD). Once a back up is made, a procedure is required to verify the program is actually stored on the backup media correctly. If you don't have the capability to review backup tape, send it to equipment manufacture for verification. Finally, write step-by-step procedures to reload the computer from scratch. A procedure that answers the question "The computer hard drive failed, now what?"

File management structures. Show an overview of the file structure in the program with a brief description of each folder. An example of this could be a folder called "Historian", which could be an application used to collect time stamped operating data. In addition, configure programs to separate customer's files from application programs. One method to achieve this is to have all user data stored under a folder called "Customer" which defines where the user can go and not go.

Programming documentation and annotation needs to be defined with the same information as on the electrical drawing. If the electrical drawing calls for a flow switch to be called 1-WW-FLS-023, then the logic annotation should be 1-WW-FLS-023 or for a FLS-023 in a program for waste water system.

Control logic drawing and information. Use some type of standard to display control drawing logic such as SAMA (Scientific Appliance Manufacture Association). Control logic loop drawings show the general control logic, but don't describe the settings of all parameters. An example is a PID block; the SAMA drawing will show only the basic functions, such as measurement, output, set point and feedback. However, a hard copy would show the hidden parameters such as proportional bands, integrals, derivatives, limits, or initial start-up settings.

Therefore, besides the drawing, make sure to generate a hard copy of all control logic, control block parameters, and system files.

What is the best way to program logic? That's easy - the best method to program control logic is to simply ask maintenance to describe how the logic works! If they can't, rewrite it or add comments so they don't have pull out a manual. Having said that, realize that the flexibility of today's computer control system allows logic designer to become an artist. Programming control logic system needs to use simple AND / OR logic, so don't use fancy programming functions that maintenance has to research every time they work on the equipment (sequencer, bit rotates, or hidden subroutines). The reason control engineers used fancy functions in the past was due to memory size, but today that excuse is gone. Some engineers just like to experiment by using every function available in PLC software just to say they did. They are out there; I've worked with a few. Simply test your program by asking maintenance to describe how the logic works. If they understand it, you did your job.

Establish standards for programming logic for equipment such as pump, valve, or fan. A standard for pump logic could be something like:

First line - pump permissive logic
Second line - start-Stop logic
Third line - trip and alarm logic
Fourth line - auto-manual controls

Also, keep logic close together just like the information on the electrical drawings, so maintenance goes to ONE screen to see what is starting or stopping a pump. As for control logic, be aware that often industry programming consultants are paid for the number of lines of logic created, instead of being paid based on the end user's ability to understand the control logic. Be sure that you don't pay a consultant for quantity…insist on quality.

Maintenance Problems in Distributed Control System (DCS). Some DCS systems don't allow maintenance to find where inputs and outputs from control logic are coming from. Why is this a problem to maintenance? If they are required to electronically jumper an output, they have no idea what they are going to effect. This could by-pass other equipment permits that allow safe operation. Updated control logic drawings *must* be maintained until all DCS vendors resolve this problem.

8.4 Project Management

Project management is the task of taking an idea from paper to reality. A project manager needs to organize and monitor the performance of any size job, whether it is as small as an outage for a single piece of equipment or as large as a major capital project. This requires a person that has the technical capability to understand the real man-hours and costs involved for each phase of the project. Certainly, he should know that it takes more than 80 man hours to run 1000 feet of 10" pipe, and less than three months to develop electrical drawings for a simple pump station. However, the one crucial characteristic of a good project manager is the flexibility to listen to other ideas and not be afraid to act on a better one.

Most projects require two separate phases of management – the *paper phase* and the *construction phase*. The **paper phase** is often characterized as the paper work needed to build the pyramid, while the construction phase is the reality of bringing the pyramid to life. As for the paper phase, you must be concerned with a number of issues. First, the *scope of the work* defines the direction you take for the entire project. An example of this would be the type of condenser selected for a HVAC system (either air-cooled or water-cooled). This is the time you begin brainstorming, sketching out ideas on napkins at lunch and asking maintenance and other end users for feedback. Define the work scope using a one line or piping & instrument drawing. Use the diagram to write a brief description about the science behind the project. Answer the question, "How does it work?" People will only approve what they understand.

Next, create a "parts and task" list.

*Part List…*This list consists of parts ("big ticket items") required for your project. Build a simple spreadsheet defining a list of the parts, manufacturer, and the company responsible to buy the parts and estimated costs.

Item	Responsibility	Manufacturer	Part Description	Cost
1	Owner	Wrench Time	200 hp compressor	$22,000

Figure 8.4a Parts List

Task List...this list defines the events that require labor hours, such as unloading trucks or developing the electrical drawings. The task list is built by walking through each event of the project from beginning to the completion (finalizing as-built drawings). Estimate the labor hours and cost of temporary material or equipment required for each major task in your project.

Item	Resp.	Task	Labor	Eq'pt	Mat'l	Total Cost
1	Owner	Install compressor	100 mhrs $5800	Crane $2700	Piping $800	$9300

Figure 8.4b Task List

The Task List answers the questions like "Who is responsible for engineering? Unloading trucks? Installing conduit? Starting-up equipment? Are you using house air or renting a compressor? You get the idea.

Another key portion of the paper phase is to establish a justification for the project. This is accomplished in the *design stage*. Simply put, is the project worth doing? One method to determine the cost justification is to take the costs from the parts and task list and compare them to the increase of production rate or reduction in equipment repair costs. A question your manager may ask is "What is the pay back period?" (or the Return on Investment). This is just the number days of using the finished project that it takes to actually pay for the project. An example of this may be a project to upgrade an air compressor control system. Assume the project cost is $30,000 and the benefit is $300 a day is energy cost. Pay back period is then 100 days. A good rule of thumb? There is none. It depends on your management team to determine an acceptable pay back period. Don't forget about the spares in the warehouse. When changing the design of equipment, keep in mind the cost of removing existing spare parts in the warehouse and the cost of new spares to replace them as part of your cost evaluation.

If the project is acceptable to management, it's time to finalize the details of the design. Here are few things to consider in the design phase to make the construction phase easier.

Limit the number of vendors / contracts, because more is not necessarily better. Make sure the contractor is responsible for small items on the project (bolts, electrical fittings, etc.). It seems to be extra important to the contractor when he is paying for it. In addition, you won't spend the whole job chasing conduit fittings and 1/2 bolts!

Shop test as much as possible. As for mechanical, pre assemble equipment in the shop if realistic to do so. Also, consider testing field connections in the shop between two parts. Assembly problems in the field have a major impact and cost on any project. For electrical equipment, energize, test, and simulate logic on every possible piece of equipment.

Supply weights and lifting information, because <u>every</u> item needs to be moved.

Supply service manuals with the equipment, and include information for storage, installation, and start-up. On drawings, highlight key dimensions that are required for the equipment.

Supply a contact list of vendor's information (phone, e-mail)

All the preparation work is done, and it’s time to get things engraved in stone. You’re at the *contract stage.* Before signing your name, walk though the project from start to finish, looking at the parts and task lists one last time. Confirm that the design, engineering drawings, contracts, and purchase orders cover all items on the parts and task list, while defining the responsibility of each item. Each item on the list is considered a contract, which requires the time frame to be defined. Therefore, a schedule is required to time stamp each item in the parts and task list. A Gantt chart (such as the one below) could be used to display the parts list schedule to indicate the order, promised delivery, and actual installed dates of each item. Next, add to the Gantt chart a schedule from the task list showing the start and finish dates of construction. We just defined the activities, critical path, and dates of events that need to take place to make the project a successful.

				2003							
	Event	Start Date	End Date	November				December			
1	Compressor delivery	11-29	11-29				x				
2	Crane Rental	12-2	12-9					x			
3	Install compressor	12-1	12-15					x	x		

Figure 8.4c Project Schedule

Consider items such as permits, insurance, safety and environmental requirements, utilities, and even the restroom. Most projects go over budget simply because somebody missed something from the parts or task list. One other point - don't forget to leave money in the contract for a performance testing and as-built documentation to be completed. Without $$$$, you loose any leverage with most vendor.

Something that should go without saying is to have a contract lawyer review and finalize all of the contracts. The days when a handshake was used as a contract ended when ethics became a required class in college!

If you recall, the *paper phase* laid the groundwork for your project. The drawings, contracts, and purchase orders are finalized. It's time to put it all together. You are now entering the **construction phase**.

Before construction begins, develop a safety plan for emergency medical, fire, or chemical hazards. Talk with local hospitals and fire departments about your work in the area.

Maintain MSDS sheets (keep them updated!) and other safety information. Establish a Toolbox Meeting by taking 5 to 10 minutes in the morning to discuss with everybody the day's work activities and potential hazards (such as major crane lifts or energizing equipment).

Next, develop a construction site plan. Review the utilities layout for power, water, air, restrooms, etc. Set up a material storage and receiving area with easy truck access and cribbing to keep equipment off the ground. Supply covered storage with temporary electrical power for electrical and instrumentation equipment (motor heaters). Provide a chemical and hydraulic storage with spill prevention and equipment to safely handle various products. Supply a work area that is high and dry for equipment, tool cribs, and work benches. Do a daily inspection on equipment, such as electrical ground faults, straps and chokers, cranes and general tools. Use some of the prime real estate to supply the work force a clean area for breaks, lunch, and restrooms.

Set up a field office / trailer to support site project management. You should lease or purchase two copiers (originals never leave the office), a telephone, a fax machine, a computer and general office supplies. Your on site documentation will include drawings, service manuals, safety information, contracts, purchase orders, log books, etc. Incidentally, the logbook is used to document daily site activities, such as manpower, major activities, material, deliveries, site conditions, and any design or construction changes. Another important tool is your camera – in fact, keep two cameras handy. The cameras are used to take photos or video of the site and any major activities (i.e. crane lift, location of underground utilities). Some day you may have to do it all over again, and pictures really are worth a thousand words! By the way – while you're sitting in the trailer waiting for all this crap to show up, you might also consider establishing accounts with local material suppliers for fasteners, electrical parts and general supplies.

Don’t hesitate to act as the project quality control, because engineers and fabricators make mistakes. Check fits and tolerances before moving materials. Look for the 1" mistake in bolt hole patterns or fits between different vendor’s equipment connections. Also, act as the project timekeeper. Keep to the schedule early, because it's harder to make up time later. Generate a punch list near the end of any project, detailing ALL problems to subcontractors before they reduce work force or leave site. Keep the work in front of them; just make sure any item are in their contract. Before final payment, review the contracts and punch lists one last time. Check on spare parts, training, and warranty requirements. The day you pay it, you own it.

Wrench Time Story…”project management 101”
An electrical contractor was awarded a large electrical construction project. He hired a couple of electricians to start the project. The next morning he stopped by the site late only to see his supervisor and two electricians sitting and reading the newspaper. The project manager walked up to the men and screamed “Let’s get to work”. The supervisor replied “we need some 3” conduit and fittings to start the job, not ½” conduit.“ The manager shouted “I don’t care want you think, get your @%&# to work.” The supervisor got up and picked up a 10 foot piece of ½” conduit. He took the conduit and stuck into the bending machine and proceeded to make 6 random 90-degree bends. Once completed, he removed the wildly bent conduit from the bender and threw it 20 feet. The manager said “what the hell are you doing?” and the supervisor replied “I’m starting my *oops* pile.”

<u>8.5 Safety & Environmental</u>

Safety and Environmental are the two most unappreciated departments in your company. All they are trying to do is make your work place safe and environmentally friendly, while at the same time keeping you out of jail!

<u>SAFETY</u> - the safety program simply helps to prevent accidents. Without writing a 600-page safety manual, the following is a list of items that are commonly could be used by maintenance daily: MSDS sheets, tag out and lockout, process management, job hazard analysis, respiratory requirements, or work permits such as welding or confined space. The focus of a safety department is to provide this information, and to ensure that everyone leaves the plant in the same condition after their shift as they were when they started!

<u>ENVIRONMENTAL</u> – helps to prevent all types of pollution. Pollution is the negative impact your plant has on the air, water, and land. The government stepped in years ago to help regulate the various types of pollution, and as time goes on, their rules become increasingly stringent. It is extremely important for you to know the laws that apply to your plant, because "I didn't know" is not a valid answer to inspectors.

To control pollution you need to control the plant's waste. Here are three general areas to look for waste:

Waste coming into the plant (solvents, oils, chemicals of any type)

Waste already at the plant – (sometimes the rules change in the middle of the game. Yesterday it was ok to use lead paint and asbestos, but today it's not.

Waste leaving plant (venting, draining, wastewater, scrap, runoff, heat, noise, etc.)

One obvious way to control waste is not to bring it into your plant. Review each MSDS sheet of every product used in your plant. If you find a problem, substitute it immediately and eliminate any future purchases. However, once it's in your plant, you have three ways to handle waste:

- Recycle it (paper, oil, metal, etc.)
- Treat it (scrubbing, neutralizing, etc.)
- Deposit it (waste management company)

Environmental requirements and records are just like safety information - it's the law. Therefore, the focus of the environmental department is to tie the environmental regulation to each particular system or piece of equipment.

Note: there is an excellent booklet by the EPA that describes how to set up waste control at your plant. The title is "*Facility Pollution Prevention Guide # EPA/600/R-92/088*" from May, 1992.

The Interface of Maintenance With Safety and Environmental

One reason for maintenance to bump heads with the safety and environmental departments is that from the maintenance standpoint, all they do is make more work for maintenance. After all, the safety and environmental folks just sit in office away from any plant activity, read a new regulation, and then respond with a memo. The typical memo may sound like this "*Effective 05/05/05 Safety Regulation #2249323 will be required of all maintenance personnel. Training classes start today.*" To a maintenance supervisor, this regulation is just another way he can get fired. A maintenance supervisor today is required to memorize the company's safety and environmental rules, OSHA standards, EPA regulations and all state and local regulations. If you don't think the supervisor is responsible, just wait until someone gets hurt, or someone throws the bearing oil down the drain. The supervisor gets at least a portion of the blame.

A good first step to break the ice between departments is having the safety and environmental personnel spend half an hour in the morning with the maintenance supervisor and the planner reviewing all the work orders. At this time, safety and environmental can assist and teach maintenance how the regulations apply in your plant, and also help to define "R" type safety and environmental work orders. After helping maintenance with work orders, the safety and environmental team needs to place their information in a maintenance friendly format, the Maintenance ID. A simple example of this application is a mechanic assigned to replace the impeller and bearings on pump 1-WW-PMP-001. The question is "What safety and environmental information does the mechanic need to know to work on this pump?

The Maintenance ID wasn't developed for maintenance but for everyone's use, including the safety and environmental department. Therefore, safety or environmental information needs to be associated to the plant, system, and Maintenance ID. If a mechanic is working in Plant #1, what emergency response procedure should she know? If she is working in the Waste Water system in Plant #1, what chemical hazards should he be concerned with? In addition, if she is working on pump 1-WW-PMP-001, what equipment needs to be locked out to safely repair the pump? Maintenance shouldn't have to dig though a 600-page safety novel to find all the hazards. It's up to the Safety department to place the information in a maintenance friendly format (the Maintenance ID). For example if sulfuric acid is used in the WW system, and a mechanic is working on a pump in the WW system, then a copy of the MSDS sheet for sulfuric acid needs to be in their hand.

It would seem the only interface maintenance has with the environmental department is the prevention of pouring oil down the drain. Wrong! One of maintenance's function is to repair and PM the equipment and instrumentation used to reduce and monitor pollution from your plant. The environmental department needs to identify and review calibration and repair of environmental sensitive equipment. The use of the Maintenance ID and the RPM method meets this requirement. Remember an environmental violation is like getting a speeding ticket; you can't tell the police officer the speedometer was broken. Another approach the environmental team could take is build a piping and instrument drawing of the plant's key systems showing typical input and output limits to each system. Information like power, influent & effluent, vents, and drains flows with allowable limits and testing procedures.

Anyone working as maintenance manager has been frustrated and confused working with OSHA and EPA regulations. One key tool for Safety and Environment Control is training. If you don't have the staff to support these functions, hire a consultant familiar with OSHA and EPA regulations familiar with your industry.

A final note: As an employee, I'm glad these agencies are out there to protect us. Imagine letting big business make up the safety and environmental rules and regulations.

8.6 The Engineer

Just like a manager or planner in your organization, the maintenance engineer needs to look at TOMORROW. Engineering defined by Webster is "the planning, designing, construction or management of machinery." Notice it said nothing about a college diploma. The focus of Maintenance or Plant engineering is any activity that will increase the plant's equipment reliability, while promoting safety and environmental awareness.

One purpose of engineering is to review equipment performance. One approach is using the RPM method, which produces three types of work orders (R, P or M). Engineering needs to be focused on "M" type work orders (modification). These are work orders that are not required to be done today, but are required to increase the safety, productivity, and reliability of the plant…TOMMORROW.

Here are a few examples of "M" type work orders that I have encountered, including solutions.

"Evaluate return idler failures on conveyor system."

Maintenance was constantly changing out and rebuilding return idlers for the conveyor system. After reviewing history of "R" work orders associated to rebuild and repair return idlers, an "M" type work order was generated to review the idler design. The original return idler design used natural rubber disks, which wear quickly and cause the belt to misalign. Engineering, a local conveyor vendor, and maintenance personnel combined to modify the return idler using a neoprene disk instead of natural rubber. Two additional disks were installed on each idler to reduce any belt misalignment problem. These changes extended a return idler life from 6 months to 3 years, and eliminated belt alignment problems.

"Increase guillotine damper seal life." Damper seals were changed out every plant outage. It was observed that every time the guillotine damper closed, the warp damper blade would damage the upper seal. An "R" work order was generated every

outage to replace damaged seals. An electrician suggested a modification to keep the damper blade in part of the seal area by simply resetting the end travel limits. What did this accomplish? The damper seal life increased from every outage to 5 years. Just a simple adjustment of a limit switch saved 100's of hours of maintenance outage time.

