CHAPTER 10
CONTROL

This chapter finally arrives at this all important issue: How does one ensure planning works from a management and supervisory standpoint? Surprisingly, it is not on the basis of indicators, although two of the 12 planning and scheduling principles describe indicators. It is on the basis of the selection and training of planners.

ORGANIZATION THEORY 101: THE RESTAURANT STORY

Dr. Stephen Paulson (1988) tells the story of John Smith who retired from the Navy. John was at loose ends for a while and began meeting daily for lunch with several of his friends. John naturally enjoyed cooking and the lunch group usually met at John's house where he made the sandwiches. Everyone would always chip in to pay for the lunch. The company and the sandwiches were good and soon more friends were coming around at noon time. Someone eventually suggested that John should lease a small shop where they could spread out and be more comfortable. There seemed to be enough income from everyone's contributions so John found a small place in Jacksonville Beach where the group could meet. Thus, John's Sandwich Shop was born.

At first, everything continued as before. John made the sandwiches and would join in the company and discussions around several tables. The "organization" of the establishment, so to speak, was simply John Smith. John took care of everything from opening the door in the morning, making the meals, and collecting the money to bussing the tables, sweeping the floor, and closing the door in the late afternoon.

As word got around, some of John's friends started bringing their other friends making the place busier than ever. Soon, John had less time to visit and was spending more time making sandwiches. That was okay with John since he enjoyed cooking. However, he really needed help and so his wife, Mary, began coming in every day to help. The organization of the sandwich empire consisted of two persons on equal footing doing whatever needed doing. John did most of the cooking, but still helped Mary buss tables and collect money. They even bought a cash register to help make change. Communication was no problem. Whenever John needed something, he called over to Mary. Whenever Mary needed something, she called over to John.

The happy atmosphere of John's Sandwich Shop delighted friends and other customers. Business thrived and soon John and Mary needed more help running things. They both decided to hire someone and they brought Joe on board for wages. Joe reported directly to John, who gave direct supervision to his activities. Normally, John had Joe bussing tables and washing dishes. Occasionally, John would direct Joe to perform other specific tasks. These tasks included activities such as sweeping the floor or running an errand to buy certain supplies that were running low.

With summer approaching and business booming, John and Mary decided to expand and take a lease on the vacant shop next door. Remodeling to remove part of the connecting wall almost tripled the sandwich shop's floor space. They also decided to hire three high school students out of school for the summer. These students had no restaurant shop experience so John organized them behind a counter. John planned for customers to enter the shop and then proceed to a counter to place their orders with his wife. Mary would handle the cash register and pour drinks. For the students, John wrote specific instructions how to make three standard sandwiches customers could order. The first student would set out and slice the type of bread requested applying the required dressing. The second student would add the required meat and tomato or other required ingredients. The last student would place the sandwich in a basket with chips and a cookie and hand it to the customer. John planned to hang around and make any special orders himself. John also continued to direct Joe in his normal assigned duties. This arrangement worked very well and the business was very successful. John did not look forward to the end of the summer when the three students would leave to return to school.

Near summer's end, John and Mary decided to hire three experienced sandwich makers who had mentioned they would not mind working at John's Sandwich Shop. John had discussed their qualifications with them at some length. These persons had quite a bit of restaurant experience which would allow John and Mary to change the organization. The three professionals were able to handle operations behind the counter almost entirely without instructions. They also were able to expand the types of sandwiches being offered. Any of the three could make nearly any specialty sandwich imaginable. They could each handle multiple complicated orders at the same time. For instance, each person could handle making a meatball sandwich (light on the sauce), which required microwaving while simultaneously shredding lettuce to place on a cold ham sandwich. The resulting success behind the counter allowed John to increase the amount of time he could visit with his friends at the tables.

As the years went by, John and Mary opened another, identical shop in neighboring St. Augustine. John and Mary later both stepped back from day-to-day operations, allowing their son to run the original store and their daughter to run the new store. Both stores remained very prosperous. John and Mary still maintained a corporate ownership of the business, but their management style was to have a family business meeting once each year after a special dinner gathering. At this meeting, John would look at his children carefully and ask two questions very seriously. The first question would always be: "What is the net profit after taxes for each store?" The second question would always be: "Does a meatball sandwich in the Jacksonville Beach shop taste exactly the same as a meatball sandwich in the St. Augustine shop?" With these two questions, John and Mary managed the multiple divisions of John's Sandwich Shop.

The restaurant story pointedly illustrates the different basic organization structures that exist, each doing best with a particular type of primary coordination method. An organization is a group of persons with a common objective, such as the maintenance of an industrial plant. Where different persons work together, they must coordinate their work. Coordination methods and practices help direct the efforts of the different persons. Planning itself is a coordination means. Planning coordinates many of the specialized areas of maintenance. Most organizations typically utilize many different coordination methods at the same time, but they usually emphasize a single primary or dominant coordination method. Emphasizing the right primary coordination method with the right type of organization makes an organization stable and effective. Using the wrong kind of primary coordination method with a particular organization structure will cause unnecessary problems and inefficiency.

Dr. Paulson's story pictures the basic organization forms with their preferred coordination methods described by Mintzberg (1983). The account first shows John Smith as an individual doing everything by himself. In the second situation, John and Mary organize and function as an "adhocracy." The *adhocracy* structure of organization consists of different persons brought informally together. The adhocracy coordinates its activities through frequent meetings and exchanges of information much as do Mary and John with their conversations as they go about doing their jobs. The next organization where John supervises Joe represents a *simple structure.* John provides the coordination needed with his direct supervision of Joe. Next, the organization of the summer students represents a *machine bureaucracy.* A machine bureaucracy achieves efficiency by coordinating with explicit rules and procedures. John wrote rules for the students to follow in their assignments. An assembly line typifies this organizational structure. Of course, if the business environment becomes more complex and varied or undergoes rapid change, rules themselves might become too complicated or subject to constant change, making this type of organization unsuitable. As Mary and John transform the store to allow significant independent judgment on the part of the sandwich makers, coordination by a set of rules becomes impractical. The concentration on obtaining skilled employees becomes their preferred coordination method. This organizational structure is known as a *professional bureaucracy.* This structure must be coordinated with attention to staffing, that is, hiring and training. When one thinks of a medical physician, one realizes that there could not be a sufficient set of rules to handle the doctor's behavior throughout each day. The doctor constantly sees different situations calling for independent judgment and skilled action. The expertise of the doctor is much more important than the standard handbook of medical procedures the doctor sometimes consults. Does the doctor have the skill not only to select, but to execute the correct procedure? A professional bureaucracy coordinates itself through the procurement of skills. Finally, Mary and John oversee the company as a *divisionalized form* of organizational structure. Mary and John see two divisions as entities to coordinate although there may be a different form or forms of organizational structure within each shop. From their level, Mary and John best coordinate the effort of either shop with indicators. The use of indicators comprises the preferred method of coordinating this type of structure. Obviously, Mary and John could not manage each shop with direct supervision or constant meetings and communication. Other methods of coordinating are also not appropriate for their level of management in the organization. Variants exist, but these same basic organizational structures are found in organizations throughout the world. The restaurant story shows which particular method of coordination is most appropriate for each of the different basic structures.

SELECTION AND TRAINING OF PLANNERS

With regard to maintenance planning, how do these lessons apply? The identification of preferred coordination methods has direct application to the planning department organization. To begin with, maintenance work orders come in all sizes and shapes, from straightforward to incredibly complex and from ordinary to unusual. Because of the extreme diversity of jobs, planners cannot be given simple instructions for how to plan them. For example, there is not a one-size-fits-all approach to scoping jobs or determining what job details are critical for a job plan. Planners may be directed to scope a job, yet the identification of the correct work scope is entirely a creation of the planner's skill. A planner may be directed to research a minifile, but the planner must recognize what made the difference in the last two filed jobs. Similarly, only the qualified planner can adequately anticipate likely job problems or spare part requirements on equipment that has not yet been dissembled. The planners must function as a professional bureaucracy, being allowed to exercise discretion and personal judgment in the effective planning organization. Thus, the primary coordination method to manage the planning group must be an emphasis on staffing. The purpose of Planning Principle 4 (skill of the planners) becomes more clear as one realizes that having qualified planners controls the successful planning organization.

Does not every job require having a qualified person? Perhaps, but this concept is not the sense of the professional bureaucracy. A person to operate under direct supervision must be willing to submit to direct supervision. A person willing to work on an assembly line must be willing and able to follow specific instructions. However, the skills required within the professional bureaucracy implies neither of these qualifications.

Without the obtaining of skilled planners as the primary coordination method, none of the other coordination methods matter. First, planners do not need to share information continuously with each other to plan jobs. Neither is there time for each planner to communicate constantly with other experienced personnel regarding job requirements. Second, no planning supervisor could adequately directly supervise the activities of planners planning hundreds of diverse work orders each week. Third, as previously discussed, no set of rules or guidelines could possibly take the place of the skilled planner on the majority of maintenance plans. This explains one of the cautions with the template approach to job planning. When all is said and done, the planner's skills must come into play to use the templates and to provide enough job specific expertise. Finally, indicators may show whether the planning group is making a difference in the work force's productivity, but indicators cannot coordinate the activity of the planners. Indicators only show whether the planners chosen have the skills necessary to make the difference.

After the selection of planners, the emphasis of supervision should be on training and other support. A school system provides an excellent model. The principal does not directly supervise any of the classrooms. The principal is not even present in the classrooms at all times. Instead, the principal performs a primary duty by procuring qualified teachers. Then the principal sustains or enhances those qualifications by making training opportunities available to teachers. For example, these might include seminars about new techniques or concepts of learning. Next, the principal supports the teachers by supplying everyday needs to allow the teachers to execute their teaching skills rather than spend time gathering supplies. For instance, teachers should not have to worry about obtaining copy supplies, having adequate student desks, or providing proper air conditioning of the classrooms. The principal organizes the front office to support the teachers. Rather than have the principal direct the teachers, the teacher should almost direct the principal and the front office group in their support needs. In this type of role, the principal coordinates and controls the smooth functioning of the school organization, a professional bureaucracy. If there are only a few planners, they may adequately report to the maintenance manager or superintendent who is also over the crew supervisors. The manager or superintendent would ensure their proper selection and provide ongoing support. If there are more planners, a planning supervisor or lead planner may be desired. In either case, the ongoing objective would be to provide training and support to the planners. Training should consist of establishing the vision, principles, and techniques of planning and scheduling. Training might also include instruction in the use of computers and a CMMS computer system. Support might include copy machines, paper supplies, computer resources as needed, filing supplies, or other physical necessities that would allow the planners to focus on planning jobs. The supervision over the planners would ensure adequate office support exists. Finally, consider that the objective of support is to keep qualified planners in place adequately performing their planning duties. Planners' wages should be competitive to ensure that qualified persons have the desire to accept and stay in the planner positions.

One sees that Planning Principle 5 (skill of the crafts) indicates that crew technicians also function within a professional bureaucracy. In addition, Scheduling Principle 5 (crew leader handles current day's work) lends this same structure to crew supervisors. This is because of the diversity of work orders and the increasing technological sophistication needed to maintain modern machinery. This is why one commonly hears admonitions to train and upgrade one's work force. However, do not job plans provide work rules, which is the preferred coordination method of the unchanging assembly line? Not at all. The work plans provide support both to the crew supervisors and to the craft technicians. The job plans provide information on job scope, crafts, and hours to allow the supervisor to assign and schedule the correct skills. The job plans provide filing support to avoid previous delays and a head start on other job information for the technicians. A heart problem would be assigned to a cardiologist and a foot problem to a podiatrist in a hospital. The office staff and nurses would provide previous medical histories to help each doctor treat each patient. Similarly, planners primarily perform triage and file services for crews. They do not normally dictate mandatory procedures. Their job plans provide support.

There is simply not enough repetition of identical jobs to establish the planners or the technicians into assembly lines coordinated with work rules. There is enough repetition of jobs to allow a planning function to support technicians in learning from past jobs.

Within such a framework, the question of "How do I control planning?" implies a fundamental misunderstanding of the situation. Once the planners have been hired, the majority of the control action has been completed.

INDICATORS

A wider perspective makes indicators or metrics also important. The restaurant story suggests the plant manager might oversee the general operation of the maintenance and operations departments as a "divisionalized form" of organization structure. Without complete attendance to the inner workings of each department, the plant manager might place heavy emphasis on indicators to control these departments. The managers of these departments should be responsible for indicating their efforts through indicators. Even within each group, opportunities exist for indicators to help coordinate efforts, though perhaps not as a primary means of coordination.

Persons can relate to overall plant availability or overall plant capacity fairly well. Figure 10.1 shows a sample overall availability metric. However, these indicators may be so global that they do not provide much assistance in determining what to do to improve their score. What factors have specifically contributed to maintaining a high availability or capacity? What factors have specifically reduced the overall availability or capacity of the plant? Other indicators should support these global indicators. Subindicators to availability or capacity might provide better information for coordinating or managing resources. The following sections present common indicators of maintenance performance.

Planned Coverage

Figure 10.2 illustrates planned coverage, a standard measure for a planning and scheduling system. Management desires that technicians spend more hours on planned jobs than unplanned jobs. This indicator is based on the actual hours technicians spend on jobs. The measure represents the percentage of these hours that are on planned work orders. The actual hours are measured regardless of the originally estimated hours of the planners. The metric utilizes actual labor hours as the unit of measure rather than quantity of work orders because the size of work orders can vary considerably. For instance, typical project work might normally be larger work orders than breakdown work orders. In addition, PM work orders might normally be smaller than breakdown work orders. Management desires for maintenance forces to spend adequate time on the appropriate type of work. Therefore, the metric should utilize a time-based unit. On the other hand, management should cautiously use work order quantities if actual time values are not initially available.

Attachment 1a

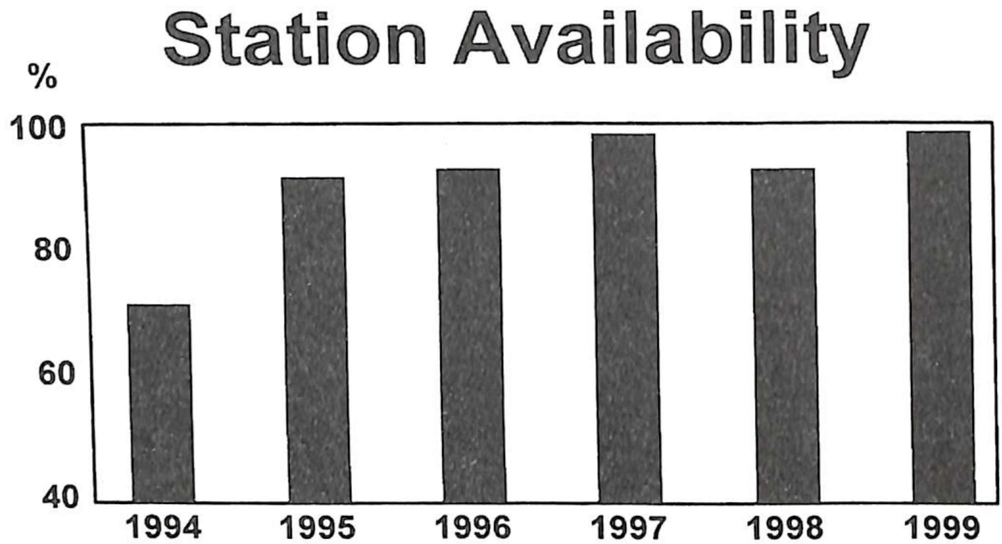

FIGURE 10.1 The simplest measure of overall maintenance effectiveness.

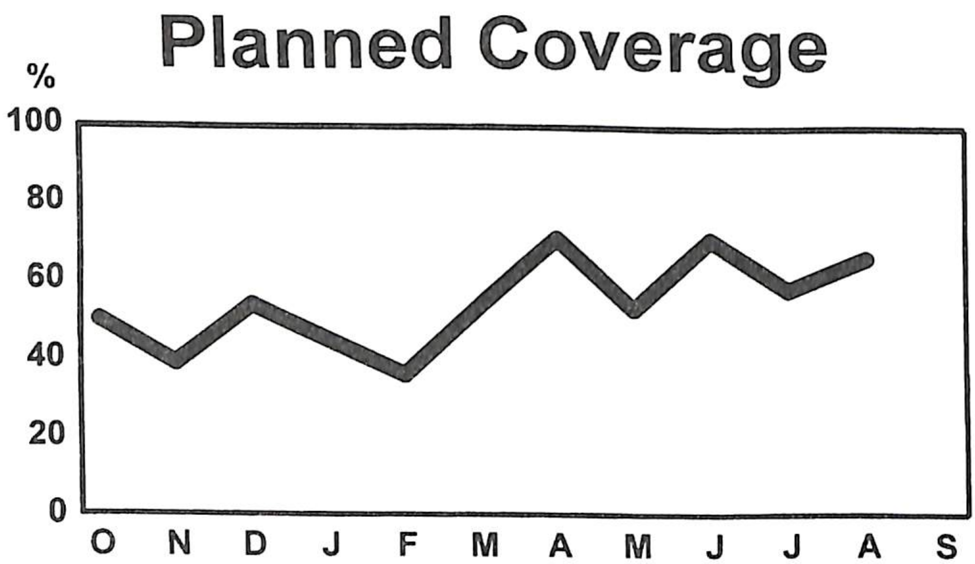

FIGURE 10.2 Management wants more labor hours spent on planned jobs.

Reactive versus Proactive

This metric measures the reactive nature of the plant maintenance work. Management desires reactive work to lessen in proportion to proactive work (Fig. 10.3). This indicator is based on the actual hours technicians spend on jobs. The actual hours are measured regardless of the originally estimated hours of the planners.

Attachment 1a

Reactive Work Hours

Figure 10.4 shows the absolute amount of reactive maintenance work. Management desires not only to perform more proactive than reactive work, it desires for the absolute amount of reactive work to decrease. The score of this indicator may be very erratic on a monthly basis and might be better measured on a yearly basis. The amount of reactive work may also initially increase as crews increase their productivity and perform more work of all types. This indicator is based on the actual hours technicians spend on jobs. The actual hours are measured regardless of the originally estimated hours of the planners.

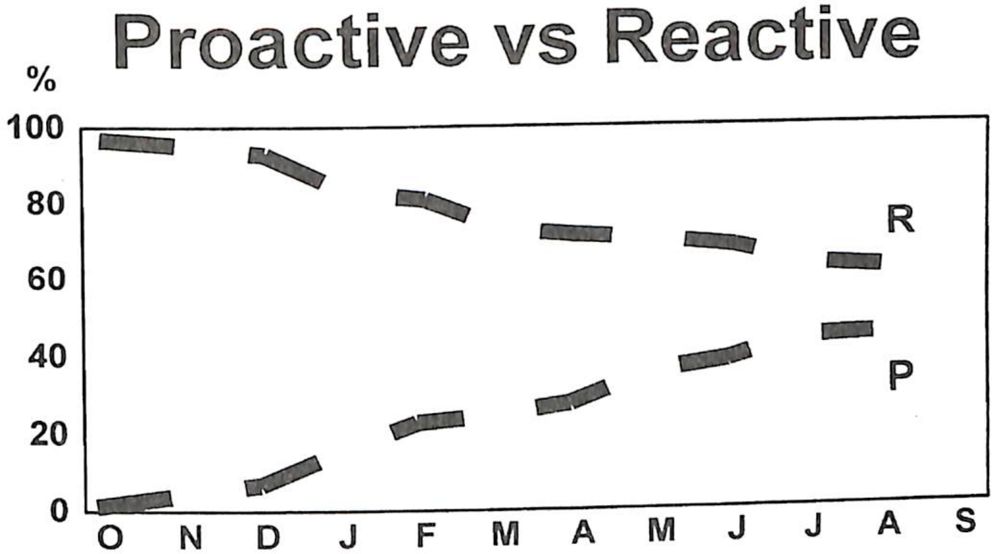

FIGURE 10.3 Management wants to spend more hours on proactive work than reactive work.

