Attachment 1a

McGRAW-HILL HANDBOOKS

MAINTENANCE PLANNING AND SCHEDULING HANDBOOK

DOC PALMER

Attachment 1a

MAINTENANCE PLANNING PRINCIPLES

1 The planners are organized into a separate department from the craft maintenance crews to facilitate specializing in planning techniques as well as focusing on future work.

2 The Planning Department concentrates on future work–work that has not been started–in order to provide the Maintenance Department at least one week of work backlog that is planned, approved, and ready to execute. This backlog allows crews to work primarily on planned work.

Crew supervisors handle the current day's work and problems. Any problems that arise after commencement of any job are resolved by the craft technicians or supervisors.

After every job completion, feedback is given by the lead technician or supervisor to the Planning Department. The feedback consists of any problems, plan changes, or other helpful information so that future work plans and schedules might be improved. The planners ensure that feedback information gets properly filed to aid future work.

3 The Planning Department maintains a simple, secure file system based on equipment tag numbers. The file system enables planners to utilize equipment data and information learned on previous work to prepare and improve work plans, especially on repetitive maintenance tasks. The majority of maintenance tasks are repetitive over a sufficient period of time. File cost information assists making repair or replace decisions.

Supervisors and plant engineers are trained to access these files to gather information they need with minimal planner assistance.

4 Planners use personal experience and file information to develop work plans to avoid anticipated work delays and quality or safety problems.

As a minimum, planners are experienced, top level technician that are trained in planning techniques.

5 The Planning Department recognizes the skill of the crafts. In general, the planner's responsibility is "what" and the craft technician's responsibility is "how." The planner determines the scope of the work request including clarification of the originator's intent where necessary. (Work requiring engineering is sent to plant engineering before planning.) The planner then plans the general strategy of the work (such as repair or replace). The craft technicians use their expertise to determine how to make the specified repair or replacement. This arrangement does not preclude the planners from being helpful by attaching procedures from the file for reference.

6 Wrench time is the primary measure of work force efficiency and of planning and scheduling effectiveness. Wrench time is the proportion of available-to-work time during which craft persons are not being kept from productively working on a job site by delays such as waiting for assignment, clearance, parts, tools, instructions, travel, coordination with other crafts, or equipment information. Work that is planned before assignment reduces unnecessary delays during jobs and work that is scheduled reduces delays between jobs.

MAINTENANCE PLANNING AND SCHEDULING HANDBOOK

Doc Palmer

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FOREWORD

We are witnessing a major change in maintenance. It is moving from an equipment repair service to a business process for increasing equipment reliability and ensuring plant capacity. Its practitioners are trading their reactive cost center mentality for a proactive equipment asset management philosophy.

As editor of a technical business magazine covering the maintenance and reliability field, I have had an opportunity to track maintenance during its move from craft to profession. I have had the pleasure of writing about its leaders, the people and organizations who are continually extending the benchmark for maintenance excellence. Many are well on their way to establishing themselves at a level where maintenance performance is measured not by simple efficiency, but by contributions to plant productivity and profitability.

One of my favorite jobs as an editor is the reporting of best practices to the maintenance community. I first met Doc Palmer during such an assignment—a magazine cover story on a plant maintenance improvement program. Since then, I have published some of his articles and heard his conference presentations, and found that he has a superb understanding of the practices leading to maintenance excellence.

One belief that the leading organizations hold in common is that maintenance is a business process and that formal planning and scheduling is key to its success. Yet, there is a dearth of practical references on the subject. Most articles and conference papers on planning and scheduling stress its strategic importance, but they do not delve into the practical details because of limitations imposed by article length or conference programming. Doc has leaped over this hurdle with his *Maintenance Planning and Scheduling Handbook*. There is now a ready reference to take the action oriented maintenance practitioner to the level of understanding needed to install a planning and scheduling function and make it work.

The book positions planning in maintenance operations and then proceeds logically to introduce the principles of planning and scheduling and explain how to make planning work. Additional sections cover the nuances of planning preventive maintenance, predictive maintenance, and project work. The book concludes with helpful information on how to get started.

Maintenance Planning and Scheduling Handbook is a welcome addition to the body of knowledge of maintenance excellence and how to achieve it.