These examples of "M" type work show how developing a long term solution you can save $$$ without increasing maintenance staff. But no plant design change is successful until you have notified everybody and documented the modification. Tracking changes made to equipment by engineering, operations, and maintenance is one of the hardest items to control in your plant. One method to document changes and keep everyone informed is to establish a dedicated person from engineering, operations, and maintenance to be responsible for changes made, including:

- Electrical…wiring diagrams
- Instrumentation…calibration sheets
- Logic…PLC (programmable logic controller) DCIS
- Process…piping and instrumentation drawings
- Mechanical assemblies, material and dimensional changes
- Service manuals

Consider installation of a new flow transmitter in Wastewater System. The table below shows all the documentation required in the Wastewater system and the people responsible for updating the changes.

Wastewater System Documentation Team

Documentation and Drawings	Engineering	Maintenance	Operations
Piping and Instrument	J. Jones	T. Mercer	G. Rasbery
Electrical	T. Westerman	D. Lamp	S. Grimes
Control logic	D. Ward	D. Preston	D. Carter
Instrumentation Cal	B. Fisher	R. Rogers	D. Baez
Service Manual	J. Weber	R. Campbell	L. Brown
Inventory records	B. Fisher	D. Lamp	D. Carter

What this means is that all changes to drawings and manuals go to (and through) these detail oriented people in every department. I know the type, and I'm not one of them.

If the focus of Maintenance and Plant Engineering is to solve the problems, develop solutions and document the design changes, then the question is "Where are the problems to solve?" An engineers' responsibility is the same as maintenance; that is, to take a proactive approach by going out and looking for them. The obvious place to look for equipment problems is to monitor the plant equipment and talk to the people that operate and maintain it.

Besides getting on the plant floor, take the time to review the data from these four reports:

- Work Order History Report
- Equipment Inspection Report
- Quality Control / Production Report
- Equipment Downtime Report

Work Order History Report

Throughout this book, we have discussed that the number of "R" work orders is an indicator of poor equipment performance. These work orders may have low labor and materials costs, but continually cause production interruptions and frustrate maintenance. The example in the table below shows is a list of "R" work order history for conveyor 1-SH-CVY-002.

1-SH-CVY-002…Extrusion press discharge conveyor #2		
Work Type	Work Order #	Work order description
R	021333	Shell jammed at discharge conveyor
R	021533	Shell jam on conveyor
R	021833	Discharge conveyor tripped
R	022333	Safe guide removed from conveyor

The list of "R" work orders is a signal to engineering that a piece of equipment requires some attention. Several factors contribute to high work order count such as incorrect machine set-up, control or a design problem.

Equipment Inspection Reports

Preventive maintenance tasks or equipment outages are an excellent time to secure equipment and inspect for problems. Maintenance, Engineering and the equipment's field service representative need to inspect equipment for potential problems. During the inspection, generate a work orders list:
R type… repair work found on equipment during inspection
P type… review preventive or predictive maintenance task.
M type… modification work that would increase the safety and reliability of equipment.

An inspection report can be used to list not only list problems, but also as a place to add suggestions to improve the equipment. Here is an example of an inspection report for the Control Air System may look like:

System … **Control Air 1-CA-ALL-001**

Work Type	Maintenance ID	Suggestion
R	1-CA-CMP-004	Crack on cooling header
P	1-CA-CMP-004	Reschedule oil test from 3 to 6 months
R	1-CA-CMP-004	Inboard bearing leaking oil
M	1-CA-PRT-010	Move conduit to allow easier calibration of pressure transmitter

By…**Tom Bird & Carl Jones** Date…**08/11/03**

Follow up the report by generating a work order or task for each problem or design modification.

Quality Control / Production Report

The monitoring process is a valuable tool used by maintenance to monitor equipment performance. Reviewing the plant output and products at various stages can be used to determine an equipment problem. A simple review of scrap / rework quantities or product quality coming out of a particular piece of equipment should forewarn maintenance of a potential problem. Is the problem caused by the operator, or from the raw material feeding into the machine? Or, could it be from the maintenance set-up of the equipment?

For example, a line technician glanced at the QC report for a part being machined. He noticed the part's chamfer was nearly out of specification. After reviewing the machine in operation, he saw loose bolts on the product fixture. He stopped production and locked out the machine, then tightened the bolts. Within minutes, the part's chamfer was on the money. No work order, just a proactive approach by maintenance.

Equipment Downtime Report

As seen with the previous example, not every problem has a work order. Just as we used the Quality Report to take an aggressive approach to locate a potential problem, the Downtime Report is another tool. Downtime is the amount of time a particular piece of equipment is *not available* to operations. This includes any equipment stoppage such as:

Product change over. Just-in-time thinking is causing plants to change production lines for a different product every hour.

Production problems. Lack of material, equipment problems up or downstream, storage problems, quality problems.

Operations repair. Some problems are so small that operations usually just repairs the problem without notifying maintenance. An example of this would be a piece of equipment jamming. The operator briefly stops machine, removes the jam, and starts back up.

Maintenance repair. Not all maintenance work is documented through a work order system. Some jobs are so small, that it's easier for maintenance to just repair the problem rather than filling out a ten-page work order.

Breaks and lunch. I know people need a break, but you may consider staggering breaks to keep process flowing and reduce downtime.

One method to track downtime is to use some form of Downtime Report. The downtime report is a tool used to find hidden production, maintenance and engineering problems. Place a report form next to each major piece of equipment and ask the operators and maintenance to log down whenever the equipment stops. Note: Also include downtime reports on your back-up equipment. Maintenance has a tendency to forget them if the plant is running. Here is an example of a downtime report for an extrusion press (1-SL-PRS-001).

Equipment…**Extrusion Press #1**			Maintenance ID…1-SL-PRS-001	
Date	Time OFF	Time ON	Op/Mec	EVENT
1/16	7:38	7:56	FW	No material
	8:23	9:01	FW/AA	Broken drive belt WO# 012222
	10:12	10:20	FW	Jam in feed chute
	11:29	12:04	AA	Lunch

Summary

Management and Engineering need to be on the same page. Here are few things to consider:

Management's responsibility to Engineering?

Set priorities of "M" type work orders in writing. Develop a method to check and review design with maintenance and other engineers. Supplying sufficient people, tools, time and money to successfully complete each project.

Engineer's responsibility to Management?

Voice your opinion. As an Engineer, you are paid for your technical expertise so express your opinion two times. The first time is to show your concern. The second time is just in case management didn't hear you the first time. After the second time follow management's decision, but don't do anything that would jeopardize the safety of people or damage the environment. *Nobody* is paying you that much.

How about evaluating an Engineer's performance?
One method to check an engineer's performance is to see if the plant's annual savings exceed the engineer's annual salary. Areas to check for the engineer's benefit to the plant performance:

- Increase in Safety and Environmental awareness
- Reduction in "R" type work orders or "P" type preventive tasks
- Increase in production
- Decrease of raw materials
- Reduce energy consumption

Final note…Management always wants a reason…

Troubleshooting equipment problems as a Plant Engineer, you may have been able to get the equipment running, but you may not know the reason for an equipment stoppage or failure. Here are a few buzzwords that will satisfy your boss's curiosity:

- If it was a *mechanical problem*, tell him the problem was vibration or alignment.
- If it was an *electrical problem*, use lightning, floating neutral, or grounding.
- If it's a *hydraulic problem*, it was dirt or air (my personal favorite…)

For Young engineers only…

One of the most important decisions a young engineer can make coming out of college is to determine what company to start your career. Don't make a job decision based on money, perks, or location. Instead, select the job based on the *manager* you will be working for because this person will be your mentor and prepare you best for the future.

Wrench time Story … “learning the hard way”
As a young plant engineer working for a coal strip mining company, I never considered “IRMO” (install, remove, maintain and operate) in my earlier designs. Every project I designed had to be modified in the field by maintenance. After a few projects, UMW maintenance department stuck a label on the back of my hard hat that read ″Cut to fit in the field″. Early in my career I didn’t realize that a maintenance welder with a sixth grade education and 30 years of welding experience knew more about welding than an engineer with a college degree and 3 months of real world experience. To this day, I still start every design concept with a sketch on paper and ask maintenance or construction people for their opinion. I just make sure I give the credit back to maintenance and leave my ego at the house.

9 Cost Center

9.1 Maintenance Cost
9.2 Equipment Cost
9.3 Inventory Cost
9.4 Operation Cost
9.5 Budget

The real definition of Maintenance…
"any work that no one else wants to do."
Fred J. Weber

9.1 Maintenance Cost

In this module, we'll be using parameters we have previously established throughout this book to get a better understanding of your maintenance expenses. Before we get started, we need to define the need for a maintenance cost system. Well, the purpose of *any* maintenance cost system is to answer the inevitable question "What does maintenance do for $1 million dollars a year?" Also, since we're discussing cost centers, be careful not to fall in to the trap of using industrial standards or key indicators to judge your maintenance department. As most seasoned maintenance managers know by now, maintenance means "any work that no one else wants to do." Because of this definition, it is difficult to compare your plant maintenance performance and expenses to those of another plant. Be careful to compare apples to apples (I hate that phrase, but it works!). Here are a few reasons why your maintenance expenses may be different then your neighbor's plant.

Purchasing parts - one plant may have a purchasing person assigned to order parts for maintenance. At another site, a maintenance technician or foreman may order parts, increasing the maintenance labor hours.

Housekeeping - one plant may contract out all of the landscaping work to a contractor, a cost that may not be attached to maintenance expenses. Another plant may charge the landscaping labor to maintenance.

PM equipment - one plant may use operators to grease and oil all equipment. Another plant may consider this function to be maintenance's responsibility.

Plant Design - one plant may have equipment designed, purchased and installed based on "lowest bid" pricing. Another plant may have been designed right the first time using state of the art technology, corrosion resistant materials, and installed by a qualified contractor.

The list goes on forever. Therefore, as long as you're improving *your* plant's performance every day, month, and year, then stop worrying about what your neighbor is doing.

To understand maintenance costs I refer to a quote from Quality Magazine and *frequently* used by an ex-Plant Director "Without data, you're just another opinion." In industry, typically a maintenance department's expenses are stored in general accounting cost centers such as the ones listed in the table below:

Cost center	**Account Number**	**Annual Cost**
Administration	12-111	100,000
Labor	13-123	250,000
Overtime	13-234	50,000
Supplies	21-444	500,000
Miscellaneous	43-882	100,000

Table 9.1a Typical Plant Cost Center

Using the information from the table above it's hard to determine what maintenance did for you last year. It's obvious from the table that "someone" in the accounting department, who spent very little time talking to the maintenance department, developed the cost centers. My two favorite cost centers used in industry today are "Other" and "Miscellaneous," where millions of dollars are hidden annually.

So to understand and improve maintenance costs, you need to be able to see them. And to see them, they need to be stored in a maintenance friendly format. Check your accounting system to see if it's maintenance friendly. Look at last year's annual maintenance expense report and see if you can answer these three questions:

1. What plant system has the highest maintenance repair cost?
2. What are the three pieces of equipment with the highest repair cost?
3. What equipment component has the highest repair cost?

If you can't answer, this module will show you the necessary steps to find the answers. To look at costs in a maintenance friendly format, we need to collect the data the same way. Remember what was the minimum information required from each work order? If you forgot here it is again: Work Order number, Maintenance ID, Material Cost, Labor Cost, Equipment Part ID, and the "RPM method". However, to have the data to mean something, it needs to be *accurately* collected.

Start by collecting labor and material costs associated to the overall system Maintenance ID, such as 1-WW-ALL-001. By the end of the year your expenses may look like this:

Maintenance ID	**Description**	**Labor cost**	**Material Cost**	**Total $**
1-WW-ALL-001	Waste water system	160,000	140,000	300,000
1-LS-ALL-001	Limestone system	280,000	220,000	500.000
1-FC-ALL-001	Facility and grounds	80,000	40,000	120,000
1-SF-ALL-001	Safety	20,000	2,000	22,000
1-TR-ALL-001	Training	10,000	5,000	15,000
1-AD-ALL-001	Administration Time	42,000	1,000	43,000

Table 9.1b Maintenance ID Cost Center

Simply by tracking costs for each overall system Maintenance ID you have supplied a better answer to our initial question: "What does maintenance do for $1 million dollars a year?"

If *management* requires more information about maintenance costs, then take another step by starting the year with 12 separate work orders. Use a work order number and the RPM method to collect the repair, preventive, and modification costs associated to each system. The maintenance cost for the end of the year may look like table 9.1c.

RPM	WO #	Maintenance ID	Labor cost	Mat'l cost	Total cost
R	1122	1-WW-ALL-001	130,000	80,000	210,000
P	1123	1-WW-ALL-001	45,000	15,000	60,000
M	1124	1-WW-ALL-001	10,000	20,000	30,000
R	1131	1-LS-ALL-001	260000	150000	310,000
P	1132	1-LS-ALL-001	70000	20000	90,000
M	1133	1-LS-ALL-001	20,000	80,000	100,000
R	1134	1-FC-ALL-001	50,000	20,000	70,000
P	1135	1-FC-ALL-001	28,000	5,000	38,000
M	1136	1-FC-ALL-001	2000	10,000	12,000
M	1137	1-SF-ALL-001	19,000	1,000	22,000
M	1138	1-TR-ALL-001	13,000	2,000	15,000
M	1139	1-AD-ALL-001	42000	100	43,000

Table 9.1c RPM + Maintenance ID Cost Center

By tracking the R, P, and M costs for each system Maintenance ID you can answer our first question, "What plant system has the highest repair maintenance cost? As the table below shows, simply locate the "R" cost for each system. For this example, it looks like the Limestone system has the highest repair cost.

RPM	WO #	Maintenance ID	Labor cost	Material cost	Total cost
R	1122	1-WW-ALL-001	130,000	80,000	210,000
R	**1131**	**1-LS-ALL-001**	**260000**	**150000**	**310,000**
R	1134	1-FC-ALL-001	50,000	20,000	70,000

Table 9.1d "R" type + Maintenance ID Cost

With twelve work orders, we were able to identify the repair, preventive and modification costs in each system. Notice the safety training, and administration costs are associated to an "M" type work. Remember, if it's not an "R" or "P" work order it must be an "M" work order.

9.2 Equipment Cost

In the last section, a work order was generated for the R, P, and M costs associated to each system. To look at equipment costs, we need to generate a separate R, P, and M work order for each piece of equipment that have associated maintenance costs. Let's go to straight to an example. Assume management needs the maintenance costs of pump #1 and pressure transmitter #21 in the Waste water system. The first thing required is for the pump and transmitter to have a unique Maintenance ID. For the pump, the Maintenance ID would be 1-WW-PMP-001, and for the transmitter, 1-WW-PTR-021. Next, maintenance needs to be able to record the RPM cost of the pump and transmitter on separate work orders. Looking at the table below, notice we still have the RPM work orders Maintenance ID 1-WW-ALL-001. These three work orders are for the RPM cost associated to equipment in the Waste water system except the pump and transmitter. For these two pieces of equipment, we added six new work orders to collect the RPM costs associated to pump 1-WW-PMP-001 and pressure transmitter 1-WW-PTR-021.

"RPM"	Work #	Maintenance ID
R	2001	1-WW-ALL-001
P	2002	1-WW-ALL-001
M	2003	1-WW-ALL-001
R	2004	1-WW-PMP-001
P	2005	1-WW-PMP-001
M	2006	1-WW-PMP-001
R	2007	1-WW-PTR-021
P	2008	1-WW-PTR-021
M	2009	1-WW-PTR-021

Table 9.2a RPM + Equipment Maintenance ID Cost

With these additional work orders associated to the equipment, we have the ability to monitor equipment costs though out the plant. To understand why equipment costs need to be separated into equipment RPM costs, let's look at an example of equipment cost *without* knowing the RPM costs. Reviewing the table below, locate three pieces of equipment with the highest cost:

Maintenance ID	Work #	Material Cost	Labor Costs	Total Cost
1-WW-PMP-001	021233	732	2372	3104
1-LS-CNV-002	021234	873	332	1205
1-WW-PMP-002	021235	702	1539	2241
1-CA-CMP-003	021236	4302	10225	14527
1-WW-PMP-001	021237	1024	1501	2525
1-LS-CNV-002	021238	433	857	1290
1-CA-CMP-001	021239	243	187	430
1-WW-ABV-001	021240	217	491	708
1-WW-PMP-003	021241	600	1222	1822
1-WW-MIX-001	021242	3273	5832	9105

Table 9.2b Equipment Cost Center w/o RPM method

Our first instinct is to look for the highest cost items, points to these three pieces of equipment on the list below:

Maintenance ID	Work #	Material Cost	Labor Costs	Total Cost
1-CA-CMP-003	021236	4302	10225	14527
1-WW-MIX-001	021242	3273	5832	9105
1-WW-PMP-001	021233	732	2372	3104

Table 9.2c Assumed Highest Equipment Cost

Looking at the cost data, we would *assume* that “1-CA-CMP-003”, “1-WW-MIX-001” and 1-WW-PMP-001 are three pieces of equipment causing the biggest problem in maintenance. However, before jumping to any conclusions, look at the same table adding one more parameter and then analyzing the data.

By recording the work order type /priority…"R"(repair, safety or environmental), "P" (preventive or predictive), or "M" (capital, modify or wish list) the table changes to this:

Maintenance ID	RPM	WO #	Material Cost	Labor Costs	Total Cost
1-WW-PMP-001	**R**	021233	732	2372	3104
1-LS-CNV-002	**R**	021234	873	332	1205
1-WW-PMP-002	**R**	021235	702	1539	2241
1-CA-CMP-003	**P**	021236	4302	10225	14527
1-WW-PMP-001	**R**	021237	1024	1501	2525
1-LS-CNV-002	**P**	021238	433	857	1290
1-CA-CMP-001	**P**	021239	243	187	430
1-WW-ABV-001	**M**	021240	217	491	708
1-WW-PMP-003	**R**	021241	600	1222	1822
1-WW-MIX-001	**M**	021242	3273	5832	9105

Table 9.2c Equipment Cost with RPM method

Now go back and review the three items that were identified as high cost items in the plant. The first item was:

Maintenance ID	RPM	WO #	Material Cost	Labor Costs	Total Cost
1-CA-CMP-003	**P**	021236	4302	10225	14527

This "P" type work order was a scheduled five year PM and overhaul on compressor #3.

The second item:

Maintenance ID	RPM	WO #	Material Cost	Labor Costs	Total Cost
1-WW-MIX-001	**M**	021242	3273	5832	9105

This work order was a modification to mixer #1 due to the installation of a new design mixer blade to improve product quality.