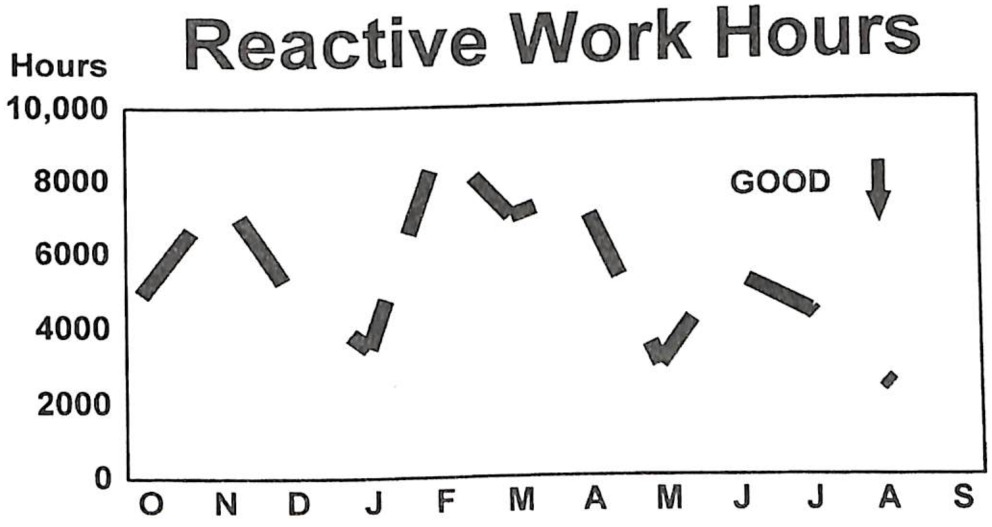

FIGURE 10.4 Management wants the overall amount of reactive work to decrease.

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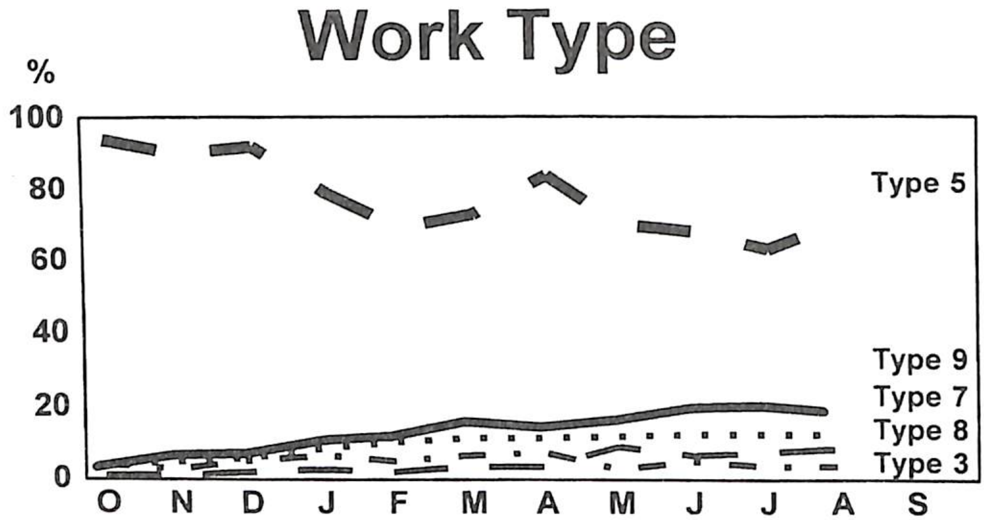

FIGURE 10.5 Another indicator of the proportions of reactive versus proactive work.

Work Type

Management needs information regarding the different types of maintenance work performed. Specific areas of interest are proportions of preventive maintenance, predictive maintenance, project work, and corrective maintenance versus actual failure and breakdown maintenance. This indicator is based on the actual hours technicians spend on jobs. The actual hours are measured regardless of the originally estimated hours of the planners. (See Fig. 10.5.)

Schedule Forecast

Figure 10.6 shows an example of an indicator tracking forecasted hours. Note how the chart indicates carryover hours. A large proportion of these hours could indicate a scheduling problem. This indicator uses hours taken directly off the form for Crew Work Hours Availability Forecast. The sample hours shown are for B Crew's forecast developed in Chap. 6.

Schedule Compliance

As discussed in Chap. 3, weekly schedule compliance provides the ultimate measure of proactivity. Some plants prefer the term *schedule success* to clarify the objective to measure control over the equipment rather than over the supervisors. Figure 10.7 shows a sample chart with data illustrating B Crew's performance. This company measures PM compliance as well. Figure 10.8 illustrates a helpful worksheet to calculate the schedule compliance score. Figure 10.9 illustrates the use of the form with B Crew numbers. The scoring of compliance gives the crew credit for all jobs that will start during the week regardless of whether they will finish. Chapter 6 explains that this gives the crew every possible benefit of any doubt of compliance.

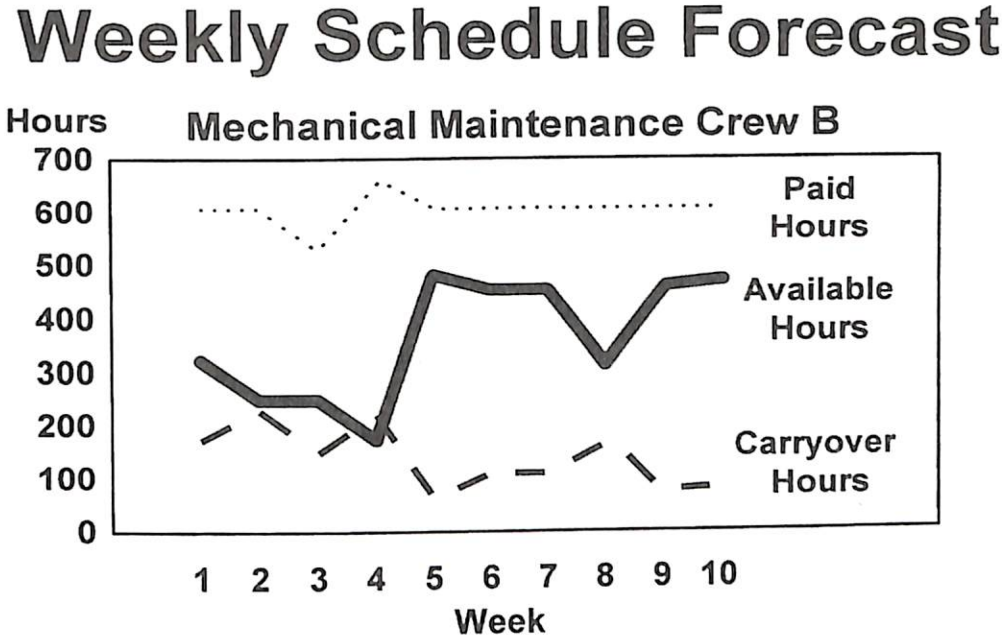

FIGURE 10.6 Maintenance might track forecast hours to help coordinate the scheduling process.

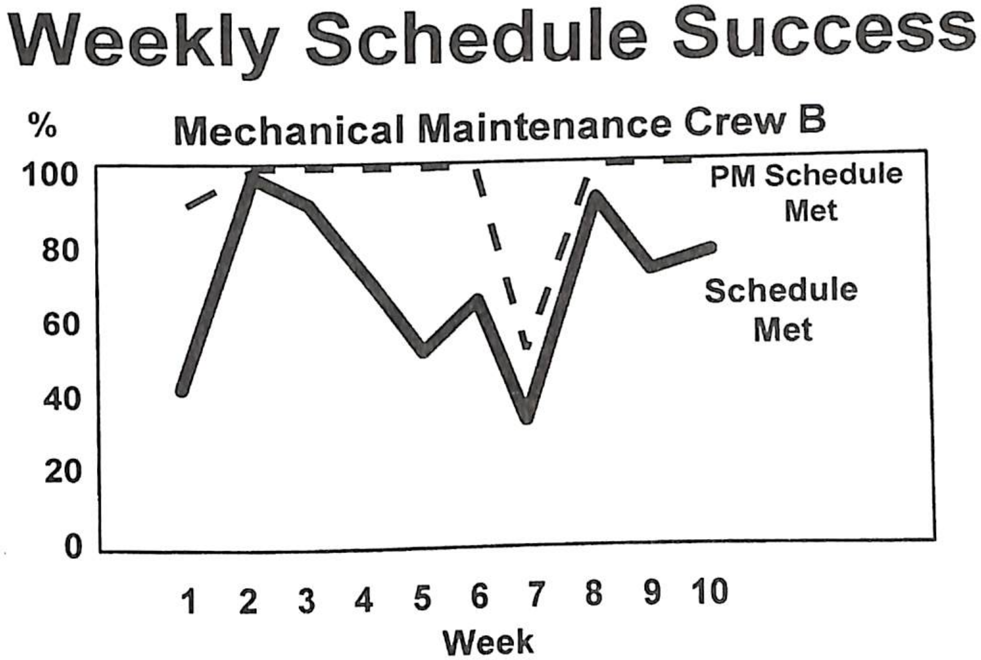

FIGURE 10.7 Schedule compliance to measure schedule success.

ADVANCE SCHEDULE WORKSHEET #2

For week of: ________ to __________
For crew: __________ By:_________ Date:________.

TOTAL SCHEDULE

A. Total Hours Scheduled ________
B. Any Available Hrs Left Unscheduled (________)
Why? (No backlog, etc.) ____________
____
C. Total Hours Returned ________
Any Hours That Were Unclearable (________)
D. Sched Hours Worked (D = A - C) ________
E. % Schedule Met (E = D/A x 100) ________%

PREVENTIVE MAINTENANCE

F. PM Hours Scheduled ________
G. PM Hours Returned ________
PM Hours That Were Unclearable (________)
H. PM Sched Hours Worked (H = F - G) ________
I. % PM Schedule Met (I = H/F x 100) ________%

FIGURE 10.8 Sample of a helpful form to calculate schedule compliance.

Wrench Time

Figure 10.10 shows a sample wrench time metric. This indicator utilized within maintenance measures the percentage of time technicians actually spend on the job. This would be time where otherwise available technicians are not involved in delays such as procuring parts, tools, or instructions. Industry commonly refers to this time as *wrench time*. In-house analysts or consultants properly measure wrench time with a work sampling methodology. What is more significant than the time on the job is the analysis of the time and circumstances that delay technicians from being on the job. Appendices G and H provide sample work sampling studies.

One limitation of wrench time analysis is that it makes no presumption of how productive a technician is while on the job. On the other hand, one would presume that the on job productivity should stay the same so increasing the amount of time on the job should increase the overall amount of work produced. Planning Principle 6 in Chap. 2 explains that increasing the amount of time technicians are on the job is the purpose of planning. The

ADVANCE SCHEDULE WORKSHEET #2

For week of: 5/11/99 to 5/14/99
For crew: B Crew By: C. Rodgers Date: 5/ 14/ 99

TOTAL SCHEDULE

A. Total Hours Scheduled	410
B. Any Available Hrs Left Unscheduled	(45)
Why? (No backlog, etc.)	Backlog ran out
C. Total Hours Returned	84
Any Hours That Were Unclearable	(0)
D. Sched Hours Worked (D = A - C)	326
E. % Schedule Met (E = D/A x 100)	78%

PREVENTIVE MAINTENANCE

F. PM Hours Scheduled	54
G. PM Hours Returned	0
PM Hours That Were Unclearable	( )
H. PM Sched Hours Worked (H = F - G)	54
I. % PM Schedule Met (I = H/F x 100)	100%

FIGURE 10.9 Sample of schedule compliance calculations.

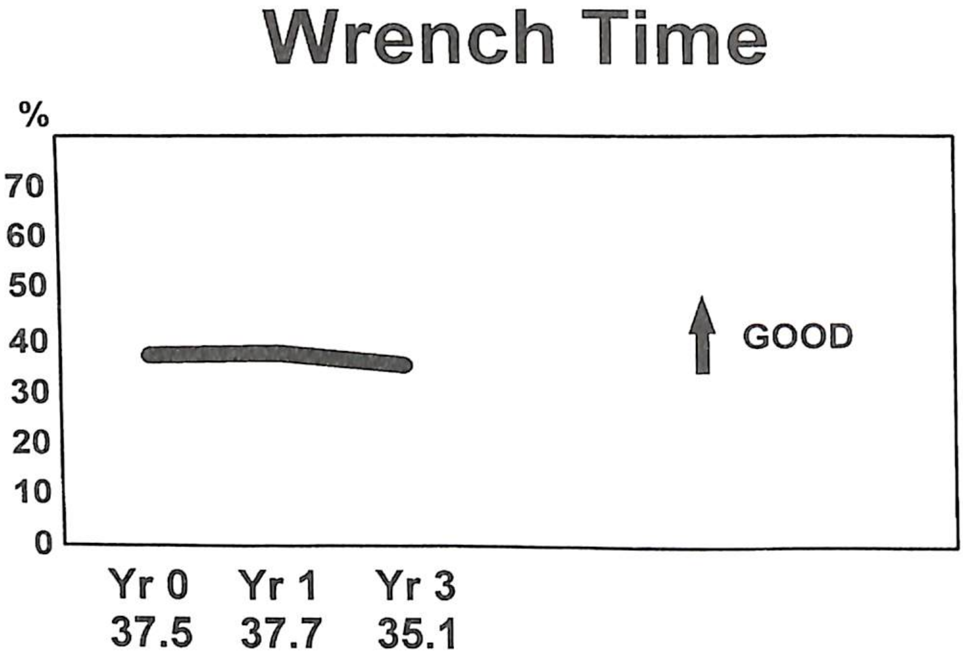

FIGURE 10.10 Sample indicator illustrating wrench time performance.

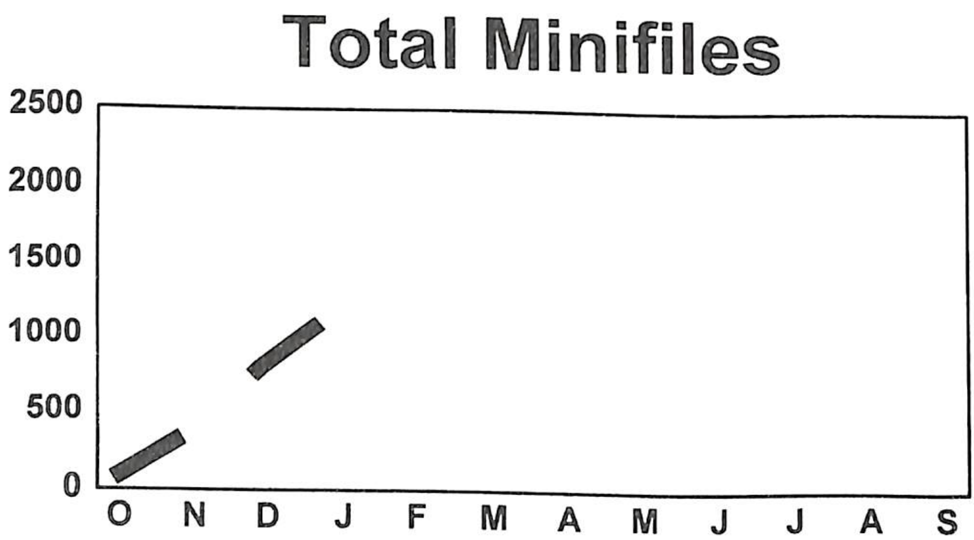

FIGURE 10.11 Ensuring planners understand the importance of the minifiles when starting a planning group.

measure of wrench time indicates the effectiveness of the planning and scheduling process rather than the efforts of the technicians themselves.

Minifiles Made

The creation of the minifiles described by Planning Principle 3 is of great importance. A planning supervisor may want to count the number of minifiles each month in the early months of a new planning organization. See Fig. 10.11.

Backlog Work Orders

Backlog of work orders is a very ominous indicator. Experience shows that many management efforts to reduce the size of a backlog result in a reduced amount of new work orders written rather than an increased number of work orders completed. The backlog is thus reduced by no longer identifying the work to which the plant should attend. The generation of new proactive work orders especially suffers. Other games played include writing larger work orders. Instead of writing a separate work order to take care of each fuel oil pump, technicians might write a single work order to take care of all three pumps. The backlog is thus further reduced by hindering the opportunity to keep good equipment records for each pump. If management intends to reduce equipment problems, it should track backlog by specific work type. The plant desires to reduce its reactive backlog, but increase its proactive backlog. The plant might define reactive work orders as failure or breakdown work orders plus other work orders as an urgent priority. The plant might define proactive work orders as project work, PM, PdM, or corrective maintenance except for ones that have become urgent. Through increasing the detection of proactive opportunities the plant can reduce its failures and reactive situations that hurt reliability. Management should vocalize this vision with caution. The simple command to reduce the backlog, but only the reactive backlog, can become confusing and counterproductive.

Work Orders Completed

Simply looking at backlogged work orders can be misleading. On the other hand, measuring the number of work orders completed each month provides an excellent check and balance when used with the backlog number. Management is interested in the maintenance group completing more work orders each month as one indication of productivity improvement. This indicator by itself might encourage the work force to write smaller work orders. For instance, instead of writing one work order to repair a pump, the indicator would tempt personnel to write three separate work orders for disassemble, repair, and reassemble. Because management pressure to reduce work order backlog tempts personnel to write fewer work orders, these two indicators help balance each other when used together.

Backlog Work Hours

Plants making sudden improvement gains in productivity often quickly run out of backlogged work. Plants in highly reactive work environments should then take advantage of the opportunity to create proactive work orders or generate reactive work orders that would have been ignored in the past. The plant's objective with a stable work force should be to maintain at least 2 weeks of craft backlog. Such identification of work promotes the smooth operation of a productive maintenance department with planning and scheduling. Unfortunately, simple quantities of work orders do not indicate labor requirements. Prompt planning should establish a backlog in terms of hours. Dividing the normal paid hours of each craft into the backlog hours produces a number of backlog weeks. Because the paid hours are normally higher than the available hours for each craft, a goal of at least 2 weeks provides ample work. Management may desire to be aware of how many weeks of backlog are available for each craft. Further analysis by crew or specific skill level is unnecessary.

SUMMARY

The management of the planners themselves is best conducted as a professional bureaucracy. That is, management emphasizes selecting personnel and training them. Management does not emphasize direct supervision, procedures, indicators, or frequent meetings for coordination. A great deal of importance rests on the qualifications of each individual planner. Organizations should select planners with an aptitude for planning. Organizations should train them in the principles and techniques of planning. The organization may obtain qualified planners either through hiring or developing persons with the necessary potential for success. Appendix M, Setting up a Planning Group, discusses how to accomplish the selection and training of maintenance planners.

While selection of planners handles the majority of planning control, management of overall maintenance does make use of several common indicators. The chief of these is overall availability. Other indicators include ones for measuring the proportion of work hours that are planned and the proportions of different types of proactive work versus reactive work. Management should use simple indicators of backlog with caution because the plant must generate a backlog to take care of maintenance. Schedule compliance helps determine if the maintenance force is controlling the equipment or if the equipment is controlling the maintenance force. Management measures crew forecasts and carryover work to help understand the functioning of the schedule process. Management uses these indicators to coordinate the efforts of the divisions or groups together.

Management uses the planning function itself to help control the working of maintenance. Management closely monitors and manages the process of selecting planners to help control the working of planning itself.

CHAPTER 11
CONCLUSION: START PLANNING

What is maintenance planning?

Maintenance planning as envisioned by the *Maintenance Planning and Scheduling Handbook* is not preventive maintenance.

Maintenance planning is not planning how to establish and organize a maintenance department.

Maintenance planning is not using a computer.

Maintenance planning is not providing a detailed procedure describing how to perform a maintenance task.

Maintenance planning is not simply identifying spare parts and special tools before a job starts.

Maintenance planning is providing file information to technicians to allow them to learn from past jobs and avoid delays. Planning also helps ensure the availability of anticipated spare parts and special tools.

Maintenance planning is providing crew supervisors with job scopes plus craft and work hour estimates to allow them better to assign daily work.

Maintenance planning is advance scheduling to allow managers to allocate work for crews based on forecasted labor availability.