Robert C. Baldwin
Editor, Maintenance Technology Magazine
Barrington, IL

CHAPTER 2
PLANNING PRINCIPLES

This chapter recaps the vision and mission of planning and then presents the principles of effective planning. Each principle identifies an important crossroad. At each crossroad, the company has to make a decision regarding alternative ways to conduct planning. The decision the company makes regarding each situation determines the ultimate success of planning. Each principle presents the recommended solution to the crossroads.

Six principles greatly contribute to the overall success of planning. First, the company organizes planners into a separate department. Second, planners concentrate on future work. Third, planners base their files on the component level of systems. Fourth, planner expertise dictates job estimates. Fifth, planners recognize the skill of the crafts. And sixth, work sampling for direct work time provides the primary measure of planning effectiveness. Figure 2.1 shows the entire text of these principles.

THE PLANNING VISION; THE MISSION

As presented in the Introduction, the mission of planning revolves around making the right jobs "ready to go." Maintenance management uses planning as a tool to reduce unnecessary job delays through advance preparation. To prepare a job in advance, a planner develops a work plan after receiving a work request. The work plan is nothing more than the assembled information that the planner makes ready for the technician who will later execute the work. Some organizations call the work plan a *work package* or a *planned package*. At a minimum, the work plan includes a job scope, identification of craft skill required, and schedule time estimates. The planner may also include a procedure for accomplishing the task and identify any parts and special tools required. The scheduling information produces the most help for the maintenance effort because it facilitates allocation of the personnel resources each week. The parts information and tool information follow in helpfulness. With the proper planning or preparation for each job, this effort sets the stage to increase the productivity of the maintenance force.

The vision of planning is simply to increase labor productivity. The mission of planning is simply to prepare the jobs to increase labor productivity. As simple as this sounds, when management implements planning, it becomes apparent that the planning system abounds with many subtleties. The inability of many companies to recognize or deal with these subtleties prevents their planning organizations from yielding productivity improvements. The following principles guide planning through these particular difficulties to be effective.