The third item:

Maintenance ID	RPM	WO #	Material Cost	Labor Costs	Total Cost
1-WW-PMP-001	**R**	021233	732	2372	3104

This was a work order with a high repair expenses. The compressor and mixer work was required to maintain the reliability and increase plant performance, but are not considered a problem to maintenance. The key to increase plant performance is to focus on the "R" type work orders. Look back at the table and locate the equipment with "R" costs associated to them. The equipment with "R" work is listed in the table below.

Maintenance ID	RPM	WO #	Material Cost	Labor Costs	Total Cost
1-WW-PMP-001	**R**	021233	732	2372	3104
1-LS-CNV-002	**R**	021234	873	332	1205
1-WW-PMP-002	**R**	021235	702	1539	2241
1-WW-PMP-001	**R**	021237	1024	1501	2525
1-WW-PMP-003	**R**	021241	600	1222	1822

Table 9.2d "R" type Equipment Costs

This example has identified three pumps and one conveyor. Reviewing the data, we are able to answer the second question

"What are the top three pieces of equipment with the highest repair cost?" It looks like pump 1-WW-PMP-001, 002 and 003.

Assume for our example we were able to determine that pumps 1-WW-PMP-001, 002 and 003 are the same model. Notice that if we stop repairing these pumps, it reduces the maintenance costs by $9692. With hundreds of these problems existing in your plant today, we need to separate the RPM equipment cost. Once the high repair cost items are identified, maintenance and engineering need to take a proactive approach by writing "M" work orders to prevent the "R" type work orders from resurfacing. Why maintenance and engineering? Because they know the equipment repair problems better than anyone does.

Another benefit of collecting the equipment's RPM costs is so that maintenance or engineering has the support data to justify any design changes to management. In the previous example, if the pump problem is resolved, it would produce an annual cost savings of $9692 in parts and labor. This number ($9692) becomes the maintenance and engineering design cost limit. Simply they can't spend $50,000 annually to fix a $9692 problem. In addition, this information gives management the ability to see if any design changes were beneficial to the plant performance by reviewing the "R" work order costs *after* the modifications to the pumps. Using the same example, "What if engineering made a design change that cost $5000 but you still had $9700 in repair costs?" The design modification wasn't worth the $5000.

Another item to consider when making design changes is the cost of a new piece of equipment compared to repairing the old equipment. Using the previous example consider, what if a new pump installed cost $900? The total cost to replace all three pumps would be $2700 compared to $9700 to repair them. In some cases, maintenance is spending several times the replacement costs in material and labor to rebuild or PM equipment. Such items like rebuilding solenoids, valves, idlers, printed circuit boards or small electric motors often incur these costs. It's important that maintenance knows how to rebuild each of these pieces of equipment because the day will come when you have no spares available and you have to rebuild it. In addition, rebuilding equipment is an excellent training tool for maintenance, while keeping one more piece of equipment out of the landfill.

9.3 Inventory Cost

In this section, we'll help you to determine which of your components has the highest repair cost. First, a quick refresher from an earlier module on Parts. Inventory in a plant is broken up into three sections:

- Operation inventory - materials used to make a product.
- General Supply inventory - general use materials
- Maintenance inventory - equipment spare parts

In most plants, maintenance is clueless as to their effect on inventory cost because equipment parts are mixed with operation and general supply inventory. For this reason, we need to physically separate equipment parts from all other inventory; maintenance inventory needs to be in a secluded area in the warehouse. These parts are stored for maintenance department. Each part has an Equipment Part ID tag on them. Now it is easy to see if any part in the warehouse has an Inventory number and Equipment Part ID it belongs to maintenance and used to determine the Maintenance inventory cost.

One benefit of the Equipment Part ID is the ability to identify excess stock. Assume you find equipment parts without an Equipment Part ID. You should ask yourself "Why is this part in stock?" The table below shows three bearings in stock BRG0012, BRG0013 and BRG0014.

Equipment Part ID	**Inventory No#**	**In Stock**	**Unit Cost**	**Total Cost**
1-LS-PMP-021-0111	BRGR0012	2	45.32	90.64
1-WW-PMP-001-0002	BRGR0012			
2-WW-PMP-020-0111	BRGR0012			
NONE	BRGR0013	3	200.23	600.69
1-WW-PMP-044-0334	BRGR0014	1	55.66	55.66
1-WW-PMP-045-0334	BRGR0014			

Table 9.3a Inventory + Equipment Part ID Cost Center

The questions you should be asking, "Why is BRG0013 in stock, and what is it used for?" Maintenance needs to remember that to material management, the bearings look like this:

Inventory No#	In Stock	Unit Cost	Total Cost
BRGR0012	2	45.32	90.64
BRGR0013	3	200.23	600.69
BRGR0014	1	55.66	55.66

Table 9.3b Inventory Cost Center

All material management knows is "someone" in maintenance said "Put three BRG0013 in stock". If BRG0013 can't be identified by any department, then consider removing them from stock and reducing inventory cost by $600.69.

The Equipment Part ID is not only used to find parts in the warehouse. It causes maintenance to think about their effect on inventory, as well as makes material management think of maintenance. For instance, as equipment problems are resolved or become obsolete, maintenance needs to review the max / min quantity of parts in the warehouse.

From our example above, what if maintenance resolved the bearing problem or replaced it with a different type? If the max / min for BRG0012 was 6 and 2 respectively, and two were in stock, material management is just about to order 4 more bearings ($181.28) to sit in inventory that will never be used. This is a waste of money.

Remember also that material management's goal is to obtain a high inventory turn ratio, which is equal to *Parts Used Annually* divided by *Parts In Stock*. Material management needs to realize that parts with Equipment Part ID require a different goal. What if no equipment failed for the year and maintenance sees no equipment failing in the future? Material management would have zero equipment parts in stock and zero purchase orders written for equipment parts during the year. That's not realistic, but what it does mean is that if maintenance is purchasing or stocking a ton of equipment parts, there is a maintenance problem. Therefore, material management's responsibility is to warn maintenance and engineering if there is a high usage of any part with an Equipment Part ID. Here is example of some parts that maybe sitting in the warehouse:

Inventory Number	Equipment Part ID	Annual Usage	In Stock	Inventory Turn Ratio
BRGR0923	1-WW-PMP-001-0018	0	3	0
BRGR0923	1-LS-PMP-023-0192	4	3	1.33
PSSW0224	??????	0	2	0
PAPR0123	Operation	100,000	5,000	20
PAPR0126	Operation	20,000	10,000	2
BUCK0500	General	200	200	1

Table 9.3c Inventory Turn Ratio

Here are a few items that may jump out at you from the example table above.

- **Inventory number… BRGR0923**
  This part is a roller bearing for two different pumps. Notice that the bearing 1-LS-PMP-023-0192 has been replaced four times. Resolving the bearing problem on pump 1-LS-PMP-023 would reduce inventory.
- **Inventory number… PAPR0123 and PAPR0126**
  These two items are operation parts and have no Equipment Part ID numbers assigned to them. Therefore, a high inventory turn ratio is required.
- **Inventory number… BUCK0500**
  This item is a plastic 5-gallon bucket stored for general usage. Why warehouse a year's supply of them when you buy them locally down the street?

- **Inventory number… PSSW0243**
  This part is a pressure switch with no Equipment Part ID and is a part a piece of equipment no longer in use. To reduce inventory costs, consider removing it.

Another time that material management, engineering, and maintenance need to talk about inventory cost is before making an equipment design change. During an equipment modification or installation of new equipment, this group needs to look at spares currently in your warehouse.

Example: Assume you have two fans (Model XYZ) operating in your plant. Inventory shows $20,000 in spare parts. Modification to your process requires that an additional fan be installed. When you bid for a new fan, a Model XYZ fan (the same as the other two in your plant) costs $80,000. However, another fan by a different manufacturer only costs $75,000. Like most organizations, you take the low bid. Just consider additional costs that may be incurred, such as $15,000 in spare parts, $2000 in special tools, and $5000 in training for maintenance. Therefore, the overall cost of the second fan went from $75,000 to $97,000.

Using the Equipment Part ID, we can try to answer which equipment component has the highest repair cost. To help determine costs, build a list of Equipment Part IDs used on different work orders and the RPM, like in the example table.

Equipment Part ID	Inventory #	RPM	WO #	Material Cost
1-WW-PMP-001-0023	BRGR0029	**R**	021233	732
1-LS-CNV-002-0111	BUSH0222	**R**	021234	673
1-WW-PMP-002-0023	**BRGR0029**	**R**	021235	732
1-CA-CMP-003-0102	IMPL0004	**P**	021236	4302
1-WW-PMP-001-0023	**BRGR0029**	**R**	021237	732
1-LS-CNV-002-0123	ROLL3343	**P**	021238	433
1-CA-CMP-001-0223	GASK0114	**P**	021239	243
1-WW-ABV-001-0112	LSSW0227	**M**	021240	217
1-WW-PMP-003-0023	**BRGR0029**	**R**	021241	732
1-WW-MIX-001-0011	BLAD0001	**M**	021242	3273

Table 9.3d RPM method + Equipment Part ID Cost

Again, sort though and find the Equipment Part ID associated to “R” work order and the table looks like the one below:

Equipment Part ID	Inventory #	RPM	WO #	Material Cost
1-WW-PMP-001-0023	**BRGR0029**	**R**	021233	732
1-LS-CNV-002-0111	BUSH0222	**R**	021234	673
1-WW-PMP-002-0023	**BRGR0029**	**R**	021235	732
1-WW-PMP-001-0023	**BRGR0029**	**R**	021237	732
1-WW-PMP-003-0023	**BRGR0029**	**R**	021241	732

Table 9.3e “R” type + Equipment Part ID Cost

View the data, and it looks like bearing BRGR0029 (used in pumps 1-WW-PMP-001, 002 and 003) is the equipment component with the highest repair cost. By now you maybe wondering why we are beating this inventory point. It’s because there are millions of dollars of out - dated equipment parts on your books just sitting in your warehouse collecting dust.

Remember… "If the part does NOT have an Equipment Part ID, then ask why is it in stock?"

9.4 Operation Cost

Operational costs are the sum of all costs related to operate and produce a product. The first question your organization needs to ask "Is the plant's objective to meet operational, maintenance, or Team Goals?" If it's Team Goals, then maintenance and operations need to be on the same page by tracking costs using the Maintenance ID. Both departments can see the effect they have on each other using the same accounting system. To accomplish this, operations needs to measure operating expenses in each system. The table below is an example of operational costs related to Plant 2 waste water system 2-WW-ALL-001:

Waste Water System… 2-WW-ALL-001			
Item	**January**	**February**	**March**
Product Output (K gallons)	2200	2400	2200
Operating Labor (mhrs)	3002	**4500**	3000
Electric (kWh)	23000	23500	23200
Air (avg. cfm)	11200	11000	**22100**
Well Water (gallons)	345	370	350
Chemical (gallons)	**67**	23	21

Table 9.4a System Operational Cost Center

Reviewing the data, operations and maintenance can observe the effect they have on each other. The example table above shows three points above its normal reading (*Chemical Usage* in January, *Operating Labor Hours* in February and *Air Usage* in March). The following could be some typical reasons for each deviation:

- January shows three times more chemical use than normal. A problem may exist in a leaking valve or vendor's chemicals not meeting specified concentration levels.

- February shows operational labor hours 1.5 times higher than January. A problem could be with the automatic controls of an inlet valve, where an additional person was required to operate the valve manually.

- March shows double the air usage, which may have been caused by a leaky regulator or pinholes in an old air pipeline. By measuring operating costs associated to a system such as air usage, maintenance can see how their performance could affect the cost in the waste water system.

Due to system dependency and the interconnecting to each other, an air leak in the waste water system causes the control air system to react. In the table below, you can see how the waste water system problem in March in the affected the cost to operate the control air system.

Control Air System…2-CA-ALL-001			
Item	**January**	**February**	**March**
Electric (kWh)	17000	17250	20200
Air (avg. cfm)	32000	32500	43500
Cooling Water (gallons)	345	370	430

Table 9.4b Effect on other System Cost Center

The collection of operating expenses relative to a system enables maintenance and engineering to develop cost benefits required for project justification. Reverting back to our problem air leak, maintenance can use the operating and repair cost savings to justify upgrading the materials used in the air piping.

Wrench Time Story…"effect on other departments"
Working in maintenance most of my career I had the tendency to blame operations for most equipment problems until a production manager set me straight. While sitting in a weekly staff meeting, I recommended to my boss that all maintenance work associated to operator error be charged to the operation's cost center. My thinking was that if maintenance costs were transferred to operations, maybe they would correct the operator's errors. A seasoned, soft spoken production manager turned to me and said "That's fine, as long as maintenance absorbs the cost of

production loss due to maintenance errors." After saying that, I realized if operations made a mistake it might take two mechanics to fix it, but if maintenance makes the mistake then 40 people go idle and no product goes out the door.

Open mouth, insert foot. I was quiet the rest of the meeting.

9.5 Budget

The budget is the financial crystal ball of your plant operating expenses. It's an estimate of what it will cost to operate and maintain your plant next year. Remember how you did this year's budget? You went to each cost center…

($$$ Spent Last year) **x 1.1** = ($$$$ Next year's Budget)

Cost center	Account Number	Annual Cost	Next Year's Budget
Administration	12-111	100,000	**110,000**
Labor	13-123	250,000	**275,000**
Overtime	13-234	50,000	**55,000**
Supplies	21-444	500,000	**550,000**
Miscellaneous	43-882	100,000	**110,000**

Table 9.5a Typical Plant Budget

Predicting the future expenses in operations and maintenance cost centers is difficult. The Operations budget is usually based on the projected sales estimate, while the maintenance budget is based on what is going to fail next year. One approach to building a budget is to understand the costs to operate a plant today. By collecting costs related to each system "Maintenance ID" today, you supply the necessary data to construct a budget for tomorrow. One reason for breaking down plant costs into individual systems is because it becomes small enough to grasp. Try it. Ask a maintenance manager how many people he needs to maintain a plant. The picture is blurred. Now ask the same manager how many people are required for the waste water system. Now the manager can see the equipment in the waste water system, he knows the work that has been done in the past, and he knows what work is required in the future. Therefore, the benefit of separating costs by system is the focus of managers. When the discussion is only about Plant # 1 waste water system operations, maintenance and material management managers are only thinking about the waste water system. It becomes a manageable piece of the pie. Therefore, the budget discussion becomes a time to analyze the requirements of the waste water system, such as things to monitor, parts to stock, people to operate, and equipment to repair and modify.

A simple table below can be set-up for each system to collect costs:

System "WW" (Waste Water System)				
Item	**January**	**February**	**March**	**April**
Operation				
Product Output				
Operating Labor				
Electric				
Air				
Well Water				
Steam				
Chemical				
Maintenance				
"R" type work				
"P" type work				
"M" type work				
Inventory				
Operation inventory				
General inventory				
Maintenance Inventory				
Purchasing				
Operation purchases				
General purchases				
Maintenance Purchases				

Table 9.5b Complete System Cost Center

For next year's budget, use the costs from each system for a year, then get a blank table and estimate the cost of each line item for the next year of each system. This type of budget breaks down the plant and system costs into a format that can easily be understood by everyone. It also forces managers to determine monthly activities of each line item for a system. For example:

Operations needs to think about projected production capacity, whether a system is operating at half capacity, full capacity, or needs to be shut down for a scheduled outage.

Maintenance needs to think about "R" type work for scheduled repair work, "P" type work (such as any planned major overhaul of equipment), and "M" type work (engineering changes such as capital projects or equipment modification).

Material management needs to think about operational material, general supplies, and maintenance parts (Equipment Part ID) requirements.

There is a benefit from tracking system cost each month. First, the budget is in a maintenance friendly accounting system such as the Maintenance ID. Second, it develops "Team Goals". The managers from each department must talk to each other at least once a month. Third, you will know the direction of each system in your plant.

Just remember to measure what you want to improve.

10 The Organization

"One of the best ways to reduce maintenance staff…
is to design and install the equipment right the first time."
Fred J. Weber

10.1 Maintenance Structure

A maintenance department can be organized in different ways. This section discusses three types of maintenance structures and their benefits. The three structures discussed here are *central* maintenance, *area* maintenance, and *system* maintenance.

Central Maintenance -- Technician reports to a supervisor in a centralized shop. A supervisor is assigned to each craft (millwright, electrician, etc.) and responsible for work assignments, training, tools, parts and support information. The supervisor tells the technician *what to do, when to do it, and how to do it*. Basically, the shop supervisor supplies the brain and the technician supplies the body. Below is an organizational chart for a Central Maintenance Structure.

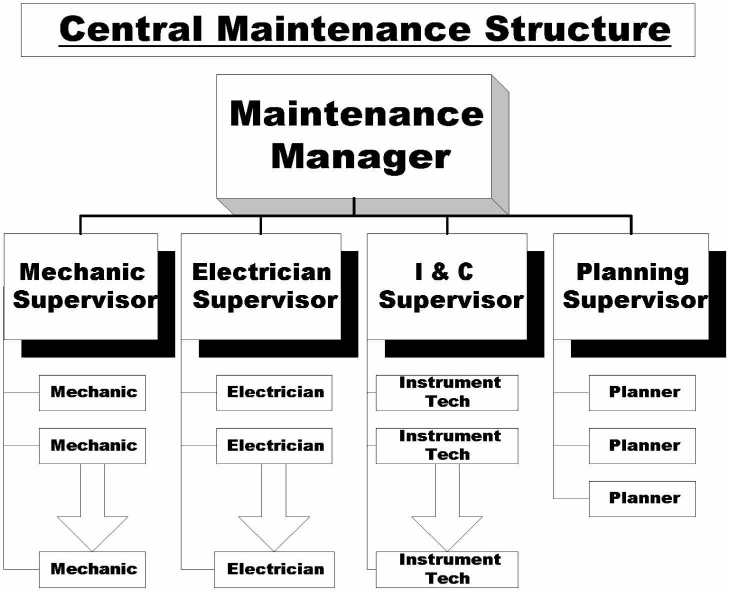


Figure 10.1a Central Maintenance Structure

Area Maintenance -- Technician reports to the area supervisor, who prioritizes work and approves material requests for a designated section of the plant. The technician is responsible for planning work and maintaining equipment within the production area. Here the area production manager tells the technician *what to do, when to do it, but not how to do it*. The organizational chart below is what a typical Area Maintenance Structure may look like.