Why do companies need maintenance planning? They need maintenance planning because it helps increase the amount of time technicians spend on direct work, actual work without delays. Maintenance planning reduces the time technicians spend in gathering parts, in finding tools, in receiving instructions, or in many other delay situations. In industry today, delays commonly cause maintenance crews to spend only 25% to 35% of their time on job sites making job progress. These delays do not even include time lost to vacation, training, or other type of administrative absences. Maintenance planning helps boost the direct work or wrench time of technicians to 55% or more. A good company at 35% with 30 maintenance technicians would enjoy the effect of having 47 technicians if it had 55% direct work time. The company would add 17 extra technicians without cost to its maintenance efforts. The company with 90 maintenance technicians would see the effort of 141 technicians, a 51-person improvement. And lest one should think maintenance planning helps only the large corporation, the company with 10 maintenance technicians would see the effort of 15 technicians, a 5-person improvement.

Attachment 1a

Why have companies not taken advantage of such an opportunity? Companies have not exploited maintenance planning for several reasons. The biggest reason has to do with a belief that direct work time could not possibly be as low as 35%. Yet, study after study reveals that companies have a typical direct work time of 35% *at best* without planning and scheduling. Other reasons primarily include fundamental misunderstandings of exactly how a planning and scheduling system properly works. This explains the great frustration of many companies that have unsuccessfully attempted improvements through maintenance planning. The inner workings of a proper system have seen limited study because of its position in the organization. The plant manager often sees maintenance planning as too low in the organization to give it direct attention. The plant engineer often sees planning as "low tech" and so not of much interest. The maintenance manager often sees planning as requiring too much of a change to the existing process of maintenance and not clearly worth the effort. Resulting efforts at planning see implementation without clear guidelines, practices, or even vision of its purpose. These companies do planning because they are supposed to do planning.

Planning does not just happen. Experience has shown that planning is a system with many subtleties requiring attention. The preceding chapters have established 12 basic principles that resolve the issues involved with a maintenance planning system. Specifics of actual practice help explain the principles. Companies might easily implement each principle to establish a maintenance planning system that allows attainment of dramatic maintenance improvement. The first principle requires keeping planners separate from the supervision of the individual crews. Separation best allows planners to concentrate on planning future work. The second principle is to avoid delays rather than to merely help deal with delays of a job that is already in progress. This principle takes advantage of the repetitious nature of most maintenance work and moves jobs up a learning curve. The third principle recognizes that planners can only practically retrieve prior job information for learning if linked to specific equipment. Specific equipment minifiles establish this link for paper documents. It is primarily within this linking principle that the CMMS has its place. Besides helping with inventory tracking, the CMMS allows management to leverage key information regarding work orders and equipment. On the other hand, a CMMS can significantly automate and otherwise facilitate the overall efforts of maintenance planning. The fourth principle provides for easy, practical estimation of job requirements through the expertise of an experienced technician as planner. The fifth principle has this planner utilize the skills of the field technicians and avoid wasting time giving more procedural information than necessary. The last planning principle, wrench time, embodies the purpose of planning to reduce delays to help technicians spend more time on jobs. Planning also involves scheduling because reducing delays during individual jobs allows supervisors to assign more jobs. Six more principles address scheduling. The first principle specifically obligates each job plan to estimate time requirements and lowest craft skill levels. To reduce interruption delays, the second principle champions the practice of not interrupting jobs already in progress through proper prioritization of work. The third principle commits crew leaders to forecast labor hours for craft skills for the next week. The fourth principle combines the forecasted labor hours with estimated job hours, sometimes utilizing persons beneath their maximum skill levels for the good of the plant. Although a scheduler in the planning department allocates the week's goal of work, crew leaders best handle the daily work assignments as established by the fifth principle. The sixth and final principle establishes the importance of schedule compliance. Not an end unto itself, this indicator measures the success of the crew taking control of the equipment. One overall consideration makes these principles practical, making the difference of their successful application. Planning must not constrain crews from immediately beginning work on urgent jobs. On reactive work planning can abbreviate its efforts while still providing helpful information. Together, these principles make the difference and make planning work.

In learning about maintenance planning, one also sees that there exists no magic answer by itself. Rather than being the latest management fad, one sees that planning provides a benefit by helping coordinate the rest of the maintenance group's resources. This brings up a valid concern. If maintenance planning assists in coordinating the rest of maintenance, how does one coordinate planning itself? The key to the coordination of activity within the planning group lies principally with the proper selection of the planners. Many times companies want to organize a new group by quickly hiring personnel and then drafting numerous procedures to govern their activities. Direct supervision or indicators then track adherence to these activities. This approach will not work with maintenance planning where management must first, above all else, carefully select qualified planners. After selecting planners, management must then imbue them with the vision and general principles of proper planning. Then management must support them in their knowing how best to conduct maintenance planning. This book explains what maintenance planning is all about and why it works. Seek the advice in App. M on how to establish a new planning organization or transform an existing one.

WIIFM means "What's In It For Me?"

For the technicians, they have a file clerk that faithfully pledges to help them avoid the painful lessons and delays of the past. They have a head start from an experienced technician that anticipates the problems of the job about to start.

For the supervisors, they have the means of knowing how many jobs they can assign to which skilled technicians.

For the managers, they have the means of improving productivity through knowing how much work that crews should execute each week and how to allocate it. Managers have the tool to assist 30 technicians achieve the effort of 47 technicians.

For the companies, they have a means of practically coordinating the expensive resources they have acquired for maintenance to improve and maintain superior plant reliability.

In conclusion, start planning.

APPENDIX B
FORMS

This appendix gives a complete set of forms used in this handbook. Readers of this book may use them as they are or modify them for maintenance in their organizations.

WORK ORDER

REQUESTER SECTION **Priority __ __**

Equipment ____________________ **Tag # ____________**

Problem or Work Requested: **Def Tag #________**

Outage Req? Y/N **Clearance Req? Y/N** **Confined Space? Y/N**

By: **Date & Time:** **APPROVAL:**

PLANNING SECTION **Assigned Crew:________** **Attachment? Y/N**

Description of work to be performed:

Labor requirements:

Parts requirements:

Special tools requirements:

By: **Date & Time:** **Job Estimate:** **Actual:**

CRAFT FEEDBACK **(Modify plan sections above: actual labor, parts, & tools)**

Work performed including equipment changes & any problems or delays:

Date & Time Started:____________ **Date & Time Completed:____________**

By: **Date :** **APPROVAL:**

CODING

FIGURE B.1 Sample work order form.

Attachment 1a

CREW WORK HOURS AVAILABILITY FORECAST

For week of: __/__/__ to __/__/__
For crew: __________ By:__________ Date: __/__/__

Craft	# Persons		Paid Hrs		Leave		Train		Misc		Carry-over*		Avail Hrs
		x 40 =		-		-		-		-		=	
		x 40 =		-		-		-		-		=	
		x 40 =		-		-		-		-		=	
		x 40 =		-		-		-		-		=	
		x 40 =		-		-		-		-		=	
		x 40 =		-		-		-		-		=	
		x 40 =		-		-		-		-		=	
		x 40 =		-		-		-		-		=	
		x 40 =		-		-		-		-		=	
		x 40 =		-		-		-		-		=	
Totals		x 40 =		-		-		-		-		=	

***Carryover work is any work which has been physically started in the current period, but will not be finished and will run over into the forecast period.**

FIGURE B.2 Crew work hours availability forecast form.

ADVANCE SCHEDULE WORKSHEET

For week of: _______ to _________
For crew: _________ By:________ Date: ________

Forecast	Available Hours Left

Totals _____ _____

Instructions: Subtract job work hours from available line total until balance reaches zero for each line or backlog runs out.

FIGURE B.3 Advance schedule worksheet.

Attachment 1a

ADVANCE SCHEDULE WORKSHEET #2

For week of: ________ to __________

For crew: __________ By:_________ Date:________.

TOTAL SCHEDULE

A. Total Hours Scheduled ________

B. Any Available Hrs Left Unscheduled (________)

Why? (No backlog, etc.) ____________

____

C. Total Hours Returned ________

Any Hours That Were Unclearable (________)

D. Sched Hours Worked (D = A - C) ________

E. % Schedule Met (E = D/A x 100) ________%

PREVENTIVE MAINTENANCE

F. PM Hours Scheduled ________

G. PM Hours Returned ________

PM Hours That Were Unclearable (________)

H. PM Sched Hours Worked (H = F - G) ________

I. % PM Schedule Met (I = H/F x 100) ________%

FIGURE B.4 Advance schedule worksheet 2 to measure schedule compliance.

DAILY SCHEDULE
DAY:______ DATE:________
SUPERVISOR:______________

WO#	Unit	Pri	Short Description																Comments
Special Codes: V-Vacation S-Sick T-Training O-Other			Special Code & Hours																
A-Assigned Off Crew			Total																

FIGURE B.5 Daily schedule form.

ALIGNMENT CHECKSHEET

____1. Break coupling and remove old grease.
____2. Inspect coupling for damage.
____3. Secure coupling. Run motor if magnetic center of motor is unknown. Mark motor shaft.
____4. Shut down motor. Set motor shaft to electrical center. Set coupling gap per coupling instructions.
____5. Inspect hold down bolts and washers for damage.
____6. Install jacking bolts on all corners of machines to be shimmed.
____7. Correct machine to be shimmed for soft foot and defective sole plates.
____8. Correct stationary machine for soft foot and defective sole plates.
____9. Remove all shims. Clean or replace as needed.
____10. Pack proper amount of grease into coupling and reassemble.
____11. Align machine. Use PdM group instructions for considering thermal growth.
____12. Tighten all fasteners. Loosen jacking bolts. Turn shaft to ensure free rotation.
____13. Attach form to work order.

Technician____________ Date______________

FIGURE B.6 Sample alignment readiness form.

UNIT 2 BURNER CHECKSHEET FORM

Burner Number:____________

Date:_____________

TECHNICIAN INITIALS EACH STEP WHEN COMPLETE

___1. Replace orifice, swirl, and spill plates

___2. Replace both gaskets.

___3. Verify correct lance setting.
Setting is: ____________

___4. Torque feed tube to 200 ft lb.

___5. Torque cap nut assembly to 77.5 ft lb.

___6. Adjust spider to provide 1/8 inch to 3/16 inch gap between outer tube and washer.

FIGURE B.7 Sample burner checksheet form.

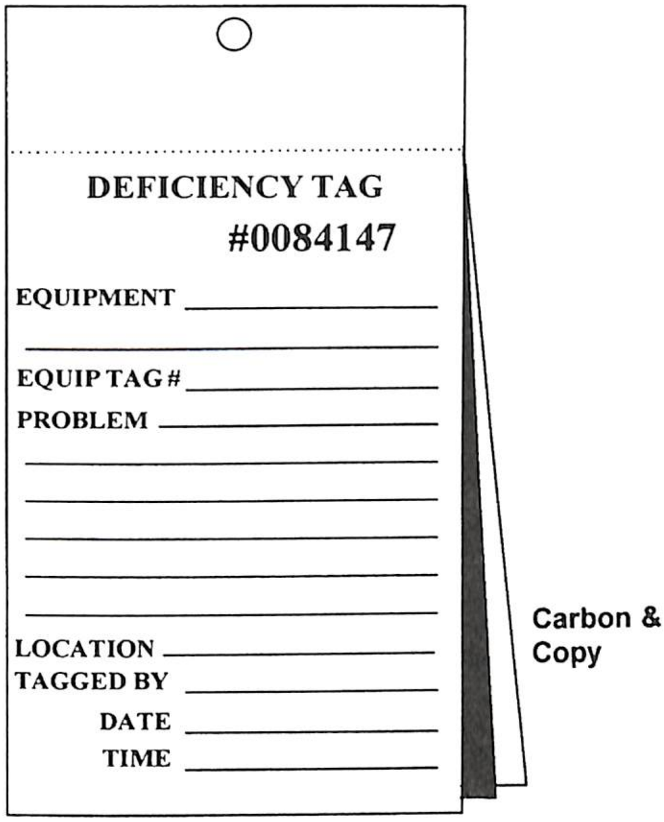

FIGURE B.8 Sample deficiency tag form.

EQUIPMENT HISTORY DATA SHEET

PAGE ___

SYSTEM ______________________

EQUIPMENT NAME ______________________

EQUIPMENT TAG # ______________________

HISTORY (Normally does not include PM's or other routine inspections.)

Work Order #	Job Description (What was done)	Complete Date	Print Revision Needed?	Work Type	Work Priority	Actual Hours Duration	Actual Labor Hours	Total Work Cost $
		/ /						
		/ /						
		/ /						
		/ /						
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EQUIPMENT TECHNICAL DATA SHEET

EQUIPMENT NAME ______________________________

EQUIPMENT TAG # ______________________________

EQUIP LOCATION ______________________________

Does this equipment have a "Standard Plan"? ______________

Manufacturer code and name ______________________

Vendor name, location, person, and phone number to contact:

____

____

NAMEPLATE INFORMATION

Model # ______________ Serial # ______________

____

____

MSDS # AND ANY OTHER SAFETY INFORMATION: (Is a Confined Space Permit needed? Describe any past accidents. What safety considerations such as scaffolding, high temperature/pressure, chemicals, etc. are there?)

____

____

____

OTHER INFORMATION AND SPECIAL NOTES FOR THIS EQUIPMENT

____

____

____

____

____

____

____

____

____

____

____

FIGURE B.10 Sample minifile form for equipment data.

PARTS INFORMATION SHEET

PAGE ___

EQUIPMENT NAME ______________________

EQUIPMENT TAG # ______________________

	Stock Number	Total Quantity Used for this Equipment	Quantity Needed for this Job*	Description
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				

*Use this column after copying this page to issue with a specific job.

FIGURE B.11 Sample minifile form for spare parts.

EQUIPMENT NORMAL PM's AND CHECKS

EQUIPMENT NAME____

EQUIPMENT TAG #____

By Maintenance Personnel

What	Frequency	*Route Designation

By Predictive Maintenance (PdM) Personnel

What	Frequency	*Route Designation

By Operations, Lab, or Other Personnel

What	Frequency	*Route Designation

*if any

FIGURE B.12 Sample minifile form for PM's.

Attachment 1a

INFORMAL CHECKSHEET TO BALANCE OBSERVATIONS

Mark the time started to locate persons within beginning half hour (B) or end half hour (E): Hand write a number beside each half hour to designate the week during which the observation occurred.

Weeks:

Time Period	Time	Mon	Tues	Wed	Thur	Fri
8	7:30-8:30	B E	B E	B E	B E	B E
9	8:30-9:30	B E	B E	B E	B E	B E
10	9:30-10:30	B E	B E	B E	B E	B E
11	10:30-11:30	B E	B E	B E	B E	B E
12	11:30-12,12:30 -1	B E	B E	B E	B E	B E
13	1 - 2	B E	B E	B E	B E	B E
14	2 - 3	B E	B E	B E	B E	B E
15	3 - 4	B E	B E	B E	B E	B E
16	4 - 5	B E	B E	B E	B E	B E
17	5 - 6	B E	B E	B E	B E	B E

Special comments:

FIGURE B.13 Sample form to ensure an even balance of work sampling study observations.

WRENCH TIME OBSERVATION DATA SHEET

STUDY ______________________

PLANT ______________________

PAGE ___ OF ___

(Cmptr Entry)	Unit Events	Observing Date	Day of Week	Person's Number	Person's Supvr Number	Work Cat #	Time Period	OT?	Any Observation Comments (such as purpose of travel)
		/ /							
		/ /							
		/ /							
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FIGURE B.14 Sample form to record work sampling observations.

APPENDIX I
THE ACTUAL DYNAMICS OF SCHEDULING

This appendix discusses two additional elements of productivity and scheduling, namely wrench time in exceptional crafts and plants and blanket work orders in any plant. The *Maintenance Planning and Scheduling Handbook* addresses these topics in this appendix so as not to distract from the main thrust of the book.

First, wrench time may be higher than the industry norm of 25 to 35% in some maintenance organizations without highly developed planning functions. The preceding two appendices showed two such examples. In App. G, the I&C (instrument and controls) group had a 38% wrench time. This I&C group did not have a planning function assisting it. The industry norm more applies to an overall maintenance force than to a specific craft. I&C and electrical crafts without planning typically should be at the top or slightly over industry norm. These groups are typically not at the desired 55% level, but their existing productivity may warrant placing them behind the mechanical group in priority for implementation of planning. In addition, in plants where I&C and electrical groups mostly support the mechanical groups, the improvement of the mechanical group's wrench time through planning improves these other crafts as well. Appendix H shows a mechanical group with a marginal planning effort. With only planning, but no weekly scheduling, the craft is at the top of the industry norm for wrench time. Certain crafts, most notably machinists, achieve 50% wrench time due to the nature of their close-at-hand work assignments.

Another situation, not illustrated by the two included wrench time studies, is that of the plant with extremely high amounts of urgent, reactive work. The craftpersons in these plants have moderate to high wrench times primarily because there is no need to schedule subsequent work assignments. The urgency of the workplace easily directs the resources to the next jobs. There is limited opportunity for idleness or breaks. The plant possesses a productive work force, but has terrible reliability. Then, as management brings more maintenance personnel to the suffering plant, the work force is able to catch its breath. The maintenance force grows to where it can keep up with the reactive work and deliver a somewhat reasonable reliability. At this point, wrench time drops as uncertainty sets in as to where to attack the next job. The discussion and all the reasons set forth in Chap. 6, Basic Scheduling, come into play to keep productivity low.

Second, so-called blanket work orders greatly damage both productivity and record keeping. Rather than accept the expense of writing work orders for every little task, many plants have blankets to which personnel charge time for certain tasks. For example, rather than write a work order, the supervisor may direct a mechanic to hang a bulletin board in the front office and "charge the time to Blanket 103" (miscellaneous mechanical work). The productivity problem created is threefold. One, the supervisor and mechanic have stepped outside of the planning and scheduling process. The supervisor could give the mechanic a time estimate, but probably will not. Two, the extraneous job was not scheduled into the week's allocation of work. As the practice of doing work on blankets expands, the week's allocation becomes meaningless without special attention to schedule compliance. The possibility of doing side jobs on blankets encourages neglect of the weekly schedule. The weekly schedule was based on the work prioritized in the best interest of the plant. These jobs will be delayed by possibly less important blanket work. Finally, the use of blankets invites giving less credibility to the planned time estimates. Instead of assigning a 9-hour job and a 1-hour job from the backlog to a technician on a 10-hour shift, the supervisor may assign only the 9-hour job. The supervisor might direct the technician to do some miscellaneous cleaning up "on the blanket." Likewise, blankets allow the technician to report 5 hours on a planned 5-hour job that took all day. The technician might rather claim the other 5 hours of the day on blanket work rather than having to document all the reasons the planned job took so long. There is a general loss of control, and many plants begin to do an extremely large portion of their work on blankets. One plant could account for less than half of their work hours being spent on specific work orders. The rest was blanket work. Besides productivity, blankets lose vital equipment history. Blanket work leaves no document to store in the paper files or information to record in electronic files. If the plant does some equipment work via work orders and some via blankets, then planners do not have complete history from which to collect delay information or base maintenance decisions going into their plans.

One sees that there are additional issues and situations affecting how planning and scheduling affect productivity. One of these is higher wrench time experienced under certain conditions without significant planning and scheduling. Certain crafts have somewhat higher wrench times than industry averages for overall maintenance. However, even these craft are helped by maintenance planning. Plants experiencing extreme trouble also often do not have poor wrench time. Yet as these plants increase their reliability, they benefit from planning and scheduling to maintain a high productivity. They must maintain higher productivity to allow completion of more proactive work. Another issue is the interference that blanket work orders cause the planning and scheduling effort. Management should eliminate or greatly restrict the use of blankets.

APPENDIX J
WORK ORDER SYSTEM AND CODES

Starting a work order system is the most important improvement one can make to a maintenance program. The work order system is the process by which the maintenance manages all plant maintenance work. The system assists the plant in keeping track of, prioritizing, planning, scheduling, analyzing, and controlling maintenance work. The plant must have a viable work order system as a foundation to planning.

This appendix illustrates a typical manual a company would use to document its work order process. Notes have been inserted to call attention to particular details. Example work orders throughout this book have used the codes from this appendix. The manual should primarily illustrate the work order form, the work order process, and identify the codes used in the system. As a CMMS becomes developed, it is not unreasonable to expect that the CMMS could contain the essentials of the work order manual and replace it.