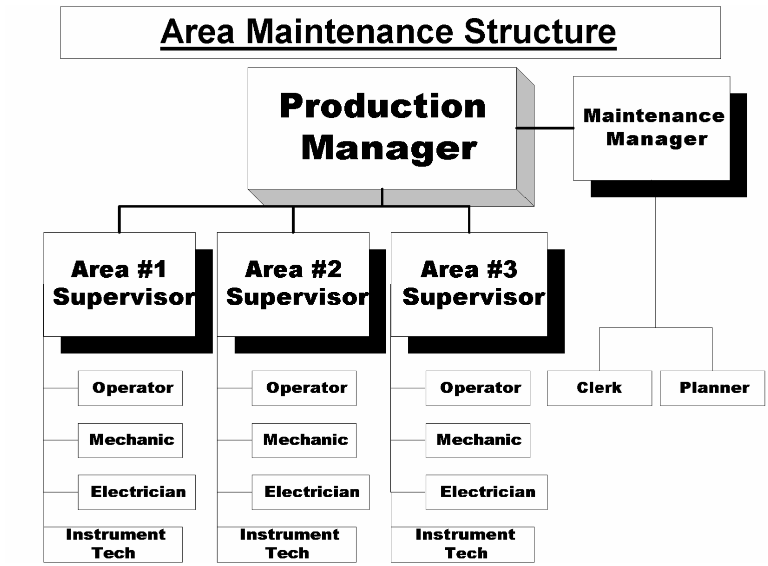


Figure 10.1b Area Maintenance Structure

System Maintenance – is actually a combination of system maintenance and project management. Earlier, we defined a system as a group of equipment related to each other, such as HVAC, fire protection, or a packaging system. The system maintenance structure is constructed by assigning a technician from each craft to the equipment associated to a particular system. A lead technician is selected from this group of technicians to coordinate tasks between craft. These self-starters plan their work while meeting all safety requirements, develop work priority, assist in training, establish preventive and predictive maintenance activities and updating system documentation. The organization chart below is what a system maintenance structure may look like.

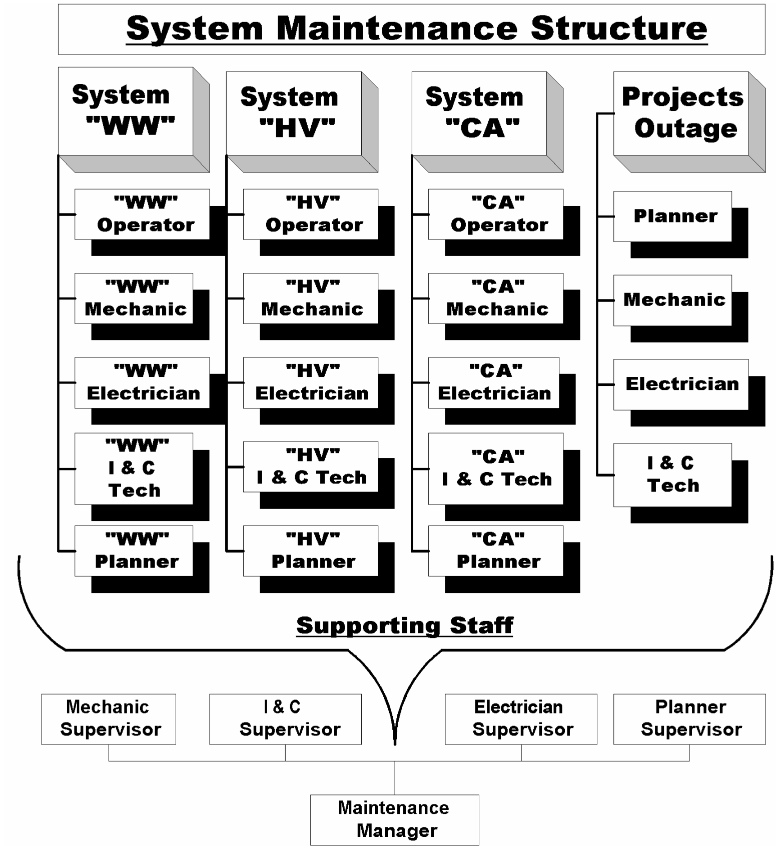


Figure 10.1c System Maintenance Structure

The responsibilities of each technician grow from repairing equipment to understanding system safety requirements, process design (physics and chemistry of the system), basic control logic, and product quality. When it is all said and done, these people become the system's in-house field service representatives, performing all work from simple repairs to supporting engineering on major projects ("M" type). The technicians report to maintenance shop supervisor, who take on a supportive role by focusing their efforts on training, safety, work quality, and developing technical skills. The big difference is that *the shop supervisor asks the technician: What can I do to help*?

A starting point for developing a system maintenance structure is to have 50% of the maintenance staff assigned to plant systems. The remaining 50% of the team can be used for projects or to assist system technicians. In addition to your maintenance team, you might consider assigning an engineer familiar with your processes to work with the team for technical support.

Now that we talked about the three types of maintenance structure (Central, Area and System), let's compare the effect each one has on the supervisor and technicians. First, we need to define the parameters for our comparison:

- Process knowledge - knowledge of how the system works
- Training capability - ability to train other individuals
- Planning capability - ability to plan and schedule work
- Problem repair ability - ability to fix equipment problems
- Problem solving ability- ability to resolve a repeated problem

Below are two tables showing the requirements of the supervisor and the technician in the three types of maintenance structures.

Supervisor

	Central	**Area**	**SYSTEM**
Process Knowledge	High	Average	Average
Training Capability	Average	Average	Average
Planning Capability	Average	Average	Average
Ability to Fix Problems	High	Average	Average
Ability to SOLVE Problems	High	Average	Average

Table 10.1d Supervisor's Responsibility

Technicians

	Central	Area	SYSTEM
Process Knowledge	Low	Average	High
Training Capability	Low	Average	High
Planning Capability	Low	Average	High
Ability to Fix Problems	Average	Average	High
Ability to SOLVE Problems	Low	Average	High

Table 10.1e Technician's Responsibility

From the tables above, it's easy to see the shift in knowledge from supervisor to technician. The "System" maintenance structure gives ownership of the plant to the technicians and allows the supervisor to think about tomorrow. One hidden benefit of this structure is the system technician is asked to repair the same repeated problem everyday. After a couple of months, those problems go away or someone is banging on your door with a solution.

Regardless of the maintenance structure you decide on, there is one key person that no maintenance organization can do without.

"Maintenance Secretary"

The Maintenance Secretary (now called "administrative assistant") is the key person in any Maintenance Structure. The purpose of the secretary is to free up time for the maintenance manager, supervisors, and planners. This individual does a TREMENDOUS amount of work for everyone. Listed below are some of their functions though out the day:

- Time keeper - vacation, work orders, safety and training schedule
- Maintain all maintenance records for OSHA or regulatory requirements
- Writes memos, files, and does any miscellaneous paper work
- Writes purchase orders and contacts vendors

- Expedites material
- Distributes company information
- Develops an equipment filing system and maintains a library
- Monitors all drawing changes and keeps original in a secure location
- Handles the phone, e-mails, faxes, and inputs data to CMMS
- Listens to maintenance people complain about their personal and work related problems, while earning one third of their salary!

For all of the %@& this over worked and under paid individual does for the maintenance organization, there should be additional rewards such as lunch, new office furniture, a car wash, or just a thank you from time to time.

10.2 Staffing and Task Analysis

A familiar line constantly uttered by most maintenance managers is "we need more people," and usually, they are right! Besides maintaining equipment, maintenance does everything in the plant that nobody else wants to do. For this reason, managers have a vague job description for their team members. Today there seems to be to two approaches for managers to define job responsibility. The first approach is to do nothing. Managers feel maintenance maintains, operations operates, and purchasing purchases, so what is the purpose? The second approach is for a manager to ask the employees to write their own job description. This indicates that there are managers in industry with no clue of what their people are doing. As a manager, you are responsible for your team, so you need to know what they are doing.

One way to define job responsibilities is by using a *task analysis*. Here are some benefits for building a task analysis:

- Develops a list of functions required to operate and maintain the plant meeting safety and environmental requirements.
- Develops Team Goals by showing the interaction between each department. Supplies management the support data for hiring contractors on tasks the organization can't do due to lack of manpower or technical skills.

Webster defines *task* as "an undertaking involving labor or difficulty". Therefore, a task analysis is a list of functions in your plant that require labor. Task analysis simply answers the question "Who is doing what?" "What" defines the task required by the plant's operation while "Who" defines the team member responsible for the task.

A task analysis comes in various shapes and sizes but for this discussion, it's simply a list of tasks required to keep your plant running today and in the future. To build a task list, we need to determine the information required for each task.

Some necessary information includes:

- task description
- department/manager responsible for the task
- labor required
- equipment required
- goals to show performance of the task

The first step is to break down the plant into systems such as HVAC, Facility, Control Air, and Limestone. Second is to list all the departments in your organization: Maintenance, Operation, Purchasing, Material management, Safety, Administration, Engineering, and even Management. Also, include any contractors on the list that may supply a work force to your organization.

To start, select one system and define the overall system requirements, such as operating schedule, capacity, and limits. Next, list the tasks and equipment required to keep the system safe and reliable. One technique to develop a task list is to act as a contractor bidding on a function in the plant. Let's say you own a HVAC company. Some things you may want to know include what is required to operate and maintain the heating and ventilation system in your plant? How many people do you need? What tools and equipment are required? What support staff is required? Before we start to build an example task list, here are a few tips:

Use action words to describe the task, like *operate, maintain, instruct*, and *record*.

For maintenance tasks, supply only enough personnel to handle all "R" and "P" type work excluding major overhauls. Manpower for "M" type work such as overhauls, capital projects, or wish list items should <u>NOT</u> be considered in your initial evaluation.

Consider a backup plan; take into account sick time, vacation, and training.

Note - Just make sure maintenance people aren't *working alone*. I know I can't do anything in the garage without asking my wife or neighbor for help.

Let's do a sample *task analysis* of the limestone material handling system. First, we need to make assumptions:

- limestone system operates five days a week, 16 hours/day
- maximum shutdown time allowed is three hours a day
- the nominal capacity rate is 300 t.p.h.
- the maximum limit is 400 t.p.h.
- the maximum service water usage is 10,000 gpd

List all tasks required for limestone system to meet safety, environmental, operational, and maintenance requirements. A task list for the limestone system may look like this:

Task	Dep't /Mg'r	Labor	Equipment	Goal
Operate and monitor system	Op / JW	4	None	Maintain limestone supply
Control board operator	Op / JW	2	None	Operate at avg. 95% capacity
Mechanical repairs and PM	MS / TW	2	Welder Touch set	Maintain 98% Availability
Electrical repairs and PM	ES / D	0.5	Megger	Maintain 98% Availability
Instrument repairs and PM	Contract	0.1	Scale weight	Maintain 98% Availability
Purchase parts	MM / JJ	0.1	Computer	Order "R" parts in an hour
Warehouse parts	MM / JJ	0.1	Computer Forklift	Stage parts at job site
Clean trucks & conveyor	Labor / DM	2	Hoses	Clean weekly
Safety training	Safety	0.2	Computer	50% below national average

Table 10.2a Sample Task Analysis

Define each system in your organization to determine your overall staffing requirements, as shown in the example table below.

Staffing System Summary

System	Operation		Maintenance			Labor	Mt'l	Train'g
	Board	Floor	MS	ES	IS			
Limestone	2	4	2	0.5	0.1	2	0.1	0.2
HVAC	0.5	0.5	2	0.5	0.5	0.5	0.1	0.1
Fire protection	0.5	0.5	2	2	0.5	1	0.5	0.2

Table 10.2b Plant Staffing Requirement

Staffing notes:

In some plants, maintenance personnel are used for operations and vice-versa. Task analysis defines departmental responsibility. If one department utilizes another employee from a different department, they should be charged for the time. In other words, "If you're going to play me, pay me." A good example of this is the purchasing of equipment parts. If maintenance is doing all the research, such as phone calls, pulling the drawings, developing spare parts specifications, and reviewing alternatives, they should be able to charge their time to another business area; in this case, purchasing.

One important element in the size of your maintenance organization is the Plant Design. The design of the plant contributes to every aspect of the plant performance and manpower requirements. With technology today, you actually may have the capability to operate the plant from your house! Selection of equipment, materials, and controls determines the maintainability of the plant. Remember, *one of the best ways to reduce maintenance staff is to design and install the equipment right the first time.* As technology grows, the push to build a plant at the lowest cost forces maintenance to become a large part of the organization. Automation allows management to run plants with fewer operators, who may even be of a lower skill level. This trend puts additional burden on maintenance, not only to fix the problems, but also to find them.

Wrench Time Story… "We need more people"
One day I asked a mechanical maintenance supervisor if his shop could do a small piping project for me. His response was "We can't do it, we need more people." I said, "Let me ask you a few questions." I asked how many major mechanical systems there were, and he replied "about 10." I asked him if he was acting as a contractor doing mechanical maintenance, how many people would you need to repair and PM System 1? He said 2. How about Systems 2 though 10?" Going though each system, we came up with approximately 50 people. Then I asked him how many people do you have now?" He said "100". He was getting a little mad by now, but I asked him how many extra people were required during a plant outage? His response was "none". I said, "Well, what the hell are they doing when all the equipment is running?" He got very upset, and while walking away, he turned and shouted, "You figure it out?" I did, and it turned out to be just another time I was speaking without thinking. I thought the maintenance department was over staffed until I looked at what they were doing. I saw over half of maintenance people working in every other department besides maintenance, such as purchasing, training, engineering, safety, operations, construction, or entering data in a CMMS. For this reason, before you think maintenance is over staffed, watch what they are doing. It's probably not maintenance. It's more likely a piping project for some engineer!

10.3 Outsourcing and Contractors

Anybody managing maintenance realizes the workload in maintenance changes during the year, and it often forces you to contract work to another company. Why does this happen? Consider the following:

- Staffing limitations - some companies just limit the number of full time employees in a department without any understanding of the workload
- Peak labor requirements - plant production may vary during the year
- Capital projects - addition or modification of equipment
- Major overhauls or plant outages - major repairs or overhauls of equipment
- Staff technical capabilities -- the people don't have the technical skills
- Poor management skills in planning and prioritization of work. You have technicians, the contractor has technicians. You have supervision, the contractor has supervision. Therefore the only difference is management.

Because of these reasons listed above, there will be a time when you need to contract out work. Here are few things to consider before any contractor steps in your plant:

Add value to your people, not the contractor's personnel. Your maintenance people are family, so give the education and money to your people before a contractor. One method is to keep the technical work "in house" and outsource labor-intensive work, such as landscaping, janitorial service, painting, etc. Train your people on functions that support the plant operation. If the plant is down, you have the technical experience available to repair the equipment. Assume maintenance is asked to rebuild an air compressor *and* paint the assembly line next month. If you only have the staff to do one of these tasks, select rebuilding the compressor, using you maintenance team and the support of a compressor service engineer. This gives your team a hands-on class on air compressors. Contract out the painting of the assembly line.

Give extra money to your people instead of the contractor. Some contractors are offered incentives or unlimited overtime to do a project. Give your maintenance shop first chance at these projects. This may be the only chance for your maintenance people have to make extra money.

Don't split a project if possible. Try to keep the responsibility of a project to ONE contractor. Example of this could be the installation of a new conveyor belt. Seems simple, it's not. What if one vendor supplies the belt and another vendor splices the belt. If the belt does not track right, both vendors are pointing at each other. The point is, if you split a contract between vendors, you need to draw a line of responsibility. Each interfacing task between vendors needs to be defined, detailed, and scheduled so each party knows their responsibility.

Check their qualifications. One method is to develop qualification guidelines for a contractor. Ask your legal, purchasing, engineering, and maintenance departments to define their requirements of a contractor. For references, you may want to visit a site where contractor is presently working. The pre-qualification list is to insure that the company you select is financially, legally, and technically competent to do the work. A proactive approach is to find contractors in the mechanical, electrical, and instrumentation fields before you need them. Build the guidelines for your plant requirements.

Here is an example of one shown below.

Contractor's Qualification list	
Company Name	
Address	
Contacts	
Reference #1	Feedback from a customer that use their service
Reference #2	Feedback from a customer that use their service
Safety record	Check workman compensation claims
Safety training	Must meet and exceed plant safety requirements
Equipment knowledge	Work force has required skills to do work
Lawsuit	List old and new lawsuits
Liens	List liens placed on company
Insurance	Describe the type and amount of insurance required

Table 10.3a Contractor's Qualification List

The Contract

If you haven't noticed, the days when purchasing equipment was done with a simple handshake are gone. Lawyers are now involved in maintenance and the entire contract process. A contract is simple a verbal or written agreement between two or more parties. Today contracts are written for every piece of equipment to prevent liability or loss of production lawsuits. For this reason, get your legal department to develop a *simple* legal contract guideline (in layman's terms). The guidelines should consist of generic information or questions an engineer or maintenance person should ask before signing a contract or starting a purchase order to determine the owner and vendor responsibility.

A contract guideline could include information like the example below.

Contract guidelines			
	Supplier	**Owner**	**Notes**
Paying for shipping			
Receiving the equipment			
Storage of equipment			
Installing the equipment			
Pay for the loss of production			
Guarantee			
List hazardous materials			

Table 10.3b Contract Guideline

Besides the general legal conditions of a contract, we need to add the requirements of the contract such as parts or labor. Consider a contract as a project, and use the Part and Task List we developed in "Project Management" to define any material and labor responsibility. The Part list consists of parts required for your project. This list consists of parts, manufacturer, responsibility, and confirmation of price. The task list defines the construction labor hours, temporary material and equipment required building your project. This list is built by walking though each event of the project from start to finish. In addition, the contract requires a schedule, which is the date each items on the parts and task list is required to assure the overall project schedule is meet. Also include the information required for maintenance, operations, and engineering to operate and maintain the equipment in the future.

The last item in a contract (the one that gets everybody's attention!) is the payment schedule. The payment schedule is the percent of contract paid based on the completion status of contract. Most payment schedules should be broken down to pay the contractor for completion of each step. The amount paid for each step should be enough to protect your company's interest, without placing a financial burden on the contractor. Your goal is to hold as much money until the end of the contract. Here are two examples of payment schedule:

Example 1	**Example 2**
25 % Contract Award 50 % Equipment on site 25 % Installation	10 % Contract Award 15 % Completion of design and drawings 35% Equipment on site 25 % Installation 10 % Performance test 5 % As-built drawing and service manual 1 % Incentive clause if schedule are meet

Table 10.3c Contract Payment Schedule

Comparing the two different payment schedules above, in Example 1 we paid out 100% after the equipment was installed and only 84% in Example 2. To the end user it means if there is any start-up problem with Example 1 contract, you may have difficultly contacting them, but in Example 2 we have 10% for testing and 5% for an updated set of prints to work from in the future. The payment schedule should be design based, so if the contractor walks off the site at any phase of the contract, the project can still be completed. Besides the final payment, to have some control of contractor from leaving the site too early, keep a running punch list of open items not completed per the contract.

With changes in the economy, contractors are willing to take on more responsibility and risk. If a contractor is responsible just for the equipment, it cost you $ 1X. Add the responsibility of installation to the job it costs $2X. Add a start-up and a performance guarantee, its $3X. Add the liability of loss of production to the contract and it cost you $4X. Did you also notice the more responsibility you add to the contractor, the more time you need to spend with a contract lawyer? The contractor's pay structure can be modified to be based on their risk and liability to the plant's performance. An example? A contractor is only supplying labor assistance in installing equipment, compared to a contractor who supplies labor and supervision and has possible penalties for not meeting a completion date or an equipment performance guarantee.

In industry, two types of contracts are used by maintenance, Turnkey or Time & Material. *Turnkey contract* is used for a defined project in which all the responsibility is in the contractor's hands. This includes parts, labor, equipment and supervision to manage the work. A contractor will typically place their best people on a turnkey project to increase their efficiency and profits. On the other hand, with a *Time & Material contract*, you pay for labor and material based on your requirements. In addition, you direct the contractor. It would seem that using a turnkey contract would make your life easier; the problem is that in maintenance it's difficult to define the job. A great example of this could be trying to write a contact to rebuild your air compressor. The problem? You won't know the work involved until you tear it down. Most maintenance work is undefined, so it forces you to use a time & material contract. Just make sure the contract supplies safe and technically qualified people.

Wrench Time Story… "parts"
One lesson I learned early in my career was to have the contractor responsible for the small parts. One of my first projects I managed I was responsible for ALL of the parts. This included nuts, bolts, electrical fittings, and even wire nuts. Most of my time was spent chasing parts and supplies that the contractor lost or threw in the mud. After that project, I always had the contractor responsible for all the material. It's amazing how a contractor can control inventory when the cost comes out of their pocket.

10.4 Operations

Make no mistake about it, the operators / production personnel run your plant. They are on the job operating the systems when most maintenance and management personnel are long asleep for the night. They work crazy shifts, holidays, weekends, etc. to produce your product. I really don't know how they do it. To do their jobs properly, these folks should be the most knowledgeable about the overall operation of your facility. While your maintenance people certainly should have a better idea about micro issues, the operators should take care of the macro job of running the entire plant. Their overall experience and knowledge should be used as a tool by maintenance; it is imperative that operations and maintenance pool their resources to solve problems.

Changes in technology and attitude have caused the operation of a plant to shift from operations driven to maintenance driven. Maintenance is more often in control of what and when equipment is repaired. As a technician once said to me "when the equipment is down and tagged out to my name, I own it." Now, no one has more respect for the guys and gals of maintenance than I do. However, I have to say that it was partially due to this type arrogance and lack of response from maintenance that the RPM method was established; so operational equipment problems can be placed as a high priority. This prevented maintenance from picking and choosing work based on whom they liked. A quick response from maintenance to equipment problems causes operations to write more work orders, develop ownership, and encourages more inspection of equipment.

From an operations standpoint, the scope of operating your facility is fairly simple. They need to know what equipment is running, what is its normal output, and has anything changed?

To encourage a smooth interface with maintenance, you may ask your operators to:

- *Properly secure and lock out equipment to prevent personnel injury*. Check and recheck to verify equipment is safe for maintenance to work on.

- *Operate the equipment per design*. Use *automatic mode* instead of *manual* mode to operate equipment. Manual mode may disable instrumentation and switches, which may cause personnel injury or equipment damage. Only operate equipment with all instrumentation and safety devices intact; no jumpers, program changes, or safety devices removed from control logic.

- *Work with maintenance during plant shut down*. Not only can operators give insight on the various systems, they can also get a hands-on education about the equipment they operate.

- *Write detailed work orders for maintenance*. This allows maintenance to have a better understanding of the problem.

- Identify problems before major breakdown occurs. To do that, operations must have the ability to see a change in equipment performance.

- *Thoroughly understand how the equipment works*. Operators should use their spare time to look at flow diagrams, logic diagrams, manufacturer's manuals, asking questions, etc. In general, try to know everything they can about the system and the equipment in that system.

- *Record the equipment's operational data*. This data helps to provide maintenance with information to troubleshoot the equipment. For instance, assume an operator is monitoring the performance of a pump. Typical data for the pump could include suction pressure, discharge pressure, seal water flow, motor current, bearing temperature, bearing oil level, or bearing vibration. Also, include the process data that could affect pump's performance, such as discharge flow or recirculation valve position. This information could be compared with previously obtained data, which would also give maintenance a baseline to work from. Finally, this information should be placed in a maintenance friendly format, such as the Maintenance ID. This information based on the pump's Maintenance ID should be easily accessible by everyone, including any predictive maintenance testing. The example below shows how some data may be stored for maintenance.

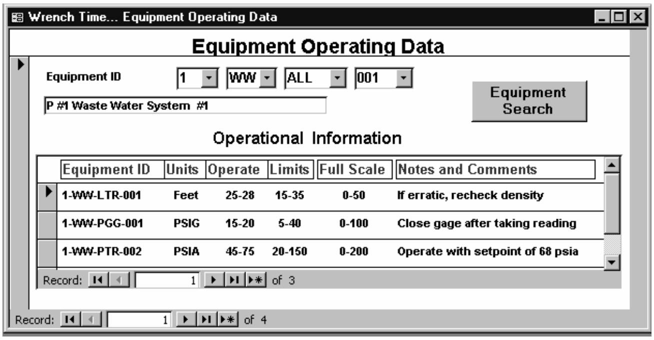


Figure 10.4a Equipment Operating Data Screen

Remember, your operators are the first line of defense against equipment failure. These folks baby sit their equipment, often twenty four hours a day. They should notice even subtle changes. The real important point here is that the professionals from maintenance and operations make your process happen, so they should always try to work together.

A Final Comment about operators:

The scope of the traditional operator job is changing. Technology has given us the ability to sit in a room and operate many processes from a computer screen. As history has proven, the more technology interfaces with an industry, inevitably less people are needed to do the same job. I recall some engineers from a power facility in Eastern Europe (built just after WWII) who were amazed that a company I worked for only had 13 operators on site to produce 900 megawatts of power. They had over 2,000 people working (including maintenance personnel) to make essentially the same amount of power! Of course, this is a vivid testimony to the impact of newer technology. Keeping our dynamic technology in mind, a trend in numerous industries for the last decade is to eliminate the operator position as it has been known in the past. In the interest of saving money, many companies now phase out operators and try to magically change a maintenance person an operator. There are many names for this combination operator / maintenance man, but the one I like best is “super tech.” Of course, this super tech now has to not only perform his prior maintenance job, but now he must learn to operate the entire facility as well. Fair? Not at all. Certainly, this results in labor savings. Yet, it also results in equipment that does not get checked on a regular basis, maintenance folks being forced to function outside of their area of expertise, etc. Let’s face it, because one person can only be one place at one time, companies are gambling that their facility will essentially run itself, and they are willing to accept the risk.

In closing, I remind you of our arrogant technician who said "when the equipment is down and tagged out to my name, I own it.” That sounds great, but remember that in days gone by, the operators would have had the equipment turned off, tagged out, blocked out, locked out, stored energy released, etc. by the time you showed up. All you probably would have had to do was sign your name on a tag or two and go to work. Be careful what you wish for, because you might get it!

10.5 The Paper Trail

Damn! I hate paper. However, as we all know by now, any organization requires paperwork to operate it. Combine this with the development of the computer, and it has caused a ton of information to fly around the plant site. The problem is, who is looking at and acting on this information? At one company where I worked, the paper problem got so bad that they actually paid a "bounty" of $200 for each form eliminated from the system! Of course, this is not as easy as just throwing out every form you can lay your hands on! To help streamline your paper trail you must locate every piece of documentation, every form, and every piece of paperwork used in your plant. This includes information like:

- OSHA and EPA documentation (or any other safety / environmental form)
- Insurance forms or inspection documentation
- Personnel
- Purchasing, Warehouse and Shipping
- Operations (production, alarm reports, downtime, etc.)
- Maintenance (PM, predictive, alignment, inspections, etc.)
- Engineering (drawings, calculations, etc.)

Each piece of documentation in your plant needs a flow path. Simply, there should be someone responsible for:

- collecting data, filling out the form, or making a calculation or drawing
- analyzing data, checking forms, checking inspection reports, etc.
- taking action on the information (ordering parts, working on equipment, sending information to EPA, etc.)
- ensuring the task is complete and correct (supervisor, boss, etc.)
- filing information for future use (maintenance planner, filing clerk, etc.)

If you have paperwork that doesn't have someone assigned to each category, it is probably useless, inaccurate, or lost. Look at the paperwork and data in your plant. Here some of the problems you may see:

- People collecting data, but no one analyzing it
- People not acting on the information you collected
- Not everyone knows where the information is filed
- To solve these problems, each document should have a department and person assigned to track each activity.

Here are a few possible flow paths for your plant…

Paperwork	Collect	Analyze	Action	Q.C./Comp	Filing
Work order	Anybody	Maint Operation	Maint.	Maint. Supervisor	Maint. Planner
Alarm sheets	Operator	Operation Supervisor	Operator	Operation Supervisor	Operation Secretary
Calibration sheets	Instrument Shop	Control Engineer	Drafting	Engr'g Instr. Shop	Instrmt Shop
Electrical drawing	Electric Shop	Engr'g	Drafting	Engr'g Elect. Shop	Electric Shop
Safety Inspection	Mechanic Safety	Safety	Maint. Manager	Safety Manager	Safety Clerk

Table 10.5a Information Responsibility and Flow path

So, hopefully you have identified the forms that are needed, as well as removed the ones that probably aren't. Now that the unnecessary forms are removed, consider a few things before allowing any new forms or reports to enter into your organization. You can easily reduce paper work by combining two forms. For instance, a purchase order and shipping / receiving ticket, a material request and purchase order, or a work order and engineering changes sheet. Also, you can add information to an existing form to prevent people from going to two locations. Add contact name, phone number, and e-mail to purchase orders. Add the warehouse location to stock items on purchase order. Add Maintenance ID to each memo, purchasing order, and warehousing functions.

Final thoughts and considerations for your plant *Information:*

- Information accuracy (garbage in = garbage out. You're just wasting time and money)
- Information usage (if nobody is looking at it, don't collect it!)
- Information cost (every blank on a form costs money to fill out and to look at. Remember, it costs $X for an employee to enter the data, and $10X to be looked at by a manager)

Damn! I hate paper work. Don't ask me why I wrote a book.

10.6 Memos and Meetings

MEMO
To: Mechanic
Date: Today
Re: FYI / CYA
For your information, you should cover your own ass.
Cordially,
Your Manager

Okay, maybe the memo trail is not quite that bad, but you understand my point. Management loves memos. All you have to do is look at the management job descriptions in employment section of your Sunday paper. The job requirements typically don't discuss proven records in reducing plant downtime, increasing plant production, or increases in safety awareness. NO, it's ability to write a memo or do spreadsheets! If the maintenance manager is required to write memos on everything, then the company should hire a technical writer or English teacher. Keep management, engineering, and maintenance focused on drawings and equipment data (the communication tool for maintenance and engineering). I've never seen a piece of equipment stop do to a sentence ending with a preposition. If you are going to write memos, try to have the important information handy, such as the Maintenance ID, equipment name, vendor information, and any other relevant names, numbers, or contact information. Also, file the memo with the equipment database so everyone was access.

MEETINGS
The only thing management seems to like better than writing memos is having meetings. Sometimes, they talk about the memos at the meetings! To prevent a meeting overload, require two items before a meeting can be held:

- *An agenda*, which is a detailed description of the meeting subject and time. Try to limit meeting to three key items to keep everyone focused. Limit meetings without an agenda to a maximum of fifteen minutes. This also includes the Social Event of the Week (also known as the staff meeting)

- *Meeting cost* : show estimated time and cost. This really stabs the MBA and accounting types in the heart, because it shows the amount of money tied up in your meeting. Example: VP of Engineering @ $70/hr, VP of Marketing @ $80/hr, four sales engineers @ $120/hr and three design engineers @ $100/hr. Consider travel time using a minimum of 20 minutes for interoffice meetings. Total the cost of this 40 minute meeting plus travel 20 minutes is equal to $370 an hour. At these hourly rates, you better not be discussing the new coffee machine.

As much as I make fun of meetings, I don't mean to imply they are not a valuable tool, because they can be. However, every attendee must be focused on one agenda. There are two meetings that should be required in maintenance, the daily meeting and the maintenance planning meeting. In maintenance, it's good to have a daily toolbox meeting in the morning to discuss where everybody is working and any safety issues. Just don't have any chairs; once they park it, it's over. As for the maintenance planning meeting, it should be broken down into systems (CA…control air, WW…wastes water, etc.).

A system agenda should be prepared with the following information:

- Current Operational problems
- Top three "R" work order
- Two weeks of "P" works
- Last but not least, management's top modification priority, the "M" work order

Discuss changes in priority, equipment availability, planning, and scheduling. Whatever you conclude, publish it and show everybody your map. Talk about what you are *going to do*, not what *you did*.

10.7 CMMS

Computer Management Maintenance System

In theory, the CMMS was designed to help maintenance by placing the information of the maintenance supervisor's filing cabinet into a computer. The thought was that everyone would have ***EASY*** access to the equipment information. Instead the only one it's helping is management, since they can monitor maintenance performance without even getting out of their chair. It's not like a maintenance person isn't busy enough fixing a pump; now management asks him to fill in all the blanks on a CMMS screen. Therefore, to the maintenance person, CMMS probably means **C**ybernetic **M**aintenance **M**onitor **S**ystem, a computer system designed to track maintenance people!

Most CMMS fail because management takes highly skilled technicians and sits them in front of a computer. After spending several million dollars for the initial installation, another million in three years for the upgrades, you hear management asks, "Why are maintenance costs increasing and equipment performance decreasing?" CMMS is a tool. It's no different from a lathe or a welding machine. Therefore, it should be purchased the same way - with a financial benefit to the organization. Remember a CMMS can't repair a pump. If your maintenance department doesn't run well without a CMMS, getting one won't repair that pump any sooner.

So, after beating down CMMS, can it be a valuable tool to maintenance? ***<u>YES!</u>*** But it needs to be designed with the maintenance person in mind. That is, designed to allow easier access of safety, parts, equipment information, and tools to help him repair the pump. For an electrician, it means access to the electrical and control drawings, for a mechanic it may be a service manual, for an instrument tech a calibration sheet, and for a planner access to parts in the warehouse. In addition, for management a CMMS should be a tool to help them understand the real performance of maintenance and equipment. If you are using a CMMS today, give it a maintenance test. Ask a technician if the CMMS is helping his job. If the answer is NO, find one or modify the one you are using today.

If you are ready to purchase a CMMS system here are some questions that may be on your mind.

What is required before you purchase a CMMS?

Everything we've discussed throughout the book at this point. That is, the equipment must be running safely, and available to operations. All equipment documentation, drawings, and control logic has been updated. A Maintenance ID is established for each piece of equipment that you want to receive data from. A Maintenance ID is established for non-equipment activities of your Maintenance team, like training or purchasing. A work order priority system is in place like the RPM method. Equipment parts are stored in an isolated location in the warehouse labeled with Equipment Part ID. Simply stated, before thinking of purchasing a CMMS, maintenance has to have a handle on all equipment safety and availability, the "R" and "P" work.

What type of CMMS should be purchased?

The type of CMMS you select depends on the data you require from the system. For illustration purposes, I've developed some CMMS screens throughout this book I thought would benefit maintenance. I started by sitting down with a pad of paper and sketching out Equipment and Work Order screens. Use my ideas, or sketch your own. Get a couple of maintenance people, a pot of coffee, and some paper and pencils. Sketch out and develop screens that are maintenance friendly. If you need some ideas, ask CMMS manufacturers to send you a demo or freeware. The purpose of this exercise is to define to two things required for your CMMS, the data and its flow path. Start with the focus of your design around the EQUIPMENT.

What equipment information do you need to access?
How about:

- Safety (tag out / lock out, permits, MSDS, etc.)
- Parts (parts requests, purchase orders, etc.)
- Information (drawings, service manuals, calibration sheets, etc.)
- Tools (any special tools)
- Equipment performance data (predictive maintenance information such as vibration, thermography, oil sampling, operating information, etc.)
- Next, sketch out some screens for…
- Work orders (request, overview, search)
- Work order plan (priority such as RPM, safety, parts, information, and tools)
- Parts / inventory (equipment and non-equipment)
- Purchasing (request, order, tracking, and search)
- Preventive maintenance (plan and schedule)
- Predictive maintenance (data from other devices or software)
- Operations (safety and equipment operating data)
- Management ($$$$ and historical data)

Sketching out different screens may give you ideas on supplying information. One idea I had while doing this was adding a query of open works on the Work Order Request screen, illustrated earlier in this book. The thought was if the operator saw the open work orders in a system, it would prevent generating duplicate work orders. So, build screens that are important to your maintenance and operations departments. Just be careful not to overload the system with useless information.

Undoubtedly, the purpose of generating your own screens is to get what you need.

Nobody knows your needs better than you; you may choose to define the data required for each screen in your CMMS as shown in table below.