This example company uses a paper work order system for persons that originate work orders. A clerk enters the work orders into the CMMS system. The plant is currently considering creating a CMMS screen to resemble its work order form and allowing persons to enter their own work orders directly into the system.

It is a good idea to have a document that sets forth the rules of using work orders. It is not necessary that the document be exceedingly thick.

COMPANY WORK ORDER SYSTEM MANUAL

TABLE OF CONTENTS

Introduction
Work Flow
Work Order Form and Required Fields
CMMS Instructions for Plant-Wide Use
Codes
- Priority
- Status
- Department and Crew
- Work Type
- Plan Type
- Outage
- Plant and Unit
- Equipment Group and System
- Equipment Type

Action Taken
Reason, Cause, and Failure
Work Order Numbering System
Manual Distribution

INTRODUCTION

The work order system is the process which the Maintenance Department uses to manage all plant maintenance work. The work order system assists the plant in keeping track of, prioritizing, planning, scheduling, analyzing, and controlling maintenance work. (The terms *WO* and *work order* have the same meaning.) A major purpose of using work orders for plant equipment is to be able to track its history. Using blanket work orders or having several pieces of equipment on the same work order destroys the process of keeping history.

The *work flow diagram* shows the steps of the cycle that occur from initiating a work order to work completion.

The plant uses the work order form as the document to record information associated with executing the work request.

After work completion, WO forms which have historical value are filed to assist future work. Codes are used with each work order to allow various sorts and analysis of maintenance work. For example, the outage code allows sorting out all work orders that must be done during a unit outage.

The CMMS (computerized maintenance management system) allows computer tracking and analysis of work orders as well as plant equipment data. The system is on the personal computer (PC) network and may be accessed from any plant.

The WO numbering system provides for assigning each separate work order a unique number to allow keeping the work done under that number separate from other maintenance work.

A *WO System Manual* is distributed to each person on the manual distribution list who is responsible for keeping it up to date with all issued revisions. The Job Planning Coordinator coordinates and distributes all revisions to the *WO System Manual*.

WORK FLOW

Work flow diagrams show the steps of the cycle that occur from initiating a work order to work completion. Figure J.1 shows the normal steps of the work process. Figure J.2 shows the steps taken during emergencies. In emergencies, action begins with verbal instructions and the paperwork follows later.

WORK ORDER FORM AND REQUIRED FIELDS

The work order form is the document used to record information associated with:

1. an identified problem, need, or work request
2. the work authorized to be done
3. the plans, details, and schedules necessary to perform the work
4. the results of that work

After work completion, the planning department files work order forms which have historical value to assist future work.

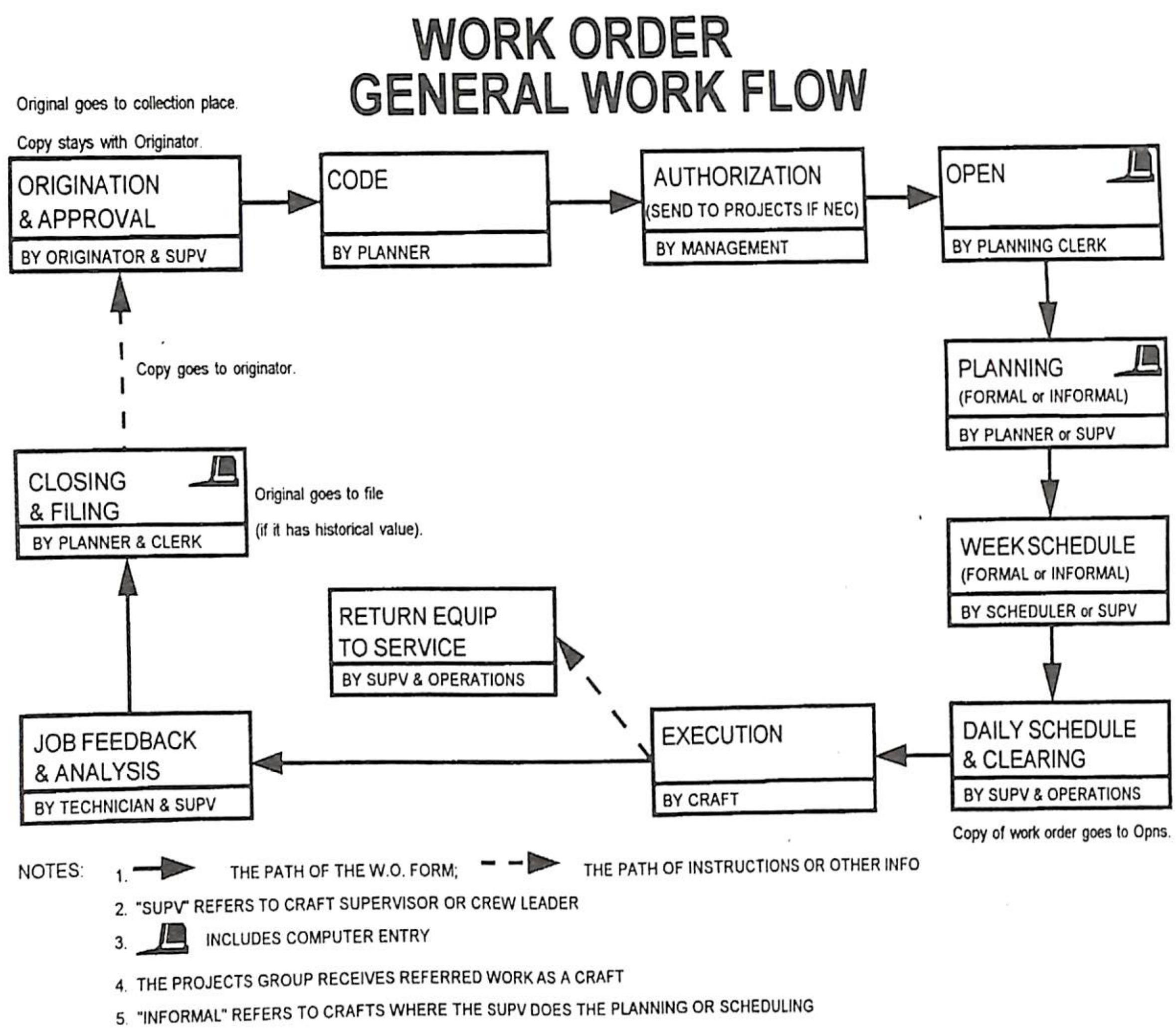

FIGURE J.1 Company work flow diagram.

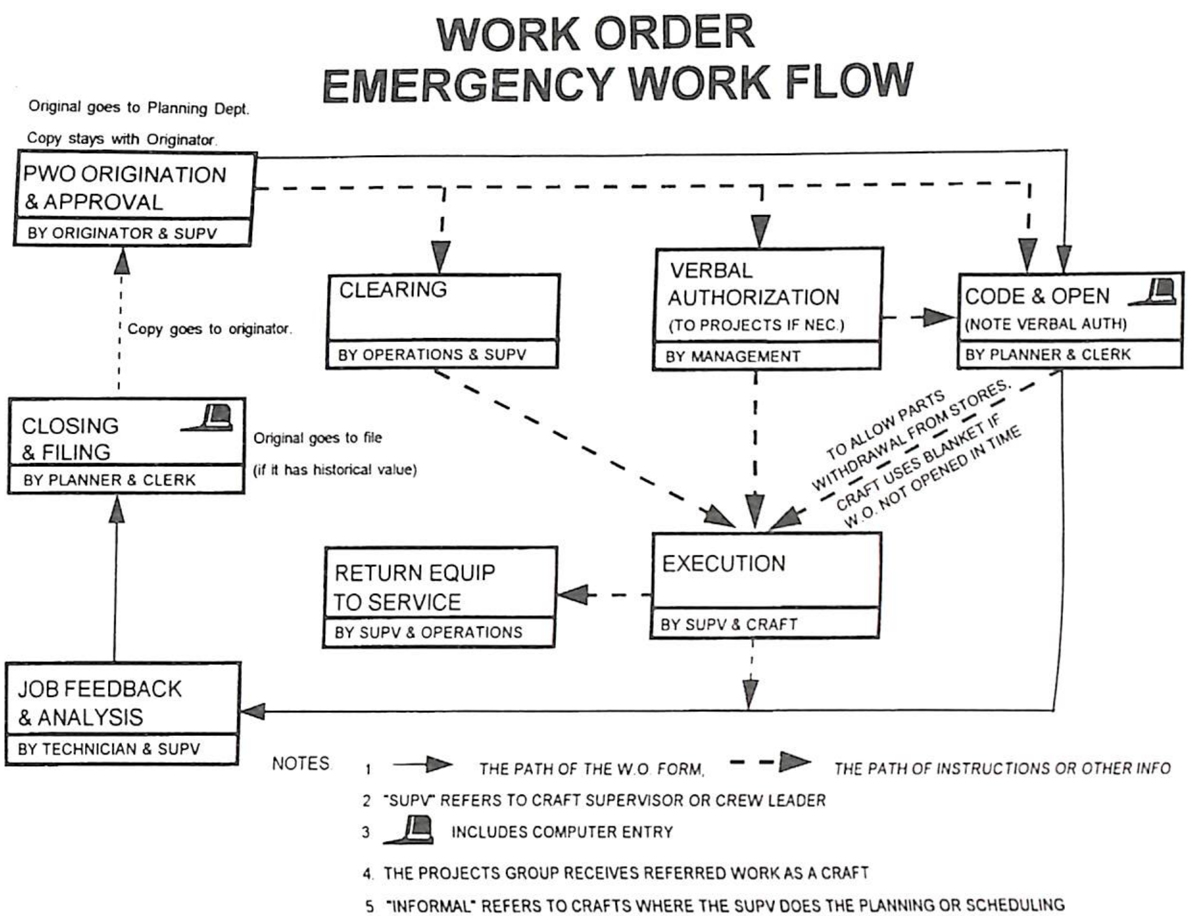

FIGURE J.2 Company emergency work flow diagram.

Figure J.3 illustrates the work order form this company uses. Figure J.4 identifies who is responsible for completing each section of the form.

The following information is used by the Job Planning Coordinator when ordering new work order forms from the printer. The JPC gives this information to the company graphics department, printer, or forms order company along with a reproducible original.

General Information

All parts are printed in black.

Carbonless paper is used.

Note that the original is reduced in size!

Copy all four parts; enlarge them to have 1/4-inch left and right margin.

Numbering should be in red ink at the top of the form.

No additional numbers should appear anywhere on the form or tab.

Numbering sequence should be as follows:

Lot 1: A000 through A999	Lot 2: B000 through B999
Lot 1: C000 through C999	Lot 2: D000 through D999
Lot 1: E000 through E999	Lot 2: F000 through F999
Lot 1: G000 through G999	Lot 2: H000 through H999
Lot 1: J000 through J999	Lot 2: K000 through K999
Lot 1: L000 through L999	Lot 2: M000 through M999
Lot 1: N000 through N999	Lot 2: P000 through P999
Lot 1: Q000 through Q999	Lot 2: R000 through R999
Lot 1: T000 through T999	Lot 2: W000 through W999
Lot 1: X000 through X999	Lot 2: Y000 through Y999

Note: Do not use letters i, o, s, u, v, or z. Package in nearly equal amounts (between 50 and 200); no specific amount is required.

Part 1 information:	White stock, 8 1/2 × 11 inch, print the front and back (see sample).
Part 2 information:	Pink stock, 8 1/2 × 11 inch, print the front only (see sample).
Part 3 information:	Blue stock, 8 1/2 inch × cut at bottom line, print the front only.
Part 4 information:	Goldenrod stock, 8 1/2 inch × cut at bottom line, printing front only (see sample).
Contacts:	Get the Job Planning Coordinator's name and phone number.

CMMS INSTRUCTIONS FOR PLANT-WIDE USE

(*Note:* This section should cut down the 1-inch-thick computer manual that came with the CMMS to a few pages of key instructions for non–planning group persons such as most plant supervisors, technicians, operators, and managers. The example used for this section has been discussed in Chap. 8 and placed in App. L dealing with a CMMS installation.)

Attachment 1a

WORK ORDER

REQUESTER SECTION Priority __ __

Equipment ______________________ Tag # ______________

Problem or Work Requested: Def Tag #________

Outage Req? Y/N Clearance Req? Y/N Confined Space? Y/N

By: Date & Time: APPROVAL:

PLANNING SECTION Assigned Crew:________ Attachment? Y/N

Description of work to be performed:

Labor requirements:

Parts requirements:

Special tools requirements:

By: Date & Time: Job Estimate: Actual:

CRAFT FEEDBACK (Modify plan sections above: actual labor, parts, & tools)

Work performed including equipment changes & any problems or delays:

Date & Time Started:____________ Date & Time Completed:____________

By: Date : APPROVAL:

CODING

FIGURE J.3 Company work order form.

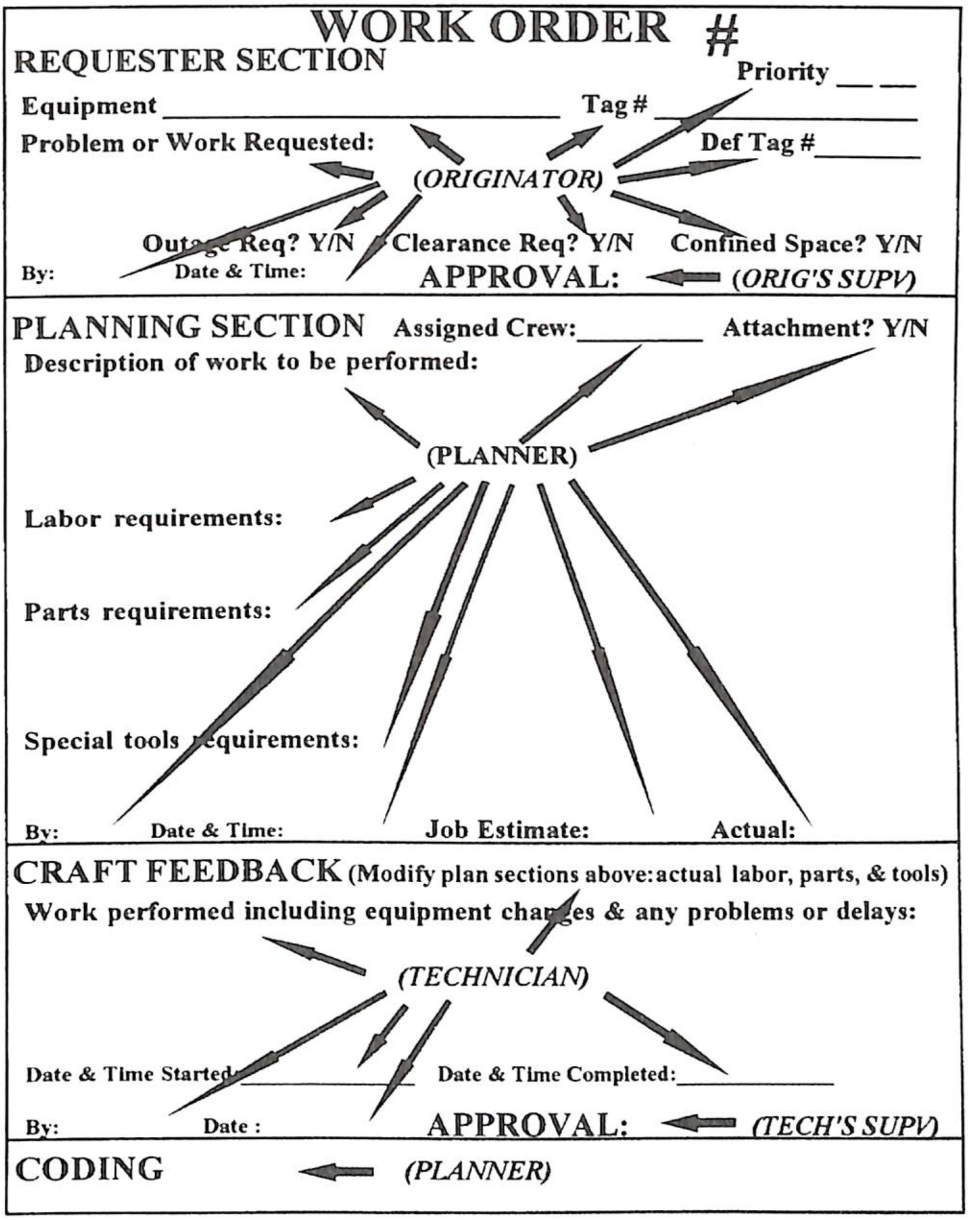

FIGURE J.4 Identification of information responsibility on work order form.

CODES

Codes are used with each work order to allow various sorts and analysis of maintenance work. For example, the outage code allows gathering all work orders that must be done during a unit outage. Here is an example set of codes for an oil and gas fired electric power station that has both steam and gas turbine generating units. These codes illustrate what codes are used for and look like.

Priority

(*Note:* Priority codes allow ranking work orders in order of importance to know which to handle first. See Scheduling Principle 2 for more discussion of their importance and how incorrect usage can hinder productivity. Organizational discipline that comes through education, communication, and management commitment helps ensure correct usage.)

Work Order Priority Codes. First digit—priority type. (*Note:* The first digit does not indicate priority preference; each type has equal weight.)

- **S** Safety
- **H** Heat rate
- **E** Environmental or regulatory
- **R** Reliability or availability
- **G** General

Second digit—priority order. (*Note:* The second digit indicates priority preference.)

- **0** Emergency Conditions
  - Loss of unit
  - Immediate or imminent loss of unit capacity
  - In violation of environmental regulations
  - Loss of unit load control
  - Emergency safety hazard
- **1** Urgent Conditions
  - Significant potential for loss of unit or unit capacity
  - Major loss of heat rate
  - Significant potential for violation of environmental regulations
  - Urgent safety hazard
- **2** Serious Conditions
  - Condition that could cause serious damage to critical equipment
  - Serious loss of heat rate
  - Condition that could cause violation of environmental regulations
  - Serious safety hazard
  - PM's
- **3** Noncritical Maintenance on Production Equipment
- **4** Noncritical Maintenance on Nonproduction Equipment

(*Note:* Therefore, work orders with "1" priorities should be handled ahead of work orders with "2" priorities and so on regardless of the letter priority type. Having the letters associated with the priorities helps persons better understand the nature and reasons behind the work orders and their numerical priorities. If one carefully examines the point criteria examples, safety is indeed given more weight in that it is easier for a safety (S) work order to receive a 1 score than it is for heat rate, a unit efficiency measure. In a well functioning plant, 0 and 1 work orders should be infrequently received. It is maintenance's objective to have mostly 2 level PM work orders and 3 and 4 level work orders as the maintenance organization goes about its task of maintaining, not recovering. There is a valid argument that such a short range between 0 and 4 tends to encourage persons to classify work orders as 1 (urgent) and 2 (serious) unnecessarily. For that reason many plants have an extended range, perhaps 0 to 10. They do not get many 10 work orders, but they do get more 3's and 4's and less false 1's and 2's.)

Status

(*Note:* These codes are solely for the CMMS, the simple reason being that the placement of paper work orders determines their status. For example, paper work orders waiting for parts are kept by the purchaser, work orders in progress are kept by the technicians, etc. The CMMS allows the rest of the plant to ascertain where the work orders are in the work order process.)

Work Order Status Codes

WAPPR—Waiting for approval. This status is the initial status of a WO before plant management has authorized the work request.

APPR—Approved. Management has authorized the work request and it is ready for planning.

WSCH—Waiting to be scheduled. The work order has been planned (if planning was necessary) and it is ready to be scheduled for work.

HOLD-MATL—Waiting for material or tools. Materials or tools are unavailable to either start or continue work.

HOLD-OTHER—Waiting for other reason than materials or tools. Work is waiting on engineering or management decision to either start or continue work.

PROJ—Project. This work is being undertaken by the corporate project group. Plant maintenance forces are not involved at this time.

SCHED—Scheduled. Work has been included on the weekly schedule.

INPRG—In progress. Work has already begun or it has been included on the next day's schedule.

COMP—Completed. Work has been completed, but the finished work and documentation have not yet been reviewed or analyzed. WO has not yet been closed..

COMP-DWGS—Completed, waiting on drawings. Work has been completed, but required drawings have not yet been revised. WO has not yet been closed.

COMP-OTHER—Completed, waiting on other. Work has been completed, but some specific requirement has not yet been submitted. WO has not yet been closed.

CLOSE—Closed. All work and documentation have been completed satisfactorily. WO is closed.

CAN—Canceled. This WO is not considered necessary. WO's may be canceled for a variety of reasons such as the WO may be a duplicate of another WO, the need for this work no longer exists, or plant management has decided not to approve the work order for economic, budget, or other reasons.

Department and Crew

(*Note:* These codes when assigned to work orders make it possible to determine and track who originated the work and who is responsible for executing the work. Backlogs and work already performed are easily sorted into crafts such as mechanical and electrical as well as into crews for responsibility.)

Department and Crew Codes

First digit—Department. Second digit—Crew.

DEPARTMENT 1. Mechanical (Cost Center 1004)
- CREW 0: Overall craft superintendent
- CREW 1
- CREW 2
- CREW 3
- CREW 4
- CREW 5

DEPARTMENT 2. Instrumentation & Controls (CC 1006)
- CREW 0: Overall craft superintendent
- CREW 1
- CREW 2

DEPARTMENT 3. Electrical (CC 1005)
- CREW 0: Overall craft superintendent
- CREW 1
- CREW 2

DEPARTMENT 4. Operations (CC 1002)
- CREW 1: A shift
- CREW 2: B shift
- CREW 3: C shift
- CREW 4: D shift
- CREW 5: Relief crew
- CREW 6: X crew

DEPARTMENT 5. Plant Administration (CC 1001)
- CREW 1: Plant Manager
- CREW 2: Plant Assistant Manager
- CREW 3: Plant Engineers
- CREW 4: Administrative Support
- CREW 5: Training Department

DEPARTMENT 6. Chemistry and Water Support Division (CC 1012)
CREW 1: Administration
CREW 2: Results Laboratory
CREW 3: Central Laboratory
DEPARTMENT 7. Performance Engineering Division (CC 1032)
CREW 1: Administration
CREW 2: Predictive Maintenance
CREW 3: Diagnostic Engineering
CREW 4: Production Analysis
CREW 5: Equip Database, Tagging, and Schematics
DEPARTMENT 8. Support Outside
CREW 1: Outage Management & Contractors (CC 1021)
CREW 2: Project Group & Contractors (use craft CC)

(*Note:* Thus, a work order coded as written by Crew 4-1 and assigned to Crew 1-3 would be a work order originated by the A shift crew in operations and it was for mechanical type work falling into the Crew 3 area of responsibility in the mechanical maintenance department.)

Work Type

(*Note:* The work type coding allows backlogs and work already performed to be sorted to determine how the plant is performing. Is most of the work trouble and breakdown type work or is most of it preventive maintenance? Is there any corrective maintenance to correct situations from turning into trouble and breakdown type problems? The company trying to have a maintenance program and not just a repair service considers this type of information.)

Work Type Codes

1. *Spare equipment (noninstalled).* Maintenance activity performed on noninstalled (spare) plant equipment. Rebuilding rotating spares is included.

2. *Structural.* Maintenance activity performed to maintain general plant structural integrity. This includes associated support work such as surface preparation, painting, structural weld repair, and insulation renewal. Insulation and lagging removal and replacement necessary to perform an inspection or repair of a covered or protected component would not be considered as structural.

3. *Project.* Maintenance activity performed on equipment or plant involving a modification, upgrading, or improvement and performed on a one-time basis, whether or not a unit outage is involved.

4. *Buildings and grounds.* Maintenance activity to maintain general plant appearance such as trash hauling, janitorial work, gardening, material handling, safety inspections, and general housekeeping efforts. *Exceptions:* Additional effort required due to extensive plant structural repairs is structural work.

5. *Trouble and breakdown.* Maintenance activity required to return a unit or plant equipment to normal operating conditions due to an equipment breakdown or failure to operate properly. Failed or improperly operating equipment discovered or worked during a planned outage is this work type only if the particular item is preventing the return to service of the unit at the time of discovery.

6. *Overhaul.* Maintenance activity performed for general overhaul inspection or rebuild of one or more major equipment groups during a scheduled outage shown on the 1-Year Outage Plan. An overhaul is intended to keep equipment in proper operating condition or restore capability that has gradually diminished over time. All work performed in preparation of, during, in cleanup from, or otherwise due to the overhaul is considered to be this work type. The work is not project work because an improvement over the original design capability is not intended. An overhaul is beyond the scope of normal preventive maintenance. The overhaul occurs before specific trouble or breakdown has happened and before predictive maintenance is recommended.

7. *Preventive maintenance.* Maintenance activity performed which is repeated at a predetermined frequency and is scheduled from a preventive maintenance listing or program. The frequency established need not be related to calendar time but can be required based on predetermined service time or events such as the number of service hours or starts. Work which is performed during an overhaul outage, but would be performed anyway if the outage was postponed, is included in this work type.

8. *Predictive maintenance.* Maintenance activity performed based on a prediction that future equipment breakdown or failure to operate properly will occur. The prediction is based on trend analysis of diagnostic data collected by techniques such as vibration or lube oil analysis. The need for maintenance would not normally have been apparent without analysis of the diagnostic data.

9. *Corrective maintenance.* Proactive maintenance activity performed based on a prediction that future equipment breakdown or failure to operate properly will occur. The intent of corrective maintenance is to maintain equipment optimum performance. The need for maintenance is normally established by inspection. The prediction is *not* based on a predictive maintenance type technology or trend analysis, nor is it based on a preventive maintenance type predetermined frequency.

Plan Type

(*Note:* The proactive and reactive part of the plan type code is similar to work type but is a broader category. In general, all the work types except number 5, trouble and breakdown, are proactive. The maintenance department wants to be working on proactive work to avoid later trouble that would inconvenience the plant operation and require excessive maintenance effort. By definition, proactive work is not urgent, so the planning department wants to spend more time planning these jobs to be most effective and efficient when executed. The planning department also wants to recognize the reactive work orders so they can be quickly passed on to the maintenance department for timely resolution. Minimum versus extensive maintenance coding also helps the planning department recognize how much effort to expend on planning the work. Small jobs are frequently not worth much time spent on planning, though some time is still necessary.)

Plan type codes. First digit—Reactive or Proactive

R Reactive

Equipment has actually broken down or failed to operate properly.

Priority-1 jobs are defined as urgent and so they are reactive.

P Proactive. Proactive work heads off more serious work later. If the damage is already done, the work is reactive.

Work done to prevent equipment from failing.

Any PM job.

Generally Predictive Maintenance initiated work that if done in time will prevent equipment problems.

Project work.

Second Digit—Minimum Maintenance or Extensive Maintenance

M Minimum maintenance. Minimum maintenance work must meet *all* of the following conditions:

Work has no historical value.

Work estimate is not more than 4 total work hours (e.g., two persons for 2 hours each or one person for 4 hours).

While parts may be required, no ordering or even reserving of parts is necessary.

E Extensive maintenance. All other work is considered "extensive."

(*Note:* "RE" would be an example plan type code for a reactive job that is also extensive.)

Outage

(*Note:* These codes are not the same as work order status codes. If the maintenance group can only perform a certain work order during a unit outage, it is critical that this limitation be recognized as soon as possible. This is regardless of whether the work order has yet been approved or planned. The planning group must be able to recognize these work orders in order to plan them more expeditiously than other work. There may or may not be a sudden window of opportunity to execute the work. If there is an unexpected outage for some other reason, it is wise to have planned these work orders in time. *Outage* refers to the condition of the entire plant unit, not the individual piece of equipment.)

Outage Codes

1. *Forced short outage.* A component failure or other condition which requires the unit to be removed from service immediately or at any time prior to the end of the upcoming weekend.

2. *Scheduled short outage.* A component failure or other condition which requires the unit to be removed from service, but not necessarily before the end of the upcoming weekend. The work does not have to be done during a major outage.

3. *Major outage.* Work which can only be done during a major outage such as a major rebuild or overhaul inspection or work on one or more major equipment groups. The outage is normally shown as a planned outage on the 1-Year Outage Plan. Testing after a major outage at limited loads is included.

4. Not Used.

5. *Forced derating.* A component failure or other condition which requires the maximum capability of the unit to be reduced immediately or at any time prior to the end of the upcoming weekend.

6. *Scheduled derating.* A component failure or other condition which requires the maximum capability of the unit to be reduced, but not necessarily before the end of the upcoming weekend. The work does not have to be done during a major outage.

7. *Potential outage, redundant installed equipment.* A trouble condition which requires a piece of redundant equipment to be taken out of service without affecting the unit capability; but if the backup equipment failed an outage or derating would result.

8. Not used.

9. *Potential outage, noninstalled spare equipment.* Work performed on noninstalled spare equipment (such as rebuilding rotating spares) where if the unit suddenly needed the spare, the spare would not be available and a more serious than normal unit outage or derating would occur.

U. *Starting up.* Work which requires the unit to be in a start-up mode where the unit is being brought on-line. Equipment tests or adjustments that can only be done during a start-up condition are included.

D. *Shutting down.* Work that can or should only be done when the unit is on line, but Dispatch no longer needs the unit and the unit is about to be shut down. Typically, equipment tests or adjustments that may trip the unit are included.

(*Note:* Thus, a work order coded as a 2 could only be done when the unit is down on outage for some reason. If a SNOW (short notice outage work) outage occurs and the outage will take 48 hours, this SNOW work order might be a candidate for including in the outage work scope. This work order could only be included if it is already planned and ready for scheduling. One might not know if the work order could be done if the job was not furnished with an expected duration via planning, say 24 or 78 hours of duration.)

Plant and Unit

(*Note:* The plant and unit coding begins the equipment coding system. The company has an "intelligent" numbering system. The equipment number identifies the plant, unit, and system of the equipment being discussed.)

Plant and Unit Codes. First digit—Plant. Second and third digits—Unit.

PLANT N—North Generating Station
- UNIT 00—Steam Plant Common
- UNIT 01—Steam Unit One
- UNIT 02—Steam Unit Two
- UNIT 03—Steam Unit Three
- UNIT 04—Steam Unit Four
- UNIT 30—Gas Turbine Plant Common
- UNIT 31—GT Unit 1
- UNIT 32—GT Unit 2
- UNIT 33—GT Unit 3
- UNIT 34—GT Unit 4

PLANT S—South Generating Station
- UNIT 00—Steam Plant Common
- UNIT 01—Steam Unit One
- UNIT 02—Steam Unit Two
- UNIT 03—Steam Unit Three
- UNIT 04—Steam Unit Five

(*Note:* Thus, a code of N02 would indicate North Station Unit 2.)

Equipment Group and System

(*Note:* Each equipment group is shown with its composing systems. For example, Group A, Air, is followed by the systems within the Air Group, System I, Instrument Air, and System S, Service Air. Following this listing is a comprehensive definition of each system.)

Group and System Codes. First digit—Group. Second digit—System.

- A Air
  - I Instrument
  - S Service
- B Boiler
  - A Air Flow for Combustion
  - B Boiler Tubes and Steam Generating Section
  - C Controls
  - E Air Preheater Heat Exchanger
  - F Burner Front
  - G Gas Flow from Combustion
  - I Aspirating Air
  - J Casing and Structure
  - P Convection Pass
  - S Sootblowers
  - T Seal Air
  - V Vents and Drains
  - W Wash Drains
- C Condensate
  - D Feedwater Heater Drains
  - F Flow
  - P Polishers
  - R Recovery
  - S Supply
  - V Vacuum Supply
- D Feedwater
  - A Auxiliary Feedwater
  - D BFP Fluid Drive
  - F Flow
  - O BFP Lube Oil
  - P Boiler Feedwater Pump
  - T BFP Steam Turbine
- E Electrical
  - C Communication
  - D 120-250 Vdc
  - I Control Room Instrumentation

- L Plant Lighting and Distribution.
- M Miscellaneous
- S Switchgear, Load Center, and MCC
- Y Switchyard

F Fuel
- B Fuel Oil Burner Supply and Return
- C Fuel Oil Service Pump
- D Diesel Storage and Transfer
- H Fuel Oil Heaters
- I Ignitor Fuel Supply
- N Natural Gas
- O Fuel Oil Storage and Transfer
- P Propane Gas
- V Vehicle Fuel Storage
- W Wharf Facility for Ship Unloading

G Generator
- D Diesel Generator
- E Exciter
- H Hydrogen
- I Isolated Phase
- O Seal Oil
- P Protection Circuit
- R Rotating Field
- S Stator
- V Voltage Regulator
- W Stator Oil and Cooling Water

H Water
- A Treatment Plant Acid
- C Treatment Plant Caustic
- D Demineralizer
- P Potable Water Supply
- R Raw Water Supply

I Intake
- C Canal
- F Fish Protection Traveling Screens
- R Intake Chemical Treatment

J Cooling Water
- C Condenser Cleaning
- I Circulating Water
- L Closed Cooling

- R River Water
- T Cooling Tower
- X Condenser

K Fire Protection
- D Dry Chemical
- P Portable
- U Gas Turbine
- W Water and Foam

N Environmental
- A Air Quality
- W Water Quality

R Reagent and Chemical
- A Acid Cleaning for Boiler
- C CO_2 and H_2 Supply
- D Condenser Discharge Chemical Injection
- M Miscellaneous
- N Nitrogen Supply
- O Fuel Oil Treatment
- P Condensate pH Chemical Injection
- W Boiler Wash

S Steam
- A Auxiliary Piping
- E Extraction Piping
- M Main Steam Piping
- P Primary Superheating Section
- Q Secondary Superheating Section
- R Reheat Piping
- S Reheat Superheating Section
- X Auxiliary Boiler

T Steam Turbine
- A HP and IP Section
- B IP Section
- C LP Section
- F Front Standard
- H HP and IP Turbine Control
- I Monitor Supervisory Instrumentation
- J Turbine Controls
- L Steam Seals
- O Lubricating Oil
- P Pedestal

- S Structure
- V Vents and Drains
- X Crossover Pipe

U Gas Turbine

- A Accessory Station
- B Bearing and Coupling
- C Compressor Section
- D DEH Control
- E Exhaust
- G Generator
- H Housing
- I Combustor Section
- J Cooling Water
- O Lubricating Oil
- P Protection and Control
- R Starting
- S Supports
- T Turbine Section
- U Turning Gear
- W Water Wash
- Z Atomizing Air

V Ventilation

- A Air Conditioning
- D Equipment Dry Layup
- M Miscellaneous Vents and Exhausts
- S Steam Heating

W Waste

- F Waste Fuel Collection
- H Water and Boiler Wash Collection
- I Water Instrumentation
- L Liquid Waste
- S Solid Waste Disposal
- W Sewage Treatment

Y Blanket Accounts

- A Operations
- B Maintenance
- C Administration
- D Engineering
- E Structural

F Production Equipment
G Facilities
H Computer

Z Miscellaneous
B Buildings and Grounds
C Turbine Deck Bridge Crane
E Electric Tools and Equipment
F Freeze Protection
H Hydraulic Tools and Equipment
L Laboratory
M Machine Shop Equipment
O Other Tools and Equipment
P Pneumatic Tools and Equipment
S Security
V Plant Vehicles

Group and System Definitions. Except as noted in the individual system definitions, several general definitions apply. Each system includes its related gauge work, instrumentation and controls, power and control wiring, and breakers. *Piping* means the complete piping system, including the pipe itself, insulation, lagging, hangers and supports, steam tracing lines, valves, safety relief valves, orifices, strainers, drains, and traps associated with that pipe. All electrical, instrumentation, and mechanical devices which exclusively serve a major component are accounted for in the same system as that component.

A AIR

AI Air Instrument

Provides compressed air to pneumatic controls and instrumentation. Includes compressors, dryers, coolers, separators, air tanks, and piping. Instrument Air can also be described as piping coming from the service air compressors when the compressors serve both systems.

AS Air Service

Provides compressed air for general plant service (house air) such as air motors and air hose connections. Includes compressors, dryers, coolers, separators, air tanks, and piping.

B BOILER

BA Boiler–Air Flow for Combustion

All combustion air ducting from the air intake ports to the windbox. Includes all related hangers and supports, dampers, damper controls, expansion joints, orifices and the windbox. Includes FD fans, fan casings, inlet vanes, motors and foundation. Includes the overfire air system. Does not include preheaters (BE) or seal air system (BT).

BB Boiler–Boiler Tubes and Steam Generating Section

Steam drum and its internals, mud drum, furnace tubes (all passes), downcomers, risers, tube headers, boiler circulation pump, and drum safety valves. The blowdown lines, drain lines, and flash tank are part of system BV. The convective pass tubes are found in system BP. The economizer is part of the feedwater flow in system DF.

BC Boiler–Controls

Controls for the fuel and air supply to the burners. Includes boiler master controls and associated signal transmitters and analyzers. Includes electronic control systems, transmitters, and terminals.

BE Boiler–Air Preheater Heat Exchanger

Regenerative or tube type air preheater. Bearings, baskets, casing, seals, lube oil system, drive motors (air and electric), and gears. Includes wash lances. Also includes the steam coil air preheater. Includes coils, inlet and outlet valves, piping from the steam source, condensate hotwell, and any condensate drain piping to condensate recovery. Does not include sootblowers which are in BS.

BF Boiler–Burner Front

Oil and gas burners, ignitors, air register, and flame controls. Steam used to purge and clean the burners and fuel oil headers at the burner decks. Includes piping downstream of the auxiliary steam header.

BG Boiler–Gas Flow for Combustion

All combustion gas ducting from the economizer plenum to and including the exhaust stack and the gas recirculation ducting. Related hangers and supports, dampers, damper controls, expansion joints, and the exhaust stack. Includes ID and GR fans, fan casings, ID fluid drives, motors, fluid drive oil coolers, the lube oil piping system, and foundation. Includes any turning gear drive systems associated with the fans. Stack gas monitoring equipment are in NA. Does not include the air preheaters (BE) or the seal air system (BT).

BI Boiler–Aspirating Air

Blowers and piping that provide aspirating air to the burner front flame scanners. The same system may also provide combustion air to the propane ignitors. Does not include seal air (BT).

BJ Boiler–Casing and Structure

Outer casing, insulation, inner casing, structural steel, access doors, gas seals, expansion joints, deck plates and grating, hand rails, stairs and ladders, access doors, and furnace buckstays. Includes any penthouse and header enclosure structures. Includes ash hoppers. Includes any penthouse blowers. Includes any boiler seal skirt which wraps around the bottom hopper of the boiler furnace. Does not include steam piping or headers (Group S).

BP Boiler–Convection Pass. Includes convective pass wall tubes and inlet and outlet headers.

BS Boiler–Sootblowers

Sootblowers, drive motors, steam supply, and air supply piping. Includes control panel interlocks and wiring. Does not include the boiler caustic wash piping (BW).

BT Boiler–Seal Air

Piping that provides seal air from the combustion air system to the induced draft and gas recirculation fan seals. Piping that provides cooling air to the gas recirculation fan. For positive pressure boilers such as South Unit 3, this system also provides seal air to sootblower and view port openings.

BV Boiler–Vents and Drains

Waterside drain lines and all vent lines necessary for boiler filling and draining. All boiler blowdown and drain piping and valving. Blowdown (flash) tank, blowdown tank drain pump. Does not include the headers being serviced by the vents and drains. Does not include the nitrogen supply which is in system RN.

BW Boiler–Wash Drains

Wash drain piping and collection troughs which serve the furnace, air preheater, and economizer sections of the boiler and includes piping prior to the sumps and trenches in system WH.

C CONDENSATE

CD Condensate–Feedwater Heater Drains

Drain piping from all feedwater heaters. Includes heater drain pumps, high- and low-pressure flash tanks, and piping up to the condensate flow system (CF). Includes turbine water induction protection system. Also includes manual vent and drain piping.