Equipment	**Work Request**	**Work Order**	**Equipment Parts**
Maintenance ID	Maintenance ID	Maintenance ID	Maintenance ID
Equipment description	Work description	Work description	Equipment Part ID
Owner's label	Short work description	Work order number	Inventory ID
Owner's equipment description	Name of person entering request	Work priority (RPM)	Vendor ID
Display all parts with the same Maintenance ID	Display open work orders with same System ID	Date	Display all parts with the same Maintenance ID
Display all work orders with the same Maintenance ID		Labor hours	Display all parts with the same Inventory ID
		Material used (Equipment Part ID)	Display all parts with the same System ID

Table 10.7a Information for CMMS screens

Just keep in mind the earlier discussion on information in the plant. Data needs to be collected, analyzed, action taken, QC and filed. Once you've determined the data you are storing, find a CMMS with screens similar to the ones you sketched. Keep in mind that software changes are expensive, so try to use their standard software. Next, ask the CMMS vendors if maintenance people were involved in developing their software. Find out who the people are, the number of years of maintenance experience, and their industrial background. Check to see if the CMMS is used in your industry (power, pulp and paper, or food industry, for instance). Go see it in action. Go to two sites where it's being used and talk to the maintenance folks using it.

By now, you should have narrowed down your CMMS choices to no more than three. Here are a few more items you may possibly consider before purchasing and implementing a CMMS system:

- *Keep maintenance screens clean*. Remove all non-maintenance information from screen. Maintenance doesn't care about the vendor's *debt cost variance*. Give accounting and management their own screens.

- *Separate User from Administrator*. The User of the portion of the system should be visual, using click and choose options. It should involve limited amount of typing required by end user. Software should use pull down menus, remember the last entry as a default, and provide running queries (as the user types, he can see selection list). Maintenance people using the system shouldn't have access to modify database. Use the *see but don't touch* philosophy.

- *Talk with computer experts* about your *hardware* (computer, modem, network), your *software* operating platform and security (Windows, Unix, etc.), your *database* (Oracle, SQL, etc.), and any possible *interface* with other computer programs (accounting, purchasing). Also, discuss the ability of the system to be modified by end user. No system is going to be exactly what you want. The software should have the flexibility to allow changes to titles and field length to match your equipment without affecting software. An example of this is software using column titles such as Cat 01, Cat 02, and Cat 03, etc. The end user should have the capability of changing these generic title names (Cat 01 to Work Priority) without affecting software.

- *Consider that the implementation of a CMMS requires people.* The end users and administrators of system need to be identified. Select people to input data. You may select one maintenance person familiar with plant equipment, and two non-maintenance personnel to enter data. Also to be established are the administrator of software, as well as people designated to handle system back-ups, software updates, maintenance end user training, and to define data required to be entered and extracted from system.

- *Consider that the implementation of a CMMS requires time*. All installation parameters should be discussed and defined. How long from beginning to use?

- *Finally, consider that the implementation of a CMMS requires money*. Use this little equation as a rule of thumb.

Number #1 - List the *cost benefits* of a CMMS. All equipment data is stored in one location, have the ability to build a bill of material for each piece of equipment, have the ability to track labor and equipment costs, etc.

Number #2 - List the *cost* to install a CMMS. Software and licenses, computers and network, people to install data, people to install software and the training of people to use software.

Number #3 - List the annual *cost to support* CMMS. Software maintenance agreement, people to input more data, people to support software, and computers and people to train users to use software

Number #4 - Do the *Math*.

Item # 1 must be greater than the sum of # 2 plus # 3!

11 Dress for GO, not for show

STEP 1 Set Priorities
STEP 2 Safety and Environmental Performance
STEP 3 Clean Up Your Plant
STEP 4 Plant Inspection
STEP 5 "RPM method"
STEP 6 Parts and Labels
STEP 7 Working on Tomorrow
STEP 8 Reality (maintenance can't do it alone)
STEP 9 Computerize Maintenance
STEP 10 Looking to Improve
STEP 11 Celebrate

"be self-confident… wave your own flag, but don't let anybody see it. Blow your own horn, but don't let anybody hear it."

Fred J. Weber

<u>STEP 1 Set priorities</u>

It's time to implement this whole plan; in fact, it's Wrench Time! This module is a step-by-step approach for organizing a maintenance department. I've discussed various ways to improve your maintenance department and I'm sure you have some great ideas too, but until you act, the words and ideas are meaningless. I'm sure you've found out throughout your career that implementing a change in your plant isn't going to be easy. So, before any changes you need to develop a plan. This module is both a summary of this book and a plan that can be used to implement some of these ideas in your plant.

The first step is to define how you are going run maintenance by setting new priorities and getting a commitment from yourself and your team. Start by understanding your priorities as a manager. First, get a picture of your family and place it on your desk. Next, get a picture of the people that work for you and hang it on your office wall. Remember whom you work for because their health and education lie in your hands. Finally, make all decisions in your plant based on your goals as a manager. The manager's goal and purpose? To make each employee's job as **<u>SAFE</u>** & **<u>EASY</u>** as possible.

Now it's time to sit down with members of your maintenance team and explain their new priorities.

\# **1** - **Take care of yourself and your family** - it simply means that your health and well being is the number one priority (for yourself <u>and</u> your family). Work safely and take all the steps necessary to leave work in the same condition as you started.

\# **2** - **Take care of co-workers -** it means if you see a co-worker that needs help, put down what you are doing and help them. For the seasoned mechanic it means to train the younger mechanic. For a young worker, it means being the dirtiest one on the job. Take all the necessary safety steps to keep your co-workers in the same condition as they started the day.

 # 3 - Operate plant while meeting safety and environmental requirements and achieving a profit - Your work priorities are activities required to keep the plant safe, reduce pollution, and help the company achieve a profit.

Now that you've set priorities, it's time for you and your staff to make a commitment to improve the quality of life for everyone in the plant.

Commitment from maintenance team

Increase maintenance person's responsibility from simply fixing problems to finding and solving them. As a manager, I always ask people working for me to inform me twice. The first time was to explain their idea; the second time was just to make sure I was listening. If I didn't act, it became my problem. Supply at least two solutions to each problem submitted to management. Who best would know a solution to an equipment problem? Your maintenance people.

Commitment from Management

Give the maintenance person the <u>incentive</u> to do a good job. No matter what three-letter theory of maintenance you use (such as RPM), the reward system MUST match the performance you want from maintenance. Your maintenance people are intelligent enough to solve any equipment problems, clean up a backlog of work orders, and get the plant running at its highest level; the problem is management's reward system. Simply speaking, maintenance people don't trust management. Maintenance knows if they fix all of the equipment problems they will lose overtime. Also, if management sees idle maintenance people some of their co-workers will loose their job. I know this from experience. Management needs to base rewards on their new priorities: helping each other, operating the plant safety, being environmentally friendly, and making a profit for the organization. Monitor items such as OSHA and EPA compliance, product quantity and quality, or equipment availability. Maintenance will follow what ever you measure, as long as it doesn't affect a maintenance person's job security, pay, or health.

An example of this would be overtime. If the typical maintenance person gets an average of 800 hours of overtime a year, make sure your reward system doesn't eliminate their $$$. In addition, as maintenance fixes all your equipment problems (and they will), you need to have a plan to develop new skills for your maintenance team such as planning, training, predictive maintenance tools, or engineering.

STEP 2 Safety and Environmental Performance

Before you move on, go back to Step 1 and read "**Commitment from Management**" again…I just wanted to make sure you were listening. Now review the plant's ability to meet safety and environmental regulations (state and federal). Select some people from operations, maintenance, and engineering responsible for the Plant's Safety and Environmental program. If your organization doesn't have a staff member trained in safety and environmental regulation, then hire one. Select a consultant familiar with your industry, with REFERENCES and the capability to train plant personnel.

Start by establishing emergency response procedures for Medical, Fire, Hazardous Materials, etc. Invite your local police, fire, and health agencies to your plant to review plant layout and voice any hazard concerns. The following is a list of safety and environmental items to start on:

Safety

- Review production and maintenance personnel to ensure safe habits.
- Build a Material Safety Data Sheet (MSDS) file for all products in your plant.
- Review design and test safety interlocks on equipment. Look for missing guards, by-passed safety devices, or safety switches taken out of service.
- Review each job in the plant for proper Safety equipment. Check for availability and proper usage of safety equipment, such as hearing protection, safety glasses, or protective clothing.
- Start a safety training classes.
- Build tagging or lockout procedures to isolate each piece of equipment

If you find a safety problem, correct it <u>immediately</u> and get the safety department involved in maintenance.

Environment

Check the land, air, water, and garbage leaving your plant. Make sure the operation of the plant doesn't affect the health of anybody in the plant or the surrounding community. One step to preventing pollution is NOT to bring it in to your plant.

- Review MSDS sheets of all materials in your plant for hazardous materials. Substitute hazardous materials and material requiring special disposal.
- Check all emission points leaving your plant. Sample all drains for water quality, vents for air quality (exhausting fumes), and trash for hazardous or recyclable materials.
- Build storage areas for chemicals and solvents, and supplement with proper handling equipment, equipment, and safety training.
- Take steps to conserve resources and start recycling (power, water, paper, oil, and metals)
- Maintain equipment (once it fails it goes to the landfill!)

If you find an environmental problem, correct it <u>immediately</u>. In addition, get the environmental department involved in maintenance.

STEP 3 Clean Up Your Plant

It's time to "dress for go, not for show" by changing your dress clothes for a pair of coveralls. But before jumping into those coveralls, sit down and develop a plan. Yes, even for the simple task of cleaning the plant, you really need a plan.

Define Systems and Responsibility

Start the plan by reviewing the plant process drawings and break up the plant into different systems, such as HVAC, Packaging line, Facility or Control Air. Establish a team for each system, with a member from each maintenance craft. Depending on plant size, system complexity, or technical knowledge, you may have people responsible for multiple systems. Take your time and sketch out a table showing the systems and teams as in the example below.

	System #1	System #2	System #3	System #4
Planner	Tony F.	Jim J.	Tony F.	Jim J.
Mechanic	Tim W Tom M. Dan P.	Rick C. Joe L. Jeff S.	Sam G. Bob B. Becky P.	Dan C. Joe B. Larry S.
Electrician	Hal C.	Glenn T.	Lou F.	Don D.
Instrument	Dave W.	Dave W.	Jack L.	Jack L.
Engineer	Sam G.	Joyce W.	Sam G.	Joyce W.
Labor	John J. Ann L. Dan P.	Pat G. Steve B. Gary R.	Joe S. Dave F. Bruce B.	Fred W. Steve M. Tony E.

Select lead person

Choose a maintenance member from each system to represent each system team.

	System #1	System #2	System #3	System #4
Lead person	Tim W,	Jim J.	Tony F.	Joyce W.

This lead person needs to train team members on any of the system's safety, environmental, process, and equipment issues. The lead people for our example are selected in the table below.

Supply equipment and materials

Have team leaders get equipment and materials to clean up their system, such as:

- Safety equipment (respiratory equipment, eye protection, MSDS sheets, gloves, etc.)
- Cleaning supplies (brooms, hoses, degreaser, soap, etc.)
- Paint and painting supplies (paint, brushes, wire brushes, tape, drop cloths, etc.)
- Ladders, forklifts, or scaffolding

Chemical, solvents and lubrication

Review the area in the plant designated for storage of all chemicals, solvents, and lubricants. Separate each chemical. Unidentified materials should be tested and disposed of correctly. Known chemicals, solvents, and lubricants need to be properly stored and labeled. Near the storage area, include a copy of the MSDS sheet and required safety equipment. Discard materials no longer in use following all safety and environmental requirements.

Equipment Parts

Define an equipment storage area or a place in the warehouse for **ALL** spare equipment parts. Separate parts based on systems such as "WW" or "CA". Also, include two additional areas, one for discarded equipment parts and the other for equipment parts that need to be rebuilt in the future (for instance, a pump that needs rebuilding or printed circuit boards that need to be tested). Also, keep items like scrap material, fasteners, pipe, or plate (non equipment parts) away from the Equipment Parts.

Waste Material

Get one big dumpster. Waste material options are store it, dispose of it correctly, recycle it, or sell it. If you don't know what it is, test it. Follow all environmental regulations.

Punch List

Walk the plant with Team Leaders and list clean-up work required in each system.

Compressed Air System	**Wastewater System**	**Chemical Feed System**
Degrease floor around compressor	Remove old strainers	Clean caustic on floor Neutralize and check with lab
Remove old suction filters	Wipe down instrument cabinet	Remove old insulation

Schedule it

Pick a day when the plant demand is slow and the outside weather is good so you can open the doors.

Secure and lockout equipment

Make it a safe work environment.

Now you're ready to get in those coveralls and help clean up the plant! What the hell, maintenance has been waiting along time to see you get dirty, give 'em a thrill!

STEP 4 Plant Inspection

Plant inspection with equipment not operational

The plant is clean and equipment locked out, so this is an excellent time to inspect the plant for problems. Have your teams make an inspection report for the equipment in their system using three pads of paper labeled R, P and M work. The inspection lists for the compressed air system may look like this:

"R" work	**System** - Compressed Air
Equipment	**Description**
Compressor	Compressor drain valve missing handle
Discharge Pressure gage	Glass cracked

"P" work	**System** - Compressed Air
Equipment	**Description**
Compressor	Suction vent filter looks dirty
Suction Pressure gauge	Missing calibration tag

"M" work	**System** - Compressed Air
Equipment	**Description**
Compressor	Add temperature gauge to cooling water discharge line
Compressor Guide valves	Need external guide valve position indication

The inspection of equipment is a review the equipment's status today compared to when it was new. The equipment's service manual and drawings are an excellent reference to determine items to look at and any changes in equipment condition. Also, consider a few other items for your inspection such as:

- *Ensure equipment is safe to inspect*. Check and recheck, tag out and lock out, flush and drain, and close and vent. Think safety.

- *Write a good description of problem*. Description must contain enough information to define the correct craft personnel and parts required to fix the problem.

- *Locating equipment problems*. Look for:

- Safety (missing guards, safety switches disconnected, critical welds bad, etc.)
- Environmental (oil leaking in drain, dust collector with bad filter, etc.)
- Mechanical (loose and worn equipment, etc.)
- Hydraulic/Pneumatic (hydraulic, water, and air leaks)
- Electrical (damaged electrical fittings and connections, electrical housekeeping includes missing grounds, jumpers, moisture, wiring termination, etc.
- Controls (check for computer jumpers in PLC or DCIS system. Test all inputs, outputs and safety devices on each piece of equipment.

- *Update Documentation*… while checking on equipment each team needs to update ALL documentation relative to their system such as process diagram, electrical drawing and equipment service information.

Plant inspection with equipment operational

Once the plant is operational again, continue to add more problems and suggestions to the "R", "P" and "M" inspection reports by observing the operating condition of the equipment.
Safely look, listen, and smell for equipment problems such as:

- Bearing noises and abnormal temperatures
- Leaks (water, oil, hydraulic, or process materials)
- Abnormal noises, cavitations, excessive rubbing, etc
- Smells (burning, chemicals leaking, etc.)
- Equipment performance problems (jamming, tripping)

Establish equipment operating base line data

Start by recording operating parameter of equipment using predictive maintenance tools and instrumentation installed on equipment. Also run performance test at three different levels if possible on equipment to develop min / max parameter. Monitor motor current, pressure, flow, vibration, or temperature. Consider building a table to list equipment operating data as shown below.

Equipment Operating Data			**System… Waste water**		
Equipment	**Units**	**Operate**	**Limits H/L**	**Full Scale**	**Comments**
Pump #1 motor current	Amps	28	54 / 20	60	Measure plant flow of 300 gpm
Pump #1 seal water pressure	PSIG	60	100 / 50	120	Check with pump running

Downtime Reports

Hang a Down Time report next to each major piece of equipment. Ask operations to monitor and record all downtime associated to any piece of equipment for two week. Examples of downtime could be lack of product, machine jamming, intermit trip, machine component failure, and even lunch.
Here is what it may look like.

Date	**Time OFF**	**Time ON**	**Op/Mec**	**What happen?**
1/16	7:38	7:56	FW	No material
	8:23	9:01	FW/AA	Broken belt WO# 012222
	10:12	10:20	FW	Jam in feed chute

Not every equipment problem is related to maintenance, but they still need to be addressed.

STEP 5 "RPM method"

To organize the work for maintenance, we need to combine existing work orders in your maintenance department with the information collected from the System Inspection reports. The system team leaders need to review the existing work order backlog and determine the system and "R", "P", or "M" of each work order and add it to the appropriate System Inspection report.

"R" work **System**...Compressed Air	
Equipment	**Description**
Compressor	Compressor drain valve missing handle
Discharge Pressure gage	Glass cracked
Compressor	WO# 021211 Compressor surging at high load
Compressor	WO# 022122 Rebuild spare guide vane controller
Compressor	WO# 023411 Motor inboard bearing running hot (190 degrees)

You do remember the RPM method…

"R" work - safety, environmental, repair, or rebuild
"P" work - PM, testing, calibration, or software back-up
"M" works - modify, change or redesign

The system team leader reviews the "R" and "P" work, then determines if any safety and environmental problems are being addressed by the safety and environmental departments. Also, the leader will ensure that any duplicate and completed work orders are removed from the list.

Order parts immediately for "R" and "P" work. By now you got everybody's attention, so don't allow the lack of parts stop the momentum. Ask purchasing to jump on any material request associated to these work orders. Ship items the next day to show that fixing problems is a high priority to plant's operation.

Once the equipment problems are under control, "R" & "P" work is completed, or you are waiting on parts, it's time to improve plant performance by focusing on "M" work. First, combine all the "M" work orders and suggestions from the plant inspection. Set up a meeting with operations, maintenance, safety, and environmental departments to review management's recommendation of the top ten "M" work orders. Below is an example of three items on the "M" List

Priority	**Equipment**	**Project description**	**Cost Est.**	**Benefit**
1	CA system	Update PID drawing	2200	Price less
2	Ext. Press	Update electrical drawing	1300	Price less
3	1-WW- PMP-001	Resolve bearing failure	4000	$8500/year

Management determines the top ten work orders to send to engineering and maintenance. Once the "M" work priorities have been set and approved, give your people the time to complete it. As one "M" work order is completed, add another one to maintain ten items on your list. Here are a few suggestions to consider on your "M" list.