CF Condensate–Flow

Condensate piping beginning at the condensate pump outlet through to the deaerator, condensate booster pumps, low- and intermediate-pressure feedwater heaters (high-pressure feedwater heaters are in system DF), the deaerator, and the deaerator storage tank. Does not include the condensate (hotwell) pump which is part of the condenser system (JX).

CP Condensate–Polishers

Serving vessels, regenerator tanks, resin, backwash pump, sluice pump, and piping.

CR Condensate–Recovery

Collects high temperature condensate from various parts of the system. May collect boiler water for transfer to storage tank. Includes condensate recovery flash tank, cooling condenser, condensate recovery transfer pump, hotwell drain pump, and piping.

CS Condensate–Supply

Includes condensate storage tanks whether the water is polished and treated water tanks or only demineralized. Includes pumps and piping to and from the demineralizer system. Also includes the boiler fill pump.

CV Condensate–Vacuum Supply

Vacuum pumps, exhaust silencers, hogging jet, primary and secondary steam air ejectors, moisture collection tanks, oil drain tanks, vacuum breaker, and piping.

D FEEDWATER

DA Feedwater–Auxiliary Feedwater

Auxiliary feedwater pump, feedwater heaters, and piping which supply the reboilers (SA). Does not include the auxiliary boiler feedwater system which is included with the auxiliary boiler (SX).

DD Feedwater–BFP Fluid Drive

Fluid drive unit to the boiler feedwater pump and fluid cooling system. Includes oil supply and return piping to BFP bearings.

DF Feedwater–Flow

Feedwater booster pumps, high-pressure feedwater heaters, economizer. Piping, including piping after the economizer up to the steam drum and piping after the deaerator storage tank. Does not include the feedwater pumps which are in system DP. For North Unit 1, this includes the piping from the economizer outlet header up to but not including the furnace first pass inlet headers, which is in system BB.

DO Feedwater–Lube Oil for BFP and BFP Steam Turbine

Lube oil storage tank, lube oil pumps, oil coolers, and piping.

DP Feedwater–Boiler Feedwater Pump

Boiler feedwater pump, motor, feedwater piping up to and including suction and discharge valves. Includes seal water piping. Does not include the fluid drive (DD) and lube oil piping (DO). Does not include a drive turbine (DT), if present.

DT Feedwater–BFP Steam Turbine

Turbine, inlet and outlet steam piping, including the steam governing valves, condensate drains. Lube oil is covered under system DO. Steam seals are included in system TL.

E ELECTRICAL

EC Electrical–Communication

All in-house and outside telephone systems. Public address system.

ED Electrical–120–250 Vdc

DC inverters and motor-generator sets used for charging the relay batteries and any other dc applications. Includes the batteries.

EI Electrical–Control Room Instrumentation

Controls and instrumentation for specific devices are part of the system in which the device resides. For example, the boiler feed pump controls belong in the boiler feed pump system. Otherwise, this system contains all other panel controls, recorders, gauges, displays, etc., located in the boiler or turbine-generator control rooms. Nonelectric controls are usually specific enough to place them in their respective systems.

EL Electrical–Plant Lighting and Distribution

All general illumination fixtures, including their wiring and switches. Includes aviation lighting and portable lighting.

EM Electrical–Miscellaneous

Reserved for any equipment that would not be in any of the other designated systems. Examples are cable trays, portable power centers, and grounding grid. Also includes electrical freeze protection circuitry if not specific to a system.

ES Electrical–Switchgear, Load Center and Motor Control Center

Includes main buses and housing. Tie breakers, feeder breakers, and related transformers. Does not include individual breakers which belong to the motors of another system.

EY Electrical–Switchyard

Switchyard breakers, power lines, and gantry work. Main transformer, startup transformer, auxiliary transformer, etc.

F FUEL

FB Fuel–Fuel Oil Burner Supply and Return

Oil supply piping downstream of fuel oil heaters, high-pressure strainers, constant differential pumps, piping serving individual burners, burners in and out controls, and oil piping upstream of the return line to the valve farm. Includes oil purge system. Does not include oil burners which are in system BF.

FC Fuel–Fuel Oil Service Pump

Fuel oil service pumps, strainers, piping up to but not including the fuel oil heaters.

FD Fuel–Diesel Storage and Transfer

No. 2 oil storage tanks, retaining dikes, transfer pumps, and piping to and from the gas turbines. Does not include the unloading dock (FW).

FH Fuel–Fuel Oil Heaters

Fuel oil heaters and related piping. Steam supply piping from auxiliary steam (SA). Not included are the condensate drains, which are part of the heater drain system (HK).

FI Fuel–Ignitor Supply

Equipment and piping leading from the natural gas (FN) and propane (FP) systems which uniquely supply the ignitors of the main burners of the boiler. Includes the natural gas trip valves, burner ignition valves, and vent piping.

FN Fuel–Natural Gas

Metering station, scrubbers, vaporizers, and piping (including vents and drains) to the burners. Does not include gas burners which are in system BF. Does not include ignitor supply as defined in system FI.

FO Fuel–Fuel Oil Storage and Transfer

Fuel oil tanks, steam coil heaters and transfer pumps including their reduction gearing and piping, including the valve farm, retaining dikes, and oil sumps. This would also include any fixed oil and water separating equipment. Also includes the supply piping between the valve farm and unit fuel oil strainers (FC) and the return piping (FB). Includes steam supply and condensate return for steam tracing.

FP Fuel–Propane Gas

Propane storage tank, vaporizer, common piping up to but not including the gas ignitor fuel supply FI. Does not include propane to the auxiliary boiler, which is part of system SX.

FV Vehicle Fuel Storage

Separate diesel or gasoline storage tank for vehicle supply. Propane for the forklifts is tapped off the main storage tank in system FP.

FW Fuel–Wharf Facility for Ship Unloading

Marine arms, unloading pumps, stripping pumps, piping, and dock structure, including the tanker-man house. The oil piping is included up to the fuel storage tanks.

G GENERATOR

GD Diesel–Engine and Generator

Includes any reserve generator driven by a piston engine (diesel or gasoline). The rest of the systems in G group are for turbine-driven generators.

GE Generator–Exciter

Generator exciter. Includes the casing, rotating and static elements, and field breaker. Includes any exciter cooler and closed cooling piping exclusive to the exciter.

GH Generator–Hydrogen

Hydrogen coolers, hydrogen control panel, hydrogen and carbon dioxide manifolds, liquid detector, purity meter, gas dryer, and hydrogen and carbon dioxide piping. Does not include the hydrogen or carbon dioxide bulk storage which are in system RC.

GI Generator–Isolated Phase

Bus assembly from the generator lead box to the main transformer, ducting, heater and cooler, and generator disconnect switch. Main generator breaker in the switchyard is in system EY.

GO Generator–Seal Oil

Main seal oil pump, emergency seal oil pump, recirculation pump, vacuum pump, vacuum tank, detraining tank, shaft seals, seal drain header, and piping. For a unit that shares a common system for generator seal oil and turbine lube oil, use system TO.

GP Generator–Protection Circuit

Various relays, transmitters, recorders, panel gauges, switches, and interlocks used to protect the generator from damage.

GR Generator–Rotating Field

Generator rotor and coils, collector ring and brushes, rotor couplings, any rotating blades, and field rheostat.

GS Generator–Stator

Main stator assembly, generator casing, support assemblies, end bells, generator bearing assemblies, fan shrouds, hydrogen diffuser baffle, bus bar enclosure, and main lead connection box and bushings.

GV Generator–Voltage Regulator

Voltage regulator assembly, excitation transformer, control panel.

GW Generator–Stator Oil and Cooling Water

Stator cooling oil tank, stator cooling pumps, coolers, vacuum pumps, and piping. Includes any stator cooling water deionizer, heat exchanger, pumps and piping.

H WATER

HA General Water–Treatment Plant Acid

Acid tank, feed pump, and related piping.

HC General Water–Treatment Plant Caustic

Caustic transfer pump, caustic mixing tank, and related piping.

HD General Water–Demineralizer

Cation, anion, and mixed bed tanks, resins, carbon purifier, degasifier or aerator, silica analyzer, transfer pump, and related piping.

HP General Water–Potable Water Supply

Plant water piping downstream of the chlorination source. This could be a city water tie-in or an on-site chlorinator. Includes the chlorinator. Includes general use fixtures such as domestic water heaters, sinks, commodes, etc. Includes any storage tanks and service pumps. Does not include piping exclusively dedicated to fire protection or fire hydrants (system KW).

HR General Water–Raw Water Supply

Well pumps, raw water booster pumps, aerator tank, and related piping which is used strictly for raw water. Does not include plant chlorination equipment, which is the beginning of system HP.

I INTAKE

IC Intake–Canal

Intake canal, log screens, bubble buster, trash rakes, cathodic protection, tide gate, and intake well. Includes stationary cranes. Mobile cranes would be in ZV. Does not include the circulating pumps, which are in system JI.

IF Intake–Fish Protection Traveling Screens

Used for filtering of debris, fish, etc., from the intake canal water before it enters the circulating pumps. Includes the traveling screen assemblies, fish return troughs, and screen wash pumps. South Stations has a screen wash pump with each screen assembly. North has a screen wash pump that supplies all screen assemblies.

IR Intake–Intake Chemical Treatment

Sodium hypochlorite or chlorine tank and piping, including the injector pump and piping to each intake well.

J COOLING WATER

JC Cooling Water–Condenser Cleaning

Condenser cleaning system.

JI Cooling Water–Circulating Water

Circulating water pumps and intake piping leading to the condenser water boxes and condenser discharge piping.

JL Cooling Water–Closed Cooling

Closed cooling provides a heat sink for various bearings, lube oil systems, and other processes throughout the plant. The system is isolated from other water systems in the plant, hence its name. The closed cooling heat exchanger discharges this heat into the river water system. Includes closed cooling heat exchangers (river water heat exchangers), closed cooling pumps and booster pumps. Includes supply and return piping. Does not include the supplied heat exchangers, each of which belongs to its respective system.

JR Cooling Water–River Water

River water is taken from the condenser inlet headers and sent to the closed cooling heat exchanger to provide a cool source for the accumulated heat of the closed cooling water system. The warmed river water is then sent to the condenser outlet header to be sent to the discharge flume or cooling towers via the circulating water piping. River water booster pumps, strainers, and piping used for providing river water between the condenser (JX) and closed cooling heat exchangers (JL).

JT Cooling Water–Cooling Tower

Cooling tower structures and components receive water from and return water to the circulating system (JI). Does not include air conditioning cooling towers.

JX Cooling Water–Condenser

Condenser shell, tubing, water boxes, condensate drain nozzles into condenser, and condensate pumps. Includes exhaust shroud between LP turbine and condenser. Includes the water box vacuum pumps used to assist the filling of the circulating water system. Does not include the vacuum pumps in system CV.

K FIRE PROTECTION

KD Fire Protection–Dry Chemical

Fixed dry chemical systems exclusively dedicated to fire protection. Includes associated alarms and controls.

KP Fire Protection–Portable

All types of portable extinguishers. Water, CO_2, Halon, potassium nitrate (Purple K), etc.

KU Fire Protection–Gas Turbine

Fixed systems self-contained in the gas turbine unit. Includes carbon dioxide and Halon systems.

KW Fire Protection–Water and Foam

Fixed dry and wet water piping systems exclusively dedicated to fire protection. Includes fire hydrants feeding from potable water supply. Includes protected areas such as burner fronts, transformers, lube oil reservoirs, and offices. Includes associated alarms and controls. Includes any exclusively dedicated fire pumps. Potable water itself is listed as system HP.

N ENVIRONMENTAL

NA Environmental–Air Quality

Atmospheric discharge monitoring equipment. Weather monitoring equipment. Opacity monitor, NO_x monitor, SO_2 monitor, CO monitor, ambient temperature and humidity probe, transmitters, analyzers, and other computer equipment.

NW Environmental–Water Quality

Groundwater monitoring wells and instrumentation. Cooling water and liquid waste discharge monitoring are included in JI and WI, respectively.

R REAGENT AND CHEMICAL

RA Chemical–Acid Cleaning for Boiler

Piping (temporary or permanent) and piping connections for acid cleaning of the boiler waterside surfaces. See system RW for caustic washing of the fireside surfaces. For the boiler wash drains, see system BW.

RC Chemical–CO_2 and H_2 Supply

This system provides bulk gas storage for the generator. Hydrogen is used in the generator as a heat removal medium. Carbon dioxide is used to purge the generator of hydrogen for fire prevention purposes. This is not considered a fixed system to be included in KD. Includes tanks, manifolds, regulators, and piping. Does not include the hydrogen panel in system GH. Does not include CO_2 supply for gas turbines or chemical waste treatment systems.

RD Condenser Discharge Chemical Injection

Chemicals such as sodium bisulfate which are used to dechlorinate the condenser discharge water.

RM Chemical–Miscellaneous

Chemical storage not specified in other systems.

RN Chemical–Nitrogen Supply

Nitrogen is used primarily for blanketing the waterside of the boiler and sometimes feedwater heaters during reserve shutdown. It is usually tied into the equipment vents. Includes tanks, manifolds, regulators, and piping.

RO Chemical–Fuel Oil Treatment

Chemicals which are added to fuel oil in order to induce an effect. Includes magnesium oxide day tanks, feed pumps, and piping into fuel oil supply.

RP Chemical–Condensate pH Chemical Injection

Chemicals which are used to neutralize the pH condition of condensate and feedwater. Includes tanks, pumps, and piping for ammonia and hydrazine injection into the condensate flow system. Also includes phosphate injection system into the steam drum. Does not include sodium hypochlorite or chlorine which are in system IR.

RW Chemical–Boiler Wash

Caustic solution used to clean the firesides of the boiler and other equipment subjected to flue gases. Includes soda ash storage tank, mixing and service tanks, related pumps, piping up to the sootblower piping (BS), and boiler wash hose connections. Includes any piping that is subjected to the boiler wash caustic solution, even if it can also be used to supply raw water. See system RA for waterside acid cleaning. The air preheater wash lances are included in system BE.

S STEAM

SA Steam–Auxiliary Piping

All auxiliary steam piping not specified in other systems. Includes desuperheater supply.

SE Steam–Extraction Piping

Steam extracted from various stages of the superheated steam flow used primarily as a heat source for feedwater heating. Extraction steam piping begins at the first field weld at the extraction nozzle (either in the turbine or steam piping) up to the final field weld at the feedwater heaters. Includes extraction drain lines up to the condenser. Does not include feedwater heaters (CF and DF) or condenser (JE).

SM Steam–Main Steam Piping

Main steam piping from the first field weld of the secondary superheater outlet header to the final field weld before the main steam stop valve at the high pressure turbine. Includes drain piping.

SP Steam–Primary Superheating Section

Primary superheater, including inlet and outlet headers, and piping to the secondary superheater section (SQ). Includes any flow control valves, hangers and tube supports. Includes attemperator and attemperator supply piping.

SQ Steam–Secondary Superheating Section

Secondary superheater, including inlet and outlet headers. Includes flow control valves, hangers, and tube supports.

SR Steam–Reheat Piping

Hot and cold reheat piping between turbine and reheat superheater. Includes attemperator and attemperator supply piping.

SH Steam–Reheat Superheating Section

Reheat superheater, including inlet and outlet headers, hangers, and tube supports.

SX Steam–Auxiliary Boiler

Auxiliary boiler(s), fuel supply, water supply, air supply, exhaust ducting, and common steam headers.

T STEAM TURBINE

TA Steam Turbine–HP and IP Section

Outer and inner casings, all internal components including HP and IP rotor, blade rings (diaphragms), stationary impulse diaphragm, balance piston, reheat seal, and nozzle block and chest. Does not include steam seals (TL). For units with separate HP and IP sections, use system TA for HP section and system TB for IP section.

TB Steam Turbine–Intermediate Pressure (IP) Section

Outer and inner casings, all internal components including IP rotor, blade rings (diaphragms), stationary impulse diaphragm, balance piston, reheat seal, and nozzle block and chest. Does not include steam seals (TL). For units with combined HP and IP sections, use system TA.

TC Steam Turbine–LP Section

Inner and outer casings and all internal components including LP rotor and blade rings (diaphragms). Includes multiple LP sections on same unit. Includes any low-pressure exhaust hood sprays and supply piping. Does not include steam seals (TL). Does not include the crossover pipe(s) which is listed in system TX.

TF Steam Turbine–Front Standard

Casing, pedestal, thrust bearing and adjuster, main speed governor and overspeed governor, and instrumentation board assembly. The shaft driven lube oil pump is part of system TO.

TH Steam Turbine–HP and IP Turbine Control

The steam side of the turbine controls. Main steam stop valves and actuators, governor valves, main steam bypass valves, warm-up valves, steam chest, piping to nozzle block, and intercept and reheat valves. Includes any drain lines from these devices.

TI Steam Turbine–Supervisory Instrumentation

Vibration monitors and controls, bearing temperature monitors and controls, cylinder expansion monitors, rotor position monitor, eccentricity monitor, speed monitor, various control valve position indicators, steam pressure and temperature indicators and transmitters, and no-load trip devices.

TJ Steam Turbine–Turbine Controls

Includes electric-hydraulic, digital-electric-hydraulic, and mechanical-hydraulic controls. Any related hydraulic pumps, piping, coolers, etc.

TL Steam Turbine–Steam Seals

Steam packing exhauster, shaft seals and casings, supply and drain piping up to the turbine casing, associated desuperheaters, regulator, and controls. Includes steam seals to any BFP turbines.

TO Steam Turbine–Lubricating Oil

Main and auxiliary pumps, lube oil reservoir, filter tank (bowser), storage tanks, coolers, and piping. For a unit that shares a common system for generator seal oil and turbine lube oil, the system is in TO.

TP Steam Turbine–Pedestal

Concrete pedestal, sole plates or pedestal cover, bearings, oil wipers and baffles, and the couplings. For all HP, IP, and LP sections. Includes the turning gear assembly which includes the bull, pinion, and reduction gears, turning gear motor, clutch, lube oil supply, and return piping.

TS Steam Turbine–Structure

Decking, stairs, handrails, enclosures, foundation, and pedestals not otherwise listed. The turbine building itself would be accounted for in buildings and grounds (ZB).

TV Steam Turbine–Vents and Drains Drain piping and valves from the various stages of primary steam turbines to their drain destinations.

TX Steam Turbine–Crossover Pipe

Includes crossover piping leading into the LP turbine. Includes bolting and thrust protection.

U GAS TURBINE

UA Gas Turbine–Accessory Station

Motor control center, fuel oil pump. Does not include starting motor, which is in system UR.

UB Gas Turbine–Bearing and Coupling

Thrust bearing loader and unloader, labyrinth seals, bearings and casings, oil wiper seal ring, and coupling.

UC Gas Turbine–Compressor Section

Provides compressed air for fuel atomization and combustion as well as combustion gas cooling. Includes compressor rotor, blade rings, and casings.

UD Gas Turbine–Digital-Electric-Hydraulic Control

Hydraulic pumps, tubing, and DEH controls.

UE Gas Turbine–Exhaust

Exhaust hood, air cone, bearing heat shield, and expansion joint.

UG Gas Turbine–Generator

Generator section of gas turbine.

UH Gas Turbine–Housing

Air inlet and exhaust housing, control, accessory, excitation, and gas turbine compartment housings.

UI Gas Turbine–Combustor Section

Combines no. 2 oil with combustion air and ignites the mixture. Includes combustion chamber assemblies, transition ducting, cross-fire tube, fuel manifold and fuel nozzles, chamber casing, and diffuser case.

UO Gas Turbine–Lubricating Oil

Provides lubricating oil to all bearings, gears, and control system. Includes oil reservoir, lube oil pumps, pressure regulators, oil coolers, oil filters, and piping.

UP Gas Turbine–Protection and Control

Temperature control circuit, fuel control and monitoring, governor and speed control, sequencer, vibration monitors and trips, overspeed trips, combustible gas detector, flame detector, relays, relay batteries, etc. Includes "false start" drain sumps, used for protection to allow fuel drainage in case of an aborted start. Does not include the DEH controls which are in system JD.

UR Gas Turbine–Starting

Starting motor, accessory gearbox, and torque converter.

US Gas Turbine–Supports

Alignment devices and pedestal foundation.

UT Gas Turbine–Turbine Section

Combustion gases expand through the turbine to provide shaft power to turn the generator and compressor sections. Includes the turbine rotor, nozzle guide vanes (blade rings), and casings.

UU Gas Turbine–Turning Gear

Prevents warping of the turbine rotor by turning it at slow speed while the unit is cooling down from operation. Includes drive assembly, jaw-type clutch, and turning gear motor.

UZ Gas Turbine–Atomizing

Air Starting air compressor, cooler, separator, tank, and piping required to provide atomizing air to the gas turbine fuel nozzles.

V VENTILATION

VA Ventilation–Air Conditioning

Includes central systems and window units.

VD Ventilation–Equipment Dry Layup

Includes dehumidification equipment and piping for short- and long-term "cold" storage.

VM Ventilation–Miscellaneous Vents and Exhausts

Includes any exhaust fans, hoods, etc., not associated with other systems.

VS Ventilation–Steam Heating

Steam or hot water heating systems used for personnel space heating needs.

W WASTE

WF Waste–Waste Fuel Collection

Waste oil tank and piping to the fuel oil service pump strainers. Piping from the various burner front collection funnels.

WH Waste–Water and Boiler Wash Collection

Sumps, sump pumps, drain trenches, including storm drains, and drain piping to chemical waste treatment system or percolation ponds (WL).

WI Waste–Water Instrumentation

Water quality monitoring equipment at the chemical waste treatment system (WL).

WL Waste–Liquid Waste

Chemical waste treatment system or percolation ponds. Includes the grit bed pumping station as it receives influent from system WH, surge tanks, sludge settling ponds, and percolation ponds. Includes any associated clarifiers. Includes the lime storage bin, rotary lime feeder and slaker, work tank, slurry pump, rapid and slow mix tanks, piping, and controls. Includes the CO_2 storage tank, refrigeration and vaporization equipment, piping, and controls. The monitoring wells surrounding a basin are included in system NW.

WS Waste–Solid Waste Disposal

Fixed systems such as a landfill.

WW Waste–Sewage Treatment

For on-site treatment, includes the sewage collection piping, lift stations, discharge piping, barscreen, aeration tank, blower, settling tank, digester, clarifier tank, and chlorine and aluminate feed systems. For discharge to the city sewage system, includes the sewage collection piping and any pumping stations.

Y BLANKET ACCOUNTS

Used for plant expense accounting for work that is not equipment specific or otherwise accounted for in another of the equipment systems. These systems are to be used sparingly and are not to be used as an easy substitute for more detailed work order coding.

YA Blanket Accounts–Operations

Operations-related expenses.

YB Blanket Accounts–Maintenance

Maintenance-related expenses.

YC Blanket Accounts–Administration

Miscellaneous administrative expenses as clerical, guarding, and grounds keeping.

YD Blanket Accounts–Engineering

Engineering expenses.

YE Blanket Accounts–Structural

Maintenance of steam structures expenses.

YF Blanket Accounts–Production Equipment

Maintenance of power production equipment.

YG Blanket Accounts–Facilities

Miscellaneous buildings expenses.

YH Blanket Accounts–Computer

This would include maintenance of mainframe and PC computer networks. Use this code for time and monies expended on a CMMS.

Z MISCELLANEOUS

ZB Miscellaneous–Buildings and Grounds

Building structures not otherwise listed in other systems. Also includes items as roads, parking lots, elevators, lawns, and picnic areas.

ZC Miscellaneous–Turbine Deck Bridge Crane

Entire crane assembly, including the brakes and gears, power wires, track, controls, and supports. Does not include portable hoists (ME), shop hoists (ZE), or mobile cranes (MV).

ZE Miscellaneous–Electric Tools and Equipment

Various fixed and portable electric driven tools and equipment. Arc welders, metallizing machines, bolt heaters, portable fans and space heaters, hand drills, electric chainfall hoists, etc.

ZF Miscellaneous–Freeze Protection

Various systems, not otherwise specified, used to protect plant equipment from freeze damage.

ZH Miscellaneous–Hydraulic Tools and Equipment

Various fixed and portable hydraulic tools. Includes presses, bending brakes, lifts, porta-power devices, and wrenches.

ZL Miscellaneous–Laboratory

Laboratory analysis equipment for fuel oil, water, and steam sampling analysis. Sample points would be listed in the involved system.

ZM Miscellaneous–Machine Shop Equipment

Drill presses, lathes, milling machines, grinders, etc.

ZO Miscellaneous–Other Tools and Equipment

Other tools, usually unpowered, not covered by the other tool systems. Includes specialized tools for turbines, oil spillage control, and safety. Includes nonproduction equipment such as ice makers. Measurement tools such as micrometers are also included.

ZP Miscellaneous–Pneumatic Tools and Equipment

Various fixed and portable pneumatic driven tools. Includes sandblasters, spray paint equipment, impact wrenches, and portable air compressors.

ZS Miscellaneous–Security

Perimeter fences and gates, guard houses, surveillance cameras, intruder alarm systems, etc.

ZV Miscellaneous–Plant Vehicles

Forklifts, mobile cranes, bulldozers and other heavy equipment, plant assigned cars, trucks and boats, etc.

(*Note:* An example of using the plant, unit, group, and system codes would be N02-CP to indicate North Station Unit 2's condensate polishing system.)

Equipment Type

(*Note:* These codes are useful for analyzing problem areas in the plant. For example, the plant could segregate work orders and determine how much plant work was being expended on pumps, equipment type code 01. Planners place these codes on the work orders during the coding process, but the codes are not part of the equipment component tag number. Equipment type codes could be included in the equipment number itself, but the numbering system would be stretched to the limit. Adding the equipment type codes to the equipment number itself may be beyond the point of diminishing returns. It can become confusing and frustrating to require a tremendous string of numbers to be manipulated. Certainly, additional intelligent equipment coding beyond these numbers would be difficult.)

These codes are to be used consistently throughout the various equipment systems. For any system described, these code numbers will be unique to the equipment described. For example, 01 means pump regardless of in what system the equipment lies. A pump in the condensate polishing system would be coded as 01 and a pump in the intake basin would be coded as 01 for the equipment type code. Certain major pieces of equipment such as the boiler feed pumps and the steam turbine generators are complex enough to merit their own Group and System designations. In these cases, major pieces may be given their own major code numbers, e.g., high-pressure steam turbine inner casing.

Equipment Type Codes

00. *General:* Intended to represent the system in general. When a specific piece of equipment is involved, this code is not to be used.

01. *Pump:* Device intended for the movement of liquids. Does not include vacuum pumps.

02. *Compressor and Vacuum Pump:* Device intended to change the pressure of the gas involved. Device should provide a pressure differential greater than 35 psi.

03. *Fan and Blower:* Device intended to increase the flow volume of the gas involved. Device should provide a pressure differential less than or equal to 35 psi.

04. *Hydraulic Coupling:* Fluid drive unit located between a driven object and its driver. (Simple couplings are considered a part of the driven object.)

05. *Gear Set:* Separately cased gear set, reduction gear, or turning gear located between a driven object and its driver. (Gear sets integral to an object are considered a part of that object. Simple couplings are considered a part of the driven object.)

06. *Pressure Vessel:* A container designed to continuously hold a pressurized fluid.

07. *Vented Vessel:* A container which is vented so that it does not hold more than static pressure head of the substance contained. The vent need not necessarily go to the atmosphere.

08. *Heat Exchanger:* Includes open and closed types such as tube-and-shell and plate-type heat exchangers, condensers, and deaerators.

09. *Piping or Ducts:* Piping which is used for transferring fluid from one point to another. Includes flexible piping and hose. Insulation, simple hangers, supports, flange work, expansion joints, etc., are considered part of the piping or duct to which it is attached. No distinction is made on operating pressure. Does not include open troughs (see item 50).

10. *Hanger Assembly:* Includes large hanger mechanisms as found on the major steam piping. (Simple hangers are considered a part of the piping under item 09—Piping.)

12. *Control Valve and Actuator:* Includes all valves with remote actuation (except solenoid valves). The valve and its actuator are considered as one item, regardless of how attached they are to each other.

13. *Solenoid Valve:* Any valve which is solenoid actuated. Includes the solenoid.

14. *Manual Valve:* A valve which must be manually operated. Includes check valves. Includes backflow preventer assemblies. Does not include safety valves.

15. *Safety Valve and Others:* Includes safety valves, relief valves, rupture disks, vacuum breakers. Can also include trip valves.

16. *Flow and Restriction Orifices:* Includes the orifice plate (Venturi or other), and upstream and downstream pressure taps.

17. *Steam Trap Assembly, Moisture Trap Assembly, Float Trap Assembly:* Includes trap, strainer, isolation valves, bypass valve, drain valve and any test valve. Continuous drains are listed here.

18. *Filter and Strainer.*

19. *Regulator.*

21. *Switchgear:* Circuit breakers, including the primary disconnects and operator with auxiliary equipment such as the switch, trip device, solenoid and arc chute assembly. For voltages of 460 and higher. Smaller voltages are typically considered a part of the equipment being served, or are listed as part of a distribution panel in systems such as EB. Breakers such as metal-clad, oil-filled, air blast and air magnetic types are included.

22. *Electric Motor, Single-Phase.*

23. *Electric Motor, Three-Phase, under 500 V.*

24. *Electric Motor, Three-Phase, 500 V+.*

25. *Electric Motor, dc.*

26. *Power and Control:* Cables, control devices, etc., between the switchgear and electrically driven device, typically a motor.

28. *Motor Starter and Contactor:* Includes the toggle switch, solenoids, relays and timers.

29. *Transformer.*

30. *Structure:* Girderwork, stairs, floors, walls, ceilings, containment walls, etc.

31. *Air Dryer:* Includes both refrigerant and desiccant type dryers. Includes the dehumidifiers.

33. *Motor Control Center:* A grouping or combination of motor starters in a single cabinet or enclosure. Consists of lead-in cables, molded case circuit breaker, starter contactor, control transformer, and fuses.

34. *Instrumentation:* All types of instruments including devices used to record information automatically on paper and flow meters. Does not include flow orifices, which are listed as major code 16. Includes rotometers and level indicator vessels.

35. *Auxiliary Driver:* Diesel engine and its accessories such as air starter, fuel pump, heat exchanger, etc., that drives the emergency fire pump. Also included is the steam engine that drives the fuel oil transfer pump.

41. *Sootblower Assembly:* Device used to remove accumulated soot and debris from a heat transfer surface. Typically found in boilers and air preheaters. Can include permanent wash lances.

43. *Attemperator:* Includes the spray head, thermal liner, inlet nozzle, and casing. Does not include the control valve, which would be coded as 12.

44. *Lubricating Assembly.*

45. *Burner Assembly:* Includes oil and natural gas burners—the nozzle, gun, diffuser, canes, etc. Does not include the air register, which would be coded as 47.

46. *Generator:* Small generators, ac or dc, such as motor-generator sets. Does not include prime mover generators, which are covered in Group G.

47. *Damper or Register Assembly:* Device for regulating gas flow, including its driver and actuator (if applicable).

48. *Exhaust Stack, Exhaust Silencers.*

49. *Traveling Screen Assembly:* Does not include the screen wash pump or troughs.

50. *Trough, Trench, Ditch, Sump Pit.*

51. *Air Motor:* A rotating pneumatic device used to provide power to a driven device such as a pump or generator.

52. *Gas Ignitor:* Natural gas and propane ignitors.

(*Note:* Notice that code 12 includes both actuators and their valves and that there is no code 11. It became impractical to classify valves as 11 separate from actuators. It was frequently difficult to tell which was the problem area, the valve or its actuator. Early planning strategy at this plant was to have the planner be alert to change the code after the job was completed to have the exact equipment identified. In actual practice, however, it became apparent that the first equipment number placed on the work order would stick and not be changed. It made life much easier to combine these devices. Later as the planning system matured and computer "help" was brought in, the computer required that everything be separate to list the manufacturer with the equipment on a one-to-one basis. Now it was easy with a paper file to list two manufacturers and scores of suppliers for any particular valve and actuator combination. At this plant, the computer was modified toallow continuation of the existing practice.)

Action Taken

(*Note:* This section of the work order manual would normally be utilized for codes to identify specific maintenance operations performed. This example plant had a list of 36 basic maintenance operations and expected either the planner or technician to select a single code representing the type of work completed. The practice ran into two problems. First, most maintenance tasks involved more than a single code. This made it difficult to judge which code was most appropriate. Second, no one ever used the codes for any type of analysis so feedback to the persons doing the coding was nonexistent. The plant abandoned using these type codes.)

Reason, Cause, and Failure

(*Note:* This section of the work order manual would normally be utilized for codes to identify specific reasons or causes of different types of failures. This example plant had a list of 200 basic maintenance operations and expected either the planner or technician to select a single code for each job. Similar to the above section for Action Taken codes, the practice ran into problems. The primary problem was that the list was so extensive that each technician generally selected about ten codes to utilize on all jobs. Each technician would have a different set of ten codes that the technician favored. In addition, no one ever used the codes for any type of analysis so feedback to the persons doing the coding was nonexistent. The plant also abandoned using these type codes. These type codes may be more useful when segregated by equipment type. Caution as expressed in Chap. 8 should be utilized when these codes are used as templates to define solutions.)

WORK ORDER NUMBERING SYSTEM

(*Note:* The WO numbering system provides for assigning each separate work order a unique number to allow keeping the work done under that number separate from other maintenance work. The work order number arrangement at many plants evolves in form such as its length and inclusion of alphabet characters. Having a record of how the numbering system works and has worked is very useful. Keeping this record pays dividends in the future if there is commitment to keeping it current.)

Current Numbering System

Each WO is numbered with a separate, unique seven-digit code.

The first digit is the plant code (as defined in the Plant and Unit Codes). The second and third digits are the last two digits in the calendar year when the WO is originated (e.g., "93"). The originator writes in the first three digits (plant and year) when initiating a WO. The last four digits are made up of one letter followed by three numbers. Each separate WO is given a unique combination of last four digits, which may be from A001 to Z999. The last four digits (unique) of the WO are already preprinted on the blank WO forms.

For example, WO number N93G457 is a unique WO number for a work order at North Station written in 1993.

The WO number is also used for the CMMS system as well as the mainframe system.

Blanket work orders are kept in the mainframe system exclusively. A WO form is not required for a blanket work order. The Maintenance Department Mainframe System Administrator assigns blanket work order numbers using the same seven-digit numbering sequence as for regular WOs except that the second and third digits are the unit codes (as defined in the Plant and Unit Codes) and the last four digits are all numbers from 8000 to 9999. The Mainframe System Administrator keeps a log to maintain consistent blanket numbers among plants and to avoid assigning duplicate blanket numbers for different activities.

For example, blanket WO numbers N009132, S009132, and K009132 are for maintenance planning activities for each plant.

The use of blanket work orders is not encouraged for equipment maintenance. The creation of a new blanket WO must be authorized by the Assistant Plant Manager.

Previous Numbering Systems

Prior to mid-December, 1993, the first digit (plant) was preprinted on the form and the second and third digits were the unit codes (as defined in the Plant and Unit Codes). The originator wrote in the Unit Code when initiating a WO. (This system was changed to the current system to allow using the same form at all plants and because there were still too few available WO numbers.)

Example: WO number N01G257 would be a unique WO number for a work order on North Unit 1.

Prior to 1991, the last four digits of regular WOs were 0001 to 7999 and blanket WOs were 8000 to 9999. (This system was eventually changed because there were too few available WO numbers.)

Prior to about 1990, each plant had separate WO numbering systems and conventions such as using NS at the beginning to designate North Station.

Notes

These are general notes for numbering work orders. Using years instead of unit for the second two digits will cause a potential conflict with old WOs and blankets in the year 2000 that will need to be addressed eventually. The conflict arises because the year 2000 and unit common both would use 00.

MANUAL DISTRIBUTION

(*Note:* The plant should keep a list of who has the manuals so that it can update their documents. It is also valuable to list actual names along with titles so that all crew supervisors, managers, engineers, planners, and even computer support persons can be included in having the work order system documentation. Normally this listing is published along with the manual in this back section. A plant with general access to an internal intranet Web site should consider discontinuing the maintenance of a hard copy work order system manual in favor of the more plant-wide access to a Web document. Alternately, a plant with a CMMS with plant-wide access may have the computer system contain the bulk of the documentation of the work order system and codes. In either case, this paper document would be discontinued because of its more limited access and the trouble of keeping it current.)

APPENDIX L
COMPUTERIZED MAINTENANCE MANAGEMENT SYSTEMS

This appendix gives additional information on implementing and utilizing a CMMS to assist planning, as referenced in Chap. 8. This information was not included in the main text to avoid detracting from the book's overall thrust of how to do planning.

SAMPLE STREAMLINED CMMS USERS' GUIDE

This section actually gives an example of how to cut down an inch-thick computer manual to a few pages of key instructions for non–planning group persons such as plant supervisors, technicians, operators, and managers. (Persons at this plant request work on a paper work order form which they deliver to the planning department for computer entry and processing. This company uses another system for inventory management.)

Basic Steps and Guidelines for Using CMMS

System Notes

1. The following text contains step-by-step instructions for basic use of the computer *to find* information. (Instructions for data *input and modification* are contained in the "CMMS Instructions for Planners" section created for the planning group. Complete instructions for CMMS use are contained in the CMMS *User's Guide and Tutorial* supplied by the vendor.)
2. Minimum PC requirements to access CMMS from the network: at least 486/33 with 8 megabytes is recommended.
3. The CMMS System Administrator at North Plant (Joe Brown, 222-2222) is responsible for setting system security and personnel rights to each CMMS screen and field.
4. CMMS is unavailable each week for a short period for system backup and adjustment. Any changes to the normal schedule for this period are published by e-mail.
5. Advisements between updates of these guidelines are published normally on e-mail.

To Enter CMMS

1. Log in to the plant network. You are now in Windows. (If you are not set up for Windows and the CMMS, contact the CMMS System Administrator for a personal setup for your computer.)
2. If you do not have mainframe rights, skip to step 3. If you have mainframe rights, double-click the mouse on the RABBIT icon for simultaneous loading of the mainframe emulation for inventory transactions. Hold down the ALT key and press the TAB key to leave the emulation. (After step 4 below you may access and leave the mainframe emulation anytime from the main menu by holding down the ALT key and pressing the TAB key.)
3. Double-click the mouse on the CMMS icon.
4. You should now have a window titled CMMS Login. Using the mouse or tab key move among the fields and type your name (or **GUEST**) for user and your password (or **GUEST**) for password. Click the mouse on the "OK" button to bring up the CMMS main menu.

(*Note:* To experiment with the CMMS, there is a test database you can access. This setup does not affect the real databases or records. Contact the CMMS System Administrator for details.)

To Exit CMMS

1. Close the window with the following: Click on the minus (−) sign on the top left corner of the window. Then click on "Close." Repeat these two steps for every window that comes up including the main menu.
2. You are now out of the CMMS itself. If you want to get out of Windows altogether, click on the minus (−) sign. Then click on "Close." Click on "Okay" for ending the windows session.

CMMS Notes

1. Each of the following step-by-step guidelines presumes you are already at the main menu.
2. The CMMS is designed for Windows and primarily relies on your using a mouse. Use the mouse (point and click) when moving around and selecting an icon from the main menu (and later when selecting a field or command from a screen).
3. Click on the window right-hand side down arrow to see the lower half of any screen.
4. Lock your caps on your keyboard.

To Query the Status of Work Orders

This section allows you to find where a work order is in the work order flow process.

By Work Order Number

1. Click on the work order icon.
2. You should now have the work order screen. Press the ESC key to reset the screen.
3. Type the work order number in the work order number field; then press the ENTER key.
4. You should now have all the fields including the Status field filled in for that work order.
5. Repeat steps 2 to 4 for other work orders.

By Equipment Number

1. Click on the work order icon.
2. You should now have the work order screen. Press the ESC key to reset the screen.
3. Type the equipment component tag number complete with all hyphens (–) (e.g., N02-FC-003).
4. Press the ENTER key, which fills in the work order screen for the first work order with that equipment number.
5. Continue to press the ENTER key to bring up each work order with that equipment number one at a time. *Or* Click on the "Listing" icon to list all the work orders for that piece of equipment.
6. Repeat steps 2 to 4 for other equipment.