- Verify process drawings and piping & instrument drawings showing all equipment and support equipment (air, water, or fire protection)
- Label electrical disconnect to match equipment (safety… verify, test and verify again)

STEP 6 Parts and Labels

One of the main problems in repairing equipment is locating parts. To solve this problem all equipment parts must be located in one place and be labeled. Actually, one of the first "M" work orders that management could approve is to organize your warehouse for maintenance.

Warehouse

Using a floor plan drawing of your warehouse, divide it into three sections: production, general supplies, and equipment.

- Production parts will have a high activity and need easy access to production floor and shipping area, while equipment parts will be slow moving.
- General maintenance and supplies should be located near the front with a sign out sheet
- Equipment parts - use a system drawing, inventory list, and an estimate of future parts to determine each system storage size. Also, make room for special tools and brackets. Label each part with identification as the one I've discussed earlier (Equipment Part ID).

Once the equipment and part identification is determined, organize the equipment parts in the warehouse. Using the system drawing, define the system storage location.

"Control Air…CA"

Next, define equipment storage area using the equipment description and Maintenance ID.

"Air Compressor… 1-CA-CMP-001"

"Air Safety Relief…1-CA-BVR-001"

Finally, label each part with the Equipment Part ID (the maintenance inventory number).

"Air Compressor Inboard Bearing"

1-CA-CMP-001-0023

Consider storage procedure for long-term storage of equipment (motor heaters, rotation of equipment with bearings or electronic cards, etc.). The equipment parts goal is for everybody in maintenance can locate ALL the spare parts to the air compressor.

Chemical Storage

Supply storage and handling procedures for chemicals or other potentially hazardous material… warnings, safety equipment and MSDS sheet.

General supplies

For general maintenance supplies, consider separating items based on maintenance craft.

- Electric Supply shop item…**"Aluminum Conduit Fitting"**
- Instrument Shop item… **"Pressure gages"**
- Pipe Fitter Shop item… **"316L Stainless Steel Pipe fitting"**

Add sign for all general supplies such as "Rags", "Buckets" or "Gloves"

Production

Materials for production are considered temporary. Setup storage area to allow supplies move using first in - first out.

STEP 7 Working on Tomorrow

The easy part is over. The highly visible activities such as cleaning up, fixing problems, and organizing material are complete. It's time to start thinking about tomorrow, including planning, preventing, and predicting. Count the number of people working on "tomorrow" in your maintenance department today. Your goal is to simply get more personnel thinking of "tomorrow".

The first step is to take the tools from one of your best technicians and give him the responsibility of making it safer and easier for the other maintenance people through planning. This person should have good knowledge of plant technology, as well as have exhibited good organizational skills in the past. This person's focus is on organizing maintenance work for tomorrow by setting priorities (RPM method), planning (S.P.I.T.), and keeping work in front of maintenance. I predict that you will quickly find out that one planner can't keep up with all the maintenance people. If that happens, get another planner! The next planner position should be semi-permanent position. Each mechanic in your maintenance department needs to be assigned to the planning group for a month, and then rotated out with another person. The goal is for to everyone to learn how to plan a work order. Remember the old adage of "plan your work, work your plan?" That is the whole idea here. The planning team needs to focus on planning, preventing, and predicting equipment failure by:

Planning work orders (keeping the following in mind)

- Safety - safety procedure to secure equipment (lockout, permits)
- Parts - spare parts storage, computer back up, tested electronic boards
- Information - service manuals, updated electrical & program documentation
- Tools - storage area for tools required for each piece of equipment

Building equipment files (one location for all equipment information gathered from the following)

- Service manuals (including part's drawing on how to assemble and disassemble)
- Equipment history (including any past work orders or purchase orders)
- Operating parameters of equipment (compare design parameters to operating results)
- Parts in stock (new, manufacture recommendation and rebuilt)
- Vendor contacts to assist in repair or parts
- Equipment drawings (mechanical, electrical or control) and
- Instrumentation calibration information

Building equipment operating database and predictive maintenance

Key element to predicting equipment failures is to know the difference between how the equipment is actual running compare to how it should be running. With operations help, establish base line data by recording every possible equipment parameter (motor current, temperature, pressures, vibration, machine output) at three load points. Review equipment history, predictive maintenance data, design data, and operating parameters of equipment. Review the recommended equipment PM schedule from the equipment manufacturer, work order history, and present PM schedule with engineering. Establish a PM task & schedule that increases equipment reliability and reduces downtime.

STEP 8 Reality (maintenance can't do it alone)

At this stage, we've placed most of the burden on maintenance by asking them to check operator's work requests, organize the warehouse, update drawings, modify equipment, and order parts. All these activities have nothing to do with maintaining equipment. The problem is that maintenance can't do it alone. They need help from other departments to be successful and prevent you from going through these steps again next year.

Management Support…

- Develop team goals that support all departments
- Recognize people that increase the health and education of their workers while increasing the profit of the company.
- Support a work priority system that benefits and is focused on the operation of the plant (how about the "RPM method?")

Engineering Support…

- Develop a failure analysis program to identify the root cause of the problem
- Make recommendation to modify or replace components that will increase the safety and reliability of equipment ("M" type)
- Develop a documentation system that requires maintenance and engineering for approval. Documentation and drawings should include process, piping & instrument, electrical, and control logic

Purchasing Support...

- Order parts based on RPM method
- Reduce approval levels in the purchasing system

Material Management...

- Layout the warehouse separating equipment and non-equipment parts
- Warehouse people should become familiar with equipment
- Expedite material based on the RPM method

Formalize responsibility of each department on paper by developing:

- Team Goals using a task analysis
- Work order flow path
- Purchase order flow path and approvals
- RPM method + Maintenance ID to track costs
- Organization structure showing everybody in the plant

STEP 9 Computerize Maintenance

Before buying or implementing any CMMS (computer maintenance management system), make sure Steps 1 though 8 are completed:

- Set priorities - establish priorities and commitment for management and the maintenance team.
- Safety and Environmental performance - place safety and environmental problems on the top of your “to do” list
- Clean up the plant - establish a clean work environment
- Plant inspection - define plant the operational problems
- "RPM method" - established a priority system to fix and solve operational and maintenance problems
- Parts and Labels - organize and label equipment parts in one location
- Working on Tomorrow - planning, preventive, and predictive programs in place. Establish a Maintenance ID for each piece or equipment and maintenance activity.
- Reality (maintenance can’t do it alone) - establish team goals with other departments to make life safer and easier for plant personnel.

If you’ve completed this already, then it’s time to get a CMMS. First, determine information to be stored in the CMMS by asking maintenance, engineering, and operations their requirements. Select from three potential systems by visiting an existing user of the system. Finally, determine if the system is cost effective.

Once you’ve purchased a system, hire clerical personnel to input data and use maintenance to supervise only. Also, hire a computer technician to support software and back-up CMMS system. Start by building an equipment database and bill of materials. Next, write a separate work order for each piece of equipment (R, P, and M) and any maintenance activities that require you to track costs. As the system grows, so will your knowledge of equipment performance.

STEP 10 Looking to Improve

Suppose you don't agree on the approach and suggestions though out this book, or think they would be too hard to implement in your plant. Here is another way to improve your maintenance department. Simply look at a typical work order coming into your maintenance shop and ask yourself how you can improve life for your maintenance team. Question each activity required for a maintenance person to do a safe and efficient job. Here is an example of a work order that may come into your plant.

Work order #	**Maintenance ID**	**Short Description**
012134	1-WW-PMP-003	Hot inboard bearing
Long Description: Pump inboard bearing is running 15 degrees hotter than normal. Verified correct valve position. Pressures and pump flow normal. Bearing temperature reading at 205 degrees F and observed high vibration in pump.		

Question each activity required to repair this pump.

How can I work on this pump in a safer manner?

- How is the equipment determined to be safe to work on (such as lock out, flushes, draining, or venting)
- What permits are required to work on pump such (job hazard analysis or welding permit?)
- Is the safety department involved?

How can I plan this job?

- Does someone review job safety, tools, and materials before handing a work order to maintenance?
- Is someone checking to see if any other work can be done on this system?
- What priority is telling maintenance to repair this pump now?
- Do you need to train people to write work orders?
- Can you walk in the warehouse and locate all the pump parts (new and rebuilt)?

- Do you have a list of purchase orders for the pump?
- Who do you call for parts and technical information?
- Who makes sure the purchased parts get to maintenance on time?

How can I learn more information about the pump?

- Is your equipment labeled?
- Is the equipment information (service manuals, drawing) stored in one location?
- What education was required before a mechanic repairs pump?
- Is someone reviewing the past performance of pump?
- Is someone recording operating parameters, failure rate, or predictive maintenance data such as vibration, thermography, or oil samples?
- Does your filing system or CMMS program allow easy access of equipment information?

To summarize this approach:

- Don't let this book *get in your way* to improving maintenance; if you have a better method, use it!
- Determine what changes will make life safer and easier for plant personnel.
- Discuss it with people that operate and work on the equipment.
- Act on it!

STEP 11   Celebrate

Once you have achieved some of these goals, celebrate the of your people. Everyone needs to be told that they've done a good job; even I need to hear it once in a while! Break down and buy lunch for everybody. Just remember, making these changes are easy, but maintaining it will be the tricky part.

Wrench Time Story …"Dress for go, not for show"
You maybe wondering where the term "dress for go, not for show" was first used. Let me describe the setting.

My mindset? The maintenance and engineering team I was managing made some major production improvements, therefore my ego was higher than normal.

The location? The vice president of our division told me to attend a meeting in another building at our location with the other vice presidents and managers. It's winter; I'm in a suburb of Chicago, and I wasn't prepared for a meeting, so I was wearing a pair of insulated coveralls from my construction days. As you can imagine, everyone else had on an expensive dress winter coat.

The incident? As I was walking into the room before the meeting, the vice president of marketing and sales was standing there in an expensive three-piece suit. He spots me in my coveralls and with a smirk and says "Nice coveralls". I turned and replied "Don't worry about me…I'm dressed for go, and not for show!"

12 Future of Maintenance

12.1 Definitions in Maintenance
12.2 Global Maintenance ID
12.3 EBMS (Equipment Based Maintenance System)
12.4 Maintenance Equipment Standards
12.5 Equipment Maintenance Consumer Report
12.6 Environmental and Safety Information
12.7 System Dependency
12.8 Equipment Alarms
12.9 Thank You

The Maintenance Paradox…

"Why is maintenance doing an excellent job?"

Fred J. Weber

12.1 Definitions of Maintenance

This last module is a series of ideas to improve maintenance in the future. The intent of these suggestions is to get the maintenance community to look outside the box; in fact, outside the "toolbox". Optimistically, these ideas will generate discussions with equipment vendors, CMMS suppliers, maintenance organizations and maintenance people in an effort to look at maintenance in a different way.

Let's start the discussion by redefining some maintenance terms:

- Backlog (Maintenance) – any open repair and preventive work orders that maintenance can work on NOW. Equipment is safe with parts, information, and tools in hand.
- Backlog (Planning) – any open repair and preventive work orders that maintenance can NOT work on NOW. Equipment is not safe, missing parts, information, or tools for maintenance to do work.
- Backlog (Management) - open improvement work order in which maintenance and engineering is missing time, money, or people to make improvements.
- Engineer - anybody who designs or modifies a piece of equipment to increase safety and reliability without any environmental impact. (College degree not necessarily required!)
- Key Indicators (Maintenance and Engineering) - reduction in "R" and "P" work orders
- Key indicators (Management) - safety, environmental and production improvements
- Maintenance person - a person who keeps the plant running safely and reliably without any incentive from management!
- Management - anybody who coordinates a group of people with the same priorities of taking care of themselves, taking care of their families, taking care of co-

workers, and operating a plant, while at the same time meeting safety and environmental requirements and achieving a profit.

- Planning - thinking of tomorrow
- Preventive maintenance - smallest amount of work required to keep a piece of equipment safe and reliable.
- Predictive maintenance - any task that locates a problem before it becomes critical to the safety and reliability of the plant and personnel.
- Root Cause Analysis - any tasks that prevent a problem from repeating.
- Scheduling - time stamping and grouping maintenance tasks to provide safe and efficient plant operation.
- Work order - a message from any plant personnel asking for maintenance assistance (fix, find, or solve an equipment problem).

12.2 Global Maintenance ID

Earlier in this book, we discussed the use of the Maintenance ID and Equipment Part ID as a maintenance friendly format use to label all equipment and their components. Imagine if all the equipment in the world was labeled the same way. Well it's possible! By adding a Company ID to the Maintenance ID, you could produce a "*Global Maintenance ID*". The format for the Global Maintenance ID would look like this:

"**Company - Plant - System - Type - Number /Letter**"

The Global Maintenance ID is an extension of the Maintenance ID we built earlier in this book. Therefore, the only thing missing is a Company ID. Assume we identify Wrench Time, Inc. with Company ID "WT345." An example of a Global Maintenance ID for Waste Water System pump #1 located at Wrench Time Inc. Plant #2 could be "WT345-2-WW-PMP-001."

Let's extend the Global Maintenance ID a step further by including each equipment component. By adding a part number to represent each equipment component, it becomes a *Global Equipment Part ID*. The format for the Global Equipment Part ID would look like this:

"Company - Plant - System - Type - Number / Letter – Part"

Assume the coupling bolts for Wrench Time, Inc.'s pump "WT345-2-WW-PMP-001" are labeled "0109." The Global Equipment Part ID would be "WT345-2-WW-PMP-001- 0109."

Simply by adding a Company ID, we've developed a global equipment identification system to label each piece of equipment and their components in the entire world!

This equipment identification structure could be used for an Internet / web based CMMS system to supply information for a root cause analysis or a vendor's global equipment cross-reference.

12.3 EBMS (Equipment Based Maintenance System)

Ever since the invention of the computer, everybody has been focused on computerizing maintenance. No doubt, there is a use for a computer in maintenance, but it needs to supply maintenance with easy access to equipment information. One method to change the mindset of the maintenance community is to change from a CMMS (Computer Maintenance Management System) to an EBMS (Equipment Based Maintenance System). The Equipment Based Maintenance System is any maintenance system centered on the EQUIPMENT, which is the bread and butter of a maintenance person. The most common Equipment Based Maintenance System is still the Maintenance supervisor's equipment filing cabinet. Inside you'll see a folder for each piece of equipment that maintenance has to be worked on. Stuffed in the folder are the manufacturer's drawings, purchase orders for parts, work order histories, and contact names. Therefore, for any CMMS to be "Equipment Based" and benefit maintenance, it needs to be focused on equipment. How about something like this – a plant person would type in a Maintenance ID and have access to anything about that equipment, from adding a work order to safety information.

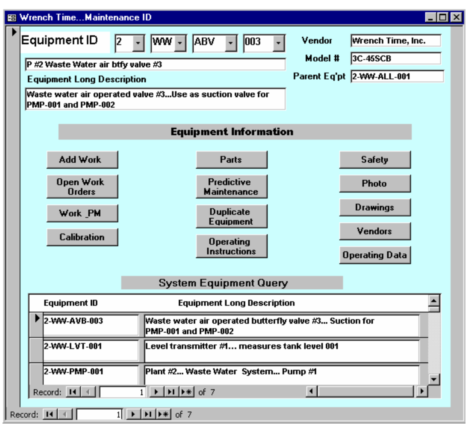


Figure 12.3a Basic EBMS screen

Another EBMS is one that uses a drawing or picture of the equipment on an HMI (human machine interface) screen. Plant personnel would click on the pump to display equipment information as shown below.

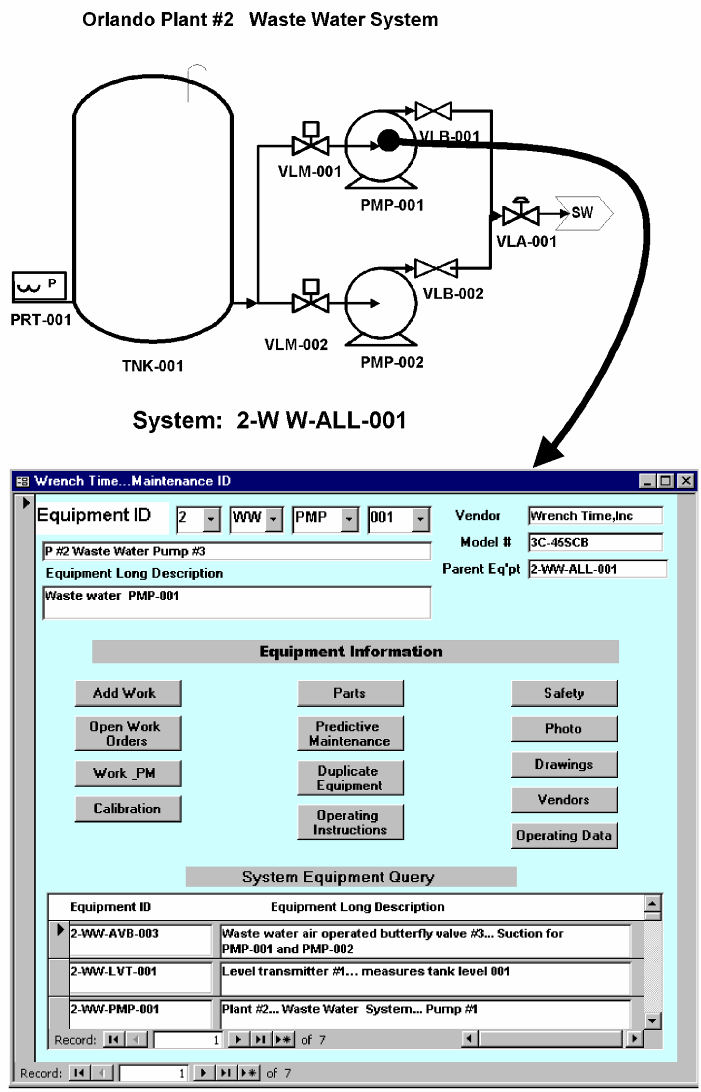


Figure 12.3b Process Drawing with EBMS screen

The next EBMS would be incorporate in a DCS (Distributed Control System) or HMI that is used in a control system. An operator selects a piece of equipment on the DCS screen, which may open the Start - Stop station for a pump. With the Start - Stop overlay open, the operator can control the pump, and has access to all the information about the pump with one click on the "Maintenance" button.