By System. Repeat the above steps for "By Equipment Number," but instead of entering an entire equipment number, enter only the station, unit, group, and system codes followed by a % (e.g., N02-FC% for the North 2 fuel oil service pump system). This entry will select all work orders for that entire system.

By Deficiency Tag Number or Other Associated Document Number. Steps 1, 2, 4, 5, and 6 are the same as for By Equipment Number. Step 3: Enter the deficiency tag number (or other document number) surrounded by asterisk signs in the Def/Other Number field (e.g., *D-56935*).

By Originator or Originating Crew. Steps 1, 2, 4, 5, and 6 are the same as for By Equipment Number. Step 3: Enter the originator or crew number surrounded by asterisk signs in the Originator field (e.g., *SMITH* or *4-1*).

By Certain Type of Work Order or by Key Words

1. Click on the work order icon.
2. You should now have the work order screen. Press the ESC key to reset the screen.
3. Type all of the information in all of the various fields that you would like the work order(s) in question to match. For example, if you wanted to consider only PM work orders that dealt with control valves you would type 7 in the work type field and 12 in the equipment type code field. (7 is the work type code for preventive maintenance and 12 is the equipment type code for control valves.)
4. You may also use arithmetic operators when entering data in the field as follows such as greater than or less than. For example, >06/01/93 in the Origination Date field would mean to consider work orders originated after June 1, 1993, only.
5. You may also use wild cards _ (underscore) for a single character and * (asterisk sign) for a string of characters. For example, if you wanted to consider only work orders that had the word "leak" anywhere in the work order description, you would type *leak* in the work order description field (the long field next to Work Order #). Another example: To consider only work orders assigned to any Operations crew you would type 4* in the Craft field. (4 is the craft code for Operations.)
6. Click on "Count" to see how many work orders exist matching the field information you specified.
7. Press the ENTER key to scroll through the individual matching work orders. *Or* You may also click on the "Listing" icon to list all the selected work orders.
8. Repeat steps 2 through 7 for other queries.

To Query for Equipment Data. *Note:* Only equipment given a equipment tag number is included in the database.

Find Equipment Nameplate Data

1. Click on the main menu equipment icon.
2. You should now have the equipment screen. Press the ESC key to reset the screen.
3. Type the equipment number (e.g., N02-FC-003) in the equipment number field (adjacent to the word "Equipment"), then press the ENTER key.
4. You should now have all the fields including the Other Equip Data field filled in for that equipment.
5. Repeat steps 2 through 4 for other equipment.

Find Groups, Systems, or Equipment by Scrolling

1. Click on the main menu equipment icon.
2. You should now have the equipment screen. Press the ESC key to reset the screen.
3. Type the unit number (e.g., N02) in the equipment number field (adjacent to the word "Equipment"); then press the ENTER key. You should now have the unit name filled in on the screen.
4. Click on the Level Down icon. After a brief pause, you should have a list of all the equipment groups for that unit. Scroll through the list to find pertinent groups.
5. Select a group by clicking, then click on the Level Down icon to get a list of systems for that group.
6. Select a system by clicking, then click on the Level Down icon to get a list of equipment for that group.
7. Click on the Level Up icon to move up in level from equipment to systems, systems to groups, or groups to units.
8. Repeat steps 2 through 7 for other units.

To Print a Copy of Any Screen, Listing, or Work Order

Click on "File," then "Print," then "Screen," "Listing," or "Work Order Form."

Reports. Clicking on the "Reports" icon gives a listing of reports that may be selected and run. Some of these reports are available now and certain others are being developed for use by the CMMS System Administrator.

SAMPLE STREAMLINED CMMS PLANNERS' GUIDE

Here is an example of trimming a thick computer manual from the CMMS vendor to just a few pages of key instructions for the planning group.

CMMS Instructions for Planners

System Notes

1. The following text contains step-by-step instructions for basic use of the CMMS to input and modify information. (Instructions to find information are contained in the "Basic Steps and Guidelines for Using CMMS" section of the *Work Order System Manual.* Complete instructions for CMMS use are contained in the vendor-supplied *User's Guide and Tutorial.*)
2. Minimum PC requirements to access CMMS from the network: at least 486/33 with 8 megabytes is recommended.
3. The CMMS System Administrator at North Plant (Joe Brown, 222-2222) is responsible for setting system security and personnel rights to each CMMS screen and field.
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(*Note:* To experiment with the CMMS, there is a test database you can access. This setup does not affect the real databases or records. Contact the CMMS System Administrator for details.)

To Exit CMMS

1. Close the window with the following: Click on the minus (–) sign on the top left corner of the window. Then click on "Close." Repeat these two steps for every window that comes up including the main menu.
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CMMS Notes

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2. The CMMS is designed for windows and primarily relies on your using a mouse. Use the mouse (point and "click") when moving around and selecting an icon from the main menu (and later when selecting a field or command from a screen).

3. Click on the window right-hand side down arrow to see the lower half of any screen.
4. Lock your Caps on your keyboard.

To Open Work Orders (by Planning Clerk)

1. Click on the "Work Order" icon.
2. You should now have the work order screen. Click on the "New Record" icon to reset the screen.
3. You are now in the Entering mode for entering data. Use the TAB key (or mouse) to move among the fields.
4. Enter the work order number and description (in the adjacent long blank). Include the equipment name at the beginning of the work order description; for example, 34002 4A SUMP PUMP PUMP IS CAVITATING.
5. Enter the equipment number complete with all hyphens (-); for example, N02-FC-003. If the equipment number is blank, N/A, or not on the work order, use the first six characters of the equipment coding and the word -ITEM. For example, N02-FC-ITEM designates that the equipment is an item in the system which the planner will later clarify.
6. *If* the database does *not* accept the record and the screen subtitle says "equipment number not found," first check for typographical errors in the entering of the equipment number such as the capital letter "O" for the number zero "0" or missing hyphens (-). If the CMMS still does not accept the equipment go to step 7.
7. To enter new equipment in the database, tab to the main menu and click on the equipment icon. You should now have the equipment screen. Click on the "New Record" icon to reset the screen and begin the entering mode. Type in the equipment number and equipment description. Type in the first six characters of the equipment coding for the level up field (e.g., N02-FC). Enter the two major equipment coding characters in the equipment type code field (e.g., 18). Enter any location or other information in the respective fields. Press the "Save record" icon to put this equipment into the database. Then close the equipment window pressing the SHIFT and F4 keys together and return to the work order screen and enter the equipment number.
8. Enter the originator (last name plus department and crew, include initial for a common last name, e.g., Smith, J. 4-1), origination date (delete system-added date if incorrect), and deficiency tag number.
9. Enter status (APPR) (put WSCH if the work type is 7). Enter work type, priority, and outage code. Enter craft, insulation?, cost center, FERC/account, and SubFERC account.
10. Enter PM week and frequency, if any.
11. To put the newly entered work order into the database, click on the "Save Record" icon.
12. Repeat steps 2 through 11 for each work order to be entered.

To Close Work Orders (by Planning Clerk)

1. Click on the work order icon.
2. You should now have the work order screen. Press the ESC key to reset the screen.
3. Enter the work order number and press the ENTER key. You should now have all the information for that work order filled into the screen fields.
4. Change the status to CLOSE (or CAN for canceled or voided work order). *Note:* If the status says HOLD, do not change the status. Stop and inform the Planning Supervisor.

5. Enter the technicians' last names and crafts. Enter the actual hours for each technician and actual job duration. Enter actual material and quantities. Enter actual tools and quantities. Enter actual end date (use the date in the technician sign off blank from the WO form). In the action taken field, enter all other job feedback.
6. To put the newly entered information into the database, click on the "Save Record" icon.
7. Repeat steps 2 through 6 for each work order to be closed.

To Plan Work Orders (by Planner)

1. Click on the "Work Order" icon.
2. You should now have the work order screen. Press the ESC key to reset the screen.
3. Enter the work order number and press the ENTER key. You should now have all the information for that work order filled into the screen fields.
4. Tab to the main menu and click on the "Plans" icon. You should now have the master plans screen. Find the desired plan and cut and paste necessary information to the current plan into the plans space of the work order screen.. Create a new master plan if one has not been previously recorded for the equipment. The work plans should begin with the equipment number and then have suffix letters as appropriate, e.g., N02-FC-003STRAINERREPLACE.
5. Enter your last name in the planner field. Enter the estimated duration, labor hours, material cost, labor cost, and tool cost. Change and correct all work order information discovered during planning including equipment number.
6. Change the status to HOLD-MATL if the work order is waiting on parts (or some special tool).
7. Enter Y in the Insulation? field if the job requires insulation work.
8. Change the status to WSCH when the planning and obtaining of parts is complete. The job is now waiting to be scheduled. *Note:* If the status says CLOSED or CAN, do not change the status. Stop and inform the Planning Supervisor.
9. Commit all changes to the database by clicking on the "Save Record" icon.
10. Repeat beginning with Step 2 to plan other work orders.
11. The planner continually improves the job plans in the master plans module by entering appropriate feedback from completed jobs before completed work order forms are given to the planning clerk for closing.

To Update Parts Ordering Information (by Purchaser or Planner)

1. Click on the work order icon.
2. You should now have the work order screen. Press the ESC key to reset the screen.
3. Enter the work order number and press the ENTER key. (*Or* enter pertinent materials tracking number using * on each side; e.g., *15789*.)
4. You should now have all the information for that work order filled into the screen fields.
5. Enter the appropriate changes to the materials tracking number field and the matl ordered/received field. Always put the date ordered next to the tracking number.
6. Change the status to HOLD-MATL or WSCH as appropriate. *Note:* If the status says CLOSE or CAN, do not change the status. Stop and inform the Planning Supervisor.

7. Commit all changes to the database by clicking on the "Save Record" icon.
8. Repeat steps 2 through 7 to update other work orders.

SAMPLE PLANT-WIDE TRAINING OUTLINE FOR CMMS

- I. Purpose and goals of CMMS and course
- II. Plant work order manual
  - A. Work order form
  - B. Codes and conventions
  - C. CMMS documentation
- III. CMMS screens
  - A. Locating and selecting fields
  - B. Data entry practice for queries
  - C. (Any special commands not yet in CMMS documentation)
- IV. Computer work
  - A. Login to CMMS
  - B. Queries practice exercises—find and print
  - C. Free practice time
- V. Test
- VI. Course evaluation

SAMPLE MILESTONE SCHEDULE FOR IMPLEMENTING A CMMS IN PHASES

This sample schedule shows how a CMMS might be gradually implemented for a maintenance group.

1. Year 1, quarter 1: Complete purchase of system
2. Year 1, quarter 2: Upgrade and add minimum hardware
3. Year 1, quarter 2: Schedule future users and computer upgrades
4. Year 1, quarter 2: Set initial signature authorities
5. Year 1, quarter 2: Begin system backup and security copies
6. Year 1, quarter 3: Implement inventory module
7. Year 1, quarter 3: Ability to check part breakdowns for equipment
8. Year 1, quarter 3: Provide vendor contact information
9. Year 1, quarter 4: Ability to search WO status
10. Year 1, quarter 4: Ability to track estimated cost and hours on planned WOs
11. Year 1, quarter 4: Ability to print search results
12. Year 2, quarter 1: Automatic generation of PMs
13. Year 2, quarter 1: Ability to check equipment nameplate data
14. Year 2, quarter 2: Ability to check equipment technical data

15. Year 2, quarter 3: Use planning module
16. Year 2, quarter 4: Provide assistance with hold tags
17. Year 2, quarter 4: Originate WOs via terminals
18. Year 2, quarter 4: Provide service contract warrantee information
19. Year 3, quarter 1: Ability to track actual cost and hours as reported on WOs
20. Year 3, quarter 2: Automatically schedule work
21. Year 3, quarter 3: Coordination of labor module with timesheet system
22. Year 3, quarter 3: Ability to track actual cost and hours with timesheet information
23. Future: Integrate tool module
24. Future?: Coordinate with PdM
25. Future?: Use condition monitoring
26. Future: Use purchasing module
27. Future: Have technicians give feedback via terminals
28. Future?: Add past history of previous years before CMMS into database

GLOSSARY

aging Automatically increasing the priority or attention given to an incomplete work order the older it becomes. The concept of aging is that an older work order should get higher attention than a similar work order only recently written. This practice may help a crew with low productivity, but hinder a crew with already high productivity. The former crew might increase its productivity to include the aged work order. The latter crew might have to drop a more serious work order to accommodate the aged, though less important, work order.

backlog Amount of identified work on work orders either by number of work orders or work hours.

blankets or blanket work orders Standing work orders not specifying specific work but allowing the collection of work hours for time accounting.

book hours Standard hours by which maintenance personnel might be paid regardless of actual hours spent.

clearing equipment or systems Tagging or locking out the necessary valves or devices surrounding equipment to be worked on so that the equipment is safe. Also may involve draining or otherwise making equipment ready to be maintained.

CMMS Computerized maintenance management system.

component level file A file made for a specific piece of equipment rather than for a system or group of equipment. Also called a *minifile* to emphasize its size relative to a system file.

confined space An area with limited access and potential respiratory hazard requiring a special permit to enter.

corrective maintenance Work to restore an equipment to proper operating condition before failure or breakdown occurs.

CPM (Critical Path Method) A schedule technique allowing determination of the overall time of a large maintenance by arranging and sequencing tasks with preceding and succeeding events.

deficiency tag An information tag hung by the requester of maintenance work to identify the equipment.

equivalent availability Equivalent availability factor (EAF). EAF is a common utility performance measure of how much generating capacity is actually available over a given period for producing power. When a unit is only available (whether it is running or not) for less than full load, the equivalent amount of its full load availability is counted. For example, a unit having boiler feedwater pump problems and only available for half-load for the entire month would have an equivalent availability of 50%.

Likewise, a unit available for full load the entire month of 30 days except for a full outage lasting three of those days would have an equivalent availability of 90%. The equivalent availability of an entire plant site or utility would be calculated by weighting the units by megawatt capacity. Equivalent availability is normally expressed as a percent such as 90%, although technically the factor itself would be shown as 0.90.

extensive maintenance Maintenance that takes more than a few hours and may have historically significant data.

equipment file, equipment history file See *component level file*.

front end loading Spending time and resources ensuring that equipment will be suitable for maintenance before the equipment is purchased or installed.

GPM Gallons per minute.

I&C Instrument and controls craft.

infant mortality The failure of a component or equipment soon after initial installation or after a maintenance operation. There is a higher percentage chance that equipment will need repair at these times than during the remainder of its time in service.

insource Using in-house resources to obtain a service or material. Making equipment or components with in-house labor.

job tool card A record kept by a tool room to keep track of tools issued to jobs rather than individual technicians.

metrics Indicators or measures of maintenance performance.

minifile See *component level file*.

minimum maintenance Maintenance work requiring less than a few hours and not historically significant.

MSDS Material Safety Data Sheet describing dangers and safety procedures for a specific hazardous substance.

MTBF (mean time between failure) A calculation showing the trend of average time periods between failures of the same equipment over time or showing the time periods between failure of different equipment. For example, "The MTBF of the circuit has improved from three weeks to over two months."

O&M manuals Operation and maintenance manuals provided by the equipment manufacturers or suppliers giving basic details on operation and maintenance of the equipment. They usually included suggested preventive maintenance tasks, troubleshooting guides, and identification of parts and special tools.

OEM Original Equipment Manufacturer.

OJT (on-the-job training) Many times either the best or the only training an employee receives is while actually doing the job either alone or under the eye of an experienced coworker.

operations, production The plant personnel responsible for operating the plant equipment and systems.

operations coordinator A specific person in the operations group specifically tasked to help maintenance planners.

originator A person that writes a work order or other request for maintenance work.

outage A condition of being out of service and unavailable for operation. Refers to the condition of the entire plant unit, not the individual piece of equipment.

overhaul Normally a major outage requiring a significant amount of time and planning.

piece workers, piece work An arrangement where technicians receive pay based on how many units are produced.

pigeon-holing Estimating a job's time requirements by referring to a table or index of similar jobs and making adjustments for particular job differences.

planner, maintenance planner The person responsible for preparing work orders for execution through applying the principles of maintenance planning.

planning, maintenance planning The preparatory work to make work orders ready to execute. This term may involve scheduling depending on how it is used.

planned job, planned work, job plan The product of the planner including all the preparatory work done.

planner active file A planner may keep the original work order in an active file and take a copy into the field for scoping purposes.

PM optimization A similar process to RCM to develop preventive maintenance tasks and frequencies to reduce likely failure modes. Makes significant use of existing PMs as a starting point.

point of diminishing returns The point where an additional action or task provides a benefit, but the benefit would not outweigh the cost of the additional action or task.

predictive maintenance The use of technologically sophisticated devices as vibration trend analysis to predict future impending equipment problems.

preventive maintenance Time- or interval-based maintenance designed to head off or detect equipment problems.

proactive maintenance Maintenance performed to head off failure and breakdown.

product life cycle The economic curves showing profitability of any given product for sale. Initially profit is low as the product is developed. Next, profit increases as sales increase. Then profit begins to drop as market substitute products and other competition become common. The company may attempt to modify the product and willingly take some drop in profit before the effect of market forces. This modified product eventually achieves greater profitability than possible from the initial product. An analogy can be made to playing tennis. One can become a fairly good player without using correct techniques. But when the player decides to adopt correct grips, stances, and other techniques, the player's ability will first drop as the new skills are learned. However, the player should be able eventually to rise above the old level of ability.

project work, project maintenance Modifying or improving a piece of equipment or system.

RCM (reliability centered maintenance) A process or system to evaluate equipment and develop preventive maintenance tasks and frequencies to reduce likely failure modes.

reactive maintenance Maintenance work performed as a response to a failure, breakdown, or other urgent equipment situation.

scoping, scope Determining the job scope, studying and defining what work a job requires, deciding the magnitude of the work involved. For an individual job, this requires determining the objective of the job. For an outage, this involves determining all the jobs involved in the outage.

shakedown Returning units or plant processes back to service after maintenance activities. The shakedown process identifies discrepancies with the maintenance work that require attention.

SNOW An acronym for short notice outage work.

stretch goals Goals that are hard to reach, but not seen as impossible.

stockout A measure of how many times the storeroom is out of stock for an item when that item is requested. Stockouts do not necessarily measure that a storeroom is either out of a material or has a less than desirable quantity on hand.

vicious cycle A situation where the solution to a circumstance creates another problem in a chain that makes the original problem worse. An example is when a plant attempts to save labor by reducing preventive maintenance. The incidence of equipment failure rises requiring more labor and leaving no time for ever doing preventive maintenance. The plant finally saves no labor and has worse equipment reliability.

Attachment 1a

ENSURE PRODUCTIVITY-BOOSTING STANDARDS IN ANY ORGANIZATION—WITH THE FIRST HOW-TO MAINTENANCE PLANNING GUIDE

Talk to any maintenance manager or plant manager, and they can tell you that planning and scheduling is critical to effective maintenance. Yet how many of them can name a ready-to-use, nuts-and-bolts guide that goes beyond theory, demonstrating how planning fits into maintenance, what principles make it work, and exactly how planning is done?

The *Maintenance Planning and Scheduling Handbook* is the one-and-only resource that covers all this, and more.

Defining "planning" as the preparatory work given to individual maintenance work orders before assigning them to specific craft persons, this never-before-available resource explains how work order planning leads to increased crew productivity—and greater overall effectiveness in just about any area of an organization's maintenance.

The *Maintenance Planning and Scheduling Handbook* includes:

- **The 6 principles of planning**
- **The 6 principles of scheduling**
- **Extensive example work scenarios that illustrate each of these principles**
- **Strategies for increasing your workforce without hiring–by implementing a new maintenance planning group or redirecting an existing one**
- **A highly useful procedure for conducting an in-house productivity study**
- **Appendixes that summarize key concepts, identify suppliers, show complete example work studies and planned work orders, and provide other valuable reference sources**

With the *Maintenance Planning and Scheduling Handbook* on your side, you can start to build a superior maintenance program *right now*—a program that helps you leverage the labor and equipment assets of your company for stellar plant productivity and profitability.

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