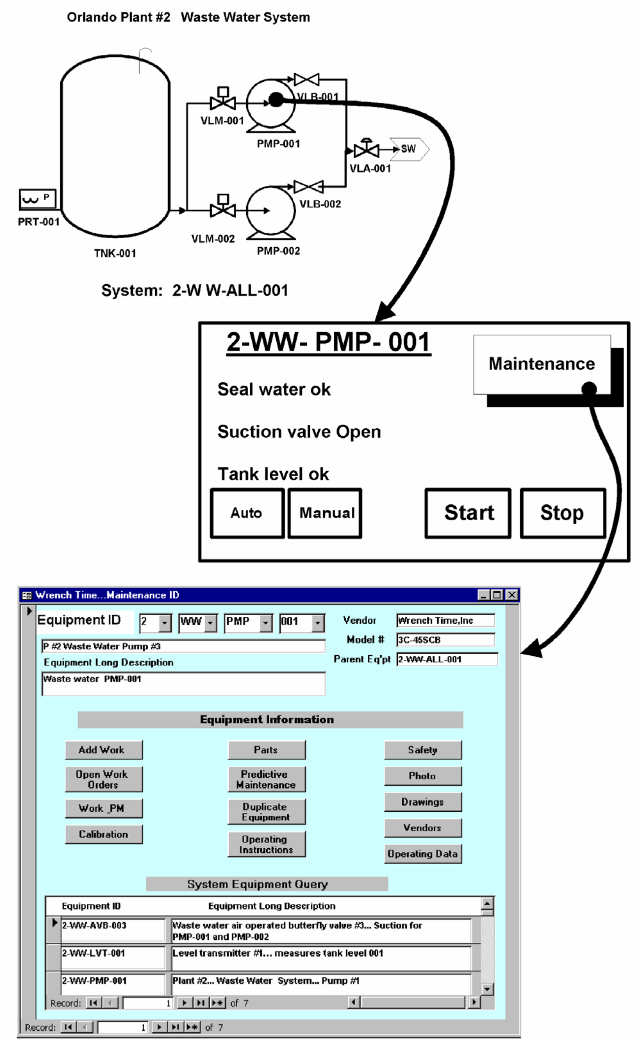


Figure 12.3c Distributed Control System with EBMS screen

12.4 Maintenance Equipment Standards

It seems like everybody would rather complain about maintenance than taking the necessary steps to make life easier for maintenance. As a manager, you probably used a better set of drawings putting together your son's bicycle than the technicians had to overhaul your compressor. So before anyone judges maintenance performance, we need to give maintenance people the information to do each job safely and accurately. If you are not convinced a standard for equipment information is necessary, take a look at how maintenance is required to find information. In some cases, maintenance has to look through sales brochures, often needing to interpret a different language just for information about the equipment they are working on. This isn't simply the equipment vendor's fault. In most cases, equipment vendors are willing to supply any information a customer needs to maintain a piece of equipment. The only question they have is "What does maintenance need?"

One way to acquire the proper information up front is for maintenance organizations to write Maintenance Equipment Standards. The purpose of the standards is to supply maintenance all the information required to work on any piece of equipment. The information would include such information as:

- Safety and Environmental requirements
- Shipping, Storage, and Installation
- Service manual (assembly and disassembly) with photos
- Preventive and Predictive maintenance
- Parts cross-sectional view showing "ALL" components
- Description of how the equipment works (such as basic physics and chemistry).
- Recommended spare parts list and specialized tools
- Drawings (electronic, hydraulic, logic, file management)
- Instrumentation calibration procedures
- Operating procedures

Let's use a pump for an example of a Maintenance Equipment Standard. Maintenance people who work on it and equipment vendors who supply it would develop this pump standard. The maintenance organization would take the comments and devise a format for the pump information to be displayed. The information would answer all questions about what is required for engineering and maintenance to safely store, install, rebuild and maintain a pump. The standard for a pump may have its information displayed in format like:

Section 1 - photos with front side and top views

Section 2 - parts with 3-D cross-sectional drawings with each part labeled

Section 3 - repair and rebuild; this section supplies maintenance with photos, drawings and information regarding repairs from basics to a complete overhaul. The information lists tools and any special fixtures needed.

Section 4 - preventive with drawings, photos, and information related to required PM.

Section 5 - predictive data at different load points and methods to record data.

Section 6 - engineering with an installation drawing showing pump mounting hole pattern, piping connection tolerances, coupling bore requirements, centerline of pump connection, and photos of a typical installation. Pump performance data like pump curves at different loads and testing methods.

Section 7 – troubleshooting; a list of pump performance problems, potential causes of problems, and the corrective actions.

The standard would require various information options:

- Language…English, Spanish, German, etc
- Units of measurement…English, Metric or both
- Media… book / manual, CD, Internet, or video

The standard would be use when purchasing a piece of equipment or requesting information.

Example:

Pump Model Wrench Time Model #227-9

Maintenance standard…S-M-CD 2456

(Besides the pump, Wrench Time would supply the pump information outlined in "Standard 2456" in Spanish, using Metric units of measurement, and in a CD format.

This multi-language standard, written by maintenance craft personnel, would require drawings and photos. In fact, lots of photos and drawings because maintenance folks are visual types; they learn by seeing. Just ask maintenance if they prefer the assembly procedure for a pump to be in a written format or to be shown with the use of photos at each step. The Standard would be free and easy to access via the Internet so all vendors had access to it. This is simply a maintenance standard, written by maintenance, for maintenance.

12.5 Equipment Maintenance Consumer Report

There is a lot of bad equipment out there. How do we know about it before we make a mistake and buy it? In the automobile industry, consumer watch groups have developed a name for a car that breaks down and needs repair all the time…LEMON. In the maintenance and industry world, how do you know what equipment is considered a "LEMON?"

Various trade magazines have developed some type of equipment consumer reporting which they call the “Reader’s Choice”. The reader’s choice is the data collected from surveys asking people whose equipment is in your plant today. The more companies that purchase / use a particular piece of equipment, the higher its rating. Is this a valid tool? Possibly, but it could just mean that a lot of people bought lousy equipment!

A better format might be an Equipment and Maintenance Consumer Report; in short, a rating system on equipment vendors. An independent group selected by the maintenance community would survey maintenance people on equipment performance as it affects maintenance. A vendor's performance would be evaluated on equipment safety and reliability, installation, maintainability, technical support and documentation. Besides meeting our maintenance standard described earlier, it could also include:

- Safety record (OSHA and workers compensation info)
- Reliability (spare parts usage)
- Factory support departments (Parts, Field Service and Engineering)
- Offsite monitoring capabilities (video cam, Internet)
- Cost and performance of Maintenance Agreement

Remember, we can continue to complain about maintenance performance, or take steps to make their job safer and easier by designing it right the first time.

12.6 Environmental and Safety Information

Earlier I mentioned that safety and environmental departments don't usually get along with maintenance. One reason is the information is hard to find and understand. If you don't believe me, read the EPA emission site plan or explain all OSHA safety standards required for your plant. For safety and environmental to be effective, the information needs to be in a maintenance friendly format… a picture, drawing or display. This display can be on a web base or HMI screen. The first display would be associated to the plant emergency called "Emergency Response and Rescue". This page would allow easy access of information for your employees, management, and emergency response team. The information could include plans, forms, procedures, and lists of materials. If an employee needs to know what is required for a fire emergency, he or she would hit the button in line with the "FIRE" label and the "EMPLOYEE" label.

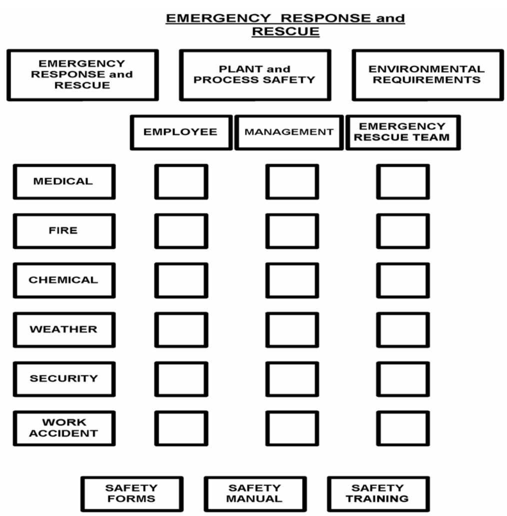


Figure 12.6a Plant Emergency Display

The next page would be more safety information labeled "Plant and Process Safety" and look like this:

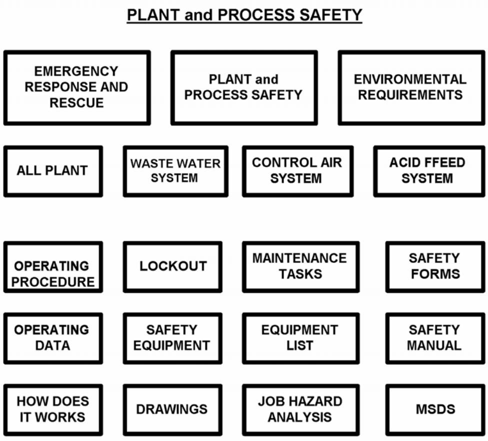


Figure 12.6b Plant and Process Safety Display

Safety information could include:

- MSDS (list of all material data safety sheets)
- Safety Manual (company safety manual)
- Process safety management
- Job Hazardous Analysis (list of all job hazard procedures used in the plant)

This page not only defines general safety information, but also defines safety information related to each system. If maintenance selected "Waste Water System" and "MSDS" is selected, the MSDS sheets related to waste water system would only be displayed. The information would be related to a particular system maintenance is working on. Maintenance now has the user-friendly safety information at their fingertips without reading though 1000 MSDS sheets. If maintenance is working in the waste water system and needs a confined space form, instead of giving maintenance a blank form have one predefined for each maintenance activity. If one is not filled out, then work with safety department to build one.

The third display would be the "Environmental Requirements." This page represents what is going into your plant, what is in your plant now, and what is leaving your plant. The information would include environmental site plans, test results, and pollution limits within and around your plant or system. Again, if maintenance is working in the waste water system, they have the capability to locate all the environmental requirements of that system. Shown below is what an environmental requirement screen could look like:

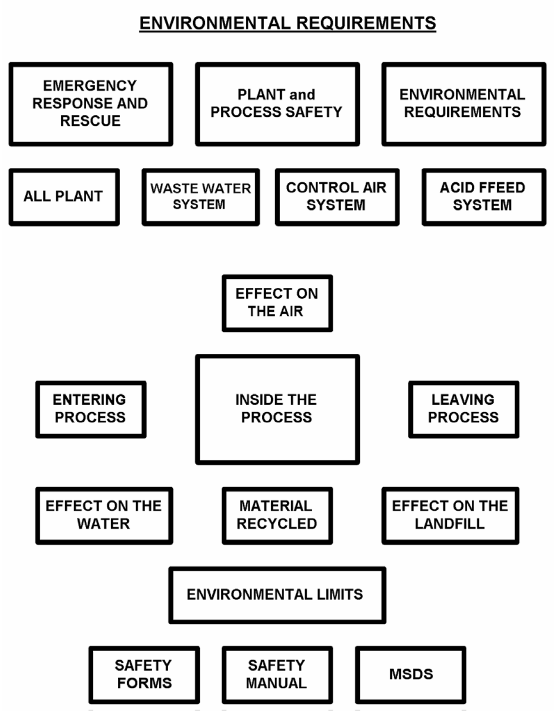


Figure 12.6c Environmental Requirement Display

Just like safety information, the environmental team needs to break down the information into each plant system.

- Entering Process - materials and chemicals used to support plant operation; for instance, the use of well water may have a limit of 12000 gallons per day.

- Inside the Process - limits and procedures for hazardous material inside the plant such as radioactive material, asbestos, or toxic chemicals
- Effect on the water - materials that could have an effect on ground water. A manufacturing plant's waste water from a wash system may be required to have a water pH limit between 6.84 and 7.16 before discharging into drain. There may be limits on water usage in the plant.
- Effect on the landfill - waste from the manufacturing process or material put in the garbage that goes to a landfill. Manufacturer's process may have a state regulation limiting the types of material allowed in the landfill.
- Effect on the Air - material discharge in atmosphere, such as regulations to limit SO_2 or NOx.
- Material Recycled - material reused by your plant or another process. State regulations (or your site plan) may require recycling of oil, paper or scrap metal.
- Leaving the Process - some site emission site plans are based on the amount of product produced each day, such as maximum megawatts produced at a power plant.

Another approach is to show the system environmental requirements by using a system process drawing or piping and instrument drawing highlighting the process vents, drains, run-off, or spill protection. The diagrams would show influent and effluent flows of various media and the emission limits.

Using either method, the company should post drawings on Internet showing limits and test results such as ground water testing, air sampling, and wildlife changes. Later a map could be generated showing all the plants and their emissions (future, present, and abandoned).

12.7 System Dependency

Sometime in maintenance, it becomes difficult to determine what equipment should be subject to PM and what spare parts you should keep in stock. Earlier we discussed a criteria based on the effect of an equipment failure to determine PM and spare parts. Another method to help determine PM and spare parts is to consider the impact of each system has on each other. A System Dependency diagram is a snap shot of the critical systems in the plant and the effect they have on each other. A quick glance of this diagram defines a system priority to maintenance to determine PM and spare parts.

To build the System Dependency diagram, place six system boxes along the top, bottom and diagonally down as shown below. The diagram below shows a plant with six systems labeled EP (Electric Power), SW (Service Water), DC (Distributed Control System), CF (Chemical Feed), WW (Waster Water), and CA (Control Air). Next, determine the system dependency by reviewing the plant processes and electrical drawings. From this information, draw a line from the support system like EP to the dependent system SW as shown below.

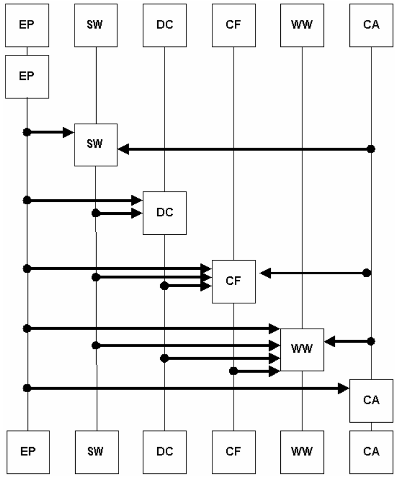


Figure 12.7a System Dependency Diagram

In the example above, the WW (Waste water) has all the other systems pointing at it because it requires CF, EP, SW, DC and CA to operate. On the other hand, EP (Electric power) is a support system for everyone; without it the plant stops.
What system would you PM next week?

12.8 Equipment Alarms

One tool commonly provided for operators to control the operation of a plant is some type of alarming system. The alarm system could be any combination of annunciators, alarm screens, and alarm printers used to warn operators of a deviation in a process or notify of a change in equipment status. However, the alarm system also has a hidden purpose; it's used to test the operator on their knowledge of the plant. How is that? When an alarm comes in, the operator must determine the cause of the alarm. That requires an operator to memorize the complete plant control logic to understand the meaning of every alarm in a plant. Most alarms are generated from hidden control logic, where only a technician or engineer knows the real reason for the alarm. The example alarm screen below is asking the operator two questions. First, what tripped pump 2-WW-PMP-001, and second, why is the pH of the influent water high?

Time	**Alarm point**	**Alarm description**	**Alarm Status**
02/22/04 12:27:34	2-WW-PMP-001_1	Waste water pump #1	TRIPPED
02/22/04 12:26:34	2-WW-PHT-002_3	Influent feed water pH	HIGH

Figure 12.8a Typical Alarm Display

In the future, instead of making alarm screens a quiz for operators, what if we help the operator by supplying a list of possible causes for each alarm? When an alarm comes in, we also open a display that provides possibilities as to the origin of the alarm, as well as suggest possible corrective actions. It would serve the same purpose as the troubleshooting section in most equipment service manuals where you see columns of information like "Problem", "Probable Cause", "Corrective Action" and "Nominal Ranges / Limits". The alarm screen becomes a tool instead of a test, which would also serve to train the operator. The display should contain an "Active Alarm List" with the capability to select a particular alarm and display the "Active Solution List." An example of the Alarm and Solution screen is shown below.

"ACTIVE ALARM LIST"

	Time	**Alarm point**	**Alarm description**	**Alarm Status**
X	02/22/04 12:27:34	2-WW-PMP-001_1	Waste water pump #1	TRIPPED
	02/22/04 12:26:34	2-WW-PHT-002_3	Influent feed water pH	HIGH

"ACTIVE SOLUTION LIST"

Alarm point… 2-WW-PMP-001_1
Alarm Status… TRIPPED
Alarm description … Waste water pump #1

PROBABLE CAUSE	**CORRECTIVE ACTION**	**NOMINAL/LIMIT RANGE**
Low seal water flow	Check solenoid	0.1 gpm
Motor overload	Reset overloads	20amps / 45amps

In addition, did you notice the use of the Maintenance ID in the alarm point?

12.9 Thank You

I want to personally thank you for purchasing "Wrench Time". By purchasing this book, I hope we were able to take care of your priorities:

"Take care of yourself and your family"… hopefully the book made life easier for you and gives you more time to spend with your family.

"Take of your co-worker"… that is to say, you use something in this book to make life better for your maintenance team.

"Operate the plant meeting safety and environmental requirements while achieving a profit"... implementing information from this book increased the safety and environmental awareness in your plant, while improving the overall plant performance.

If nothing else, the book gets you thinking about maintenance. To quote Eleanor Roosevelt… "Great minds discuss ideas; average minds discuss events; small minds discuss people."

One thing I never solved was the Maintenance Paradox, which is "Why is maintenance doing an excellent job?" After interviewing maintenance people and management, I never found a good response. If you happen to run across the answer, write a book. I'll buy it.

Good luck in your career. Remember to take a break occasionally, grab a cup of coffee, and get one for me. Take care of yourself and your family.

Thanks again…Fred

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