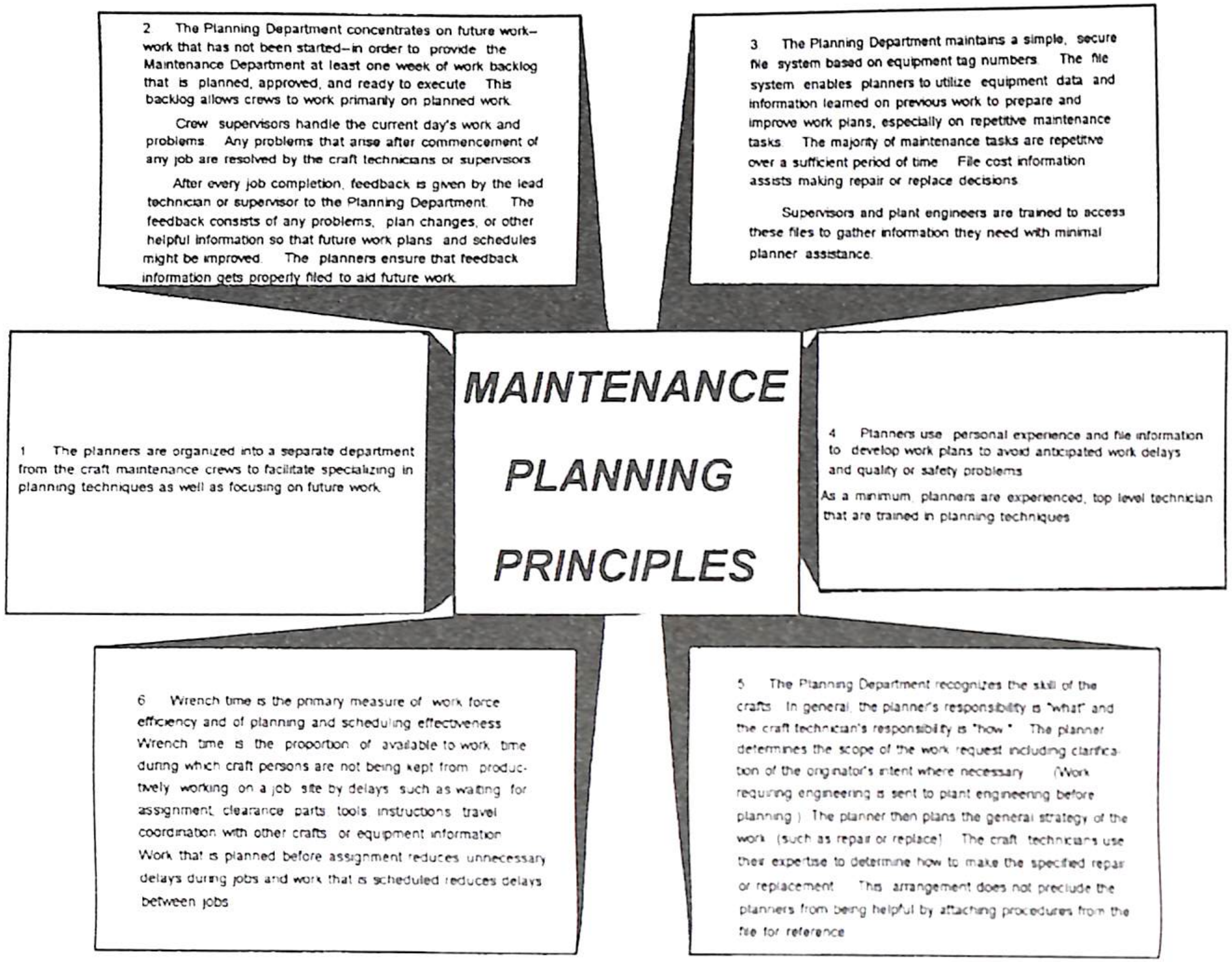

FIGURE 2.1 *The six maintenance planning principles.*

PRINCIPLE 1: SEPARATE DEPARTMENT

Planning Principle 1 (Fig. 2.2) states

The planners are organized into a separate department from the craft maintenance crews to facilitate specializing in planning techniques as well as focusing on future work.

The first principle dictates that planners are not members of the craft crew for which they plan. Planners report to a different supervisor than that of the craft crew. The company places planners into a separate crew of their own. They have their own supervisor. With a small number of planners, the planners might report to the same manager who holds authority over the crew supervisors. There may be a lead planner with some responsibility to provide direction and ensure consistency within the planning group.

The problem with giving the crew supervisors authority over their respective planners is that the crew focuses almost exclusively on executing assigned work. The crew members execute work; the planners do not. The planners must be engaged in preparing work that has not yet begun. In actual practice, the crew supervisor receives too much pressure for the supervisor not to use the planner to assist work that has already begun. The crew supervisor must have repairs completed. It is tempting to reassign a planner to a toolbox and say, "The planner is a qualified welder who can come help us." Even in a plant with few reactive jobs, the supervisor should still have significant motivation to keep actively completing an assigned backlog of work to keep the plant out of a reactive maintenance mode. The supervisor has an obligation to complete the assigned work in an expeditious manner with a minimum of interruptions or delays. Once any job encounters delays, the supervisor feels pressure to minimize them. With direct access to the superior craft skills of a maintenance planner, the supervisor would always have significant motivation to take a planner away from planning duties. To the crew supervisor, the present is always more urgent than the future. The work in progress is always more important than the job not yet begun.

Management may contribute to this problem when planners report to crew supervisors. The pressure is especially intense if the maintenance manager has given a specific direction to the crew supervisor, such as "Put that pump back on line today!" How does the supervisor balance this instruction against the manager's admonition last year, "Try

✦Principle 1

Separate Department

✦Planners not on craft crews

✦Planners not pulling wrenchs

FIGURE 2.2 Separation reduces temptation.

not to use the planner on field work unless necessary"? There will always be important work to complete today and the temptation to delay preparing for tomorrow's work.

Not only does the crew supervisor favor assigning craft work to the planner, the rest of the crew members as well place more relative importance on the work in progress than the paperwork of the planner. Such peer pressure encourages the planner to assist on jobs already begun or to take assignments directly for craft work willingly.

The natural inclination of the crew supervisor to place highest importance on assigned work, the unconscious pressure from management to encourage supervisors to give craft work to planners, and the peer pressure from fellow crew members all contribute to taking planners away from planning duties. In actual practice, planners on maintenance crews frequently work craft jobs and devote inadequate time to planning activities. As a result, crews have insufficient work to execute on a planned basis merely because planners do not have time to plan much work. This situation may also lead to another problem that manifests itself in an insidious fashion. Because planning contributes to scheduling, the lack of planning effort may decrease the number of work assignments to crews. The amount of work the company expects from each crew decreases. The work assigned becomes more reactive in nature because the plant executes less proactive work to head off problems. Gradually, the plant returns to a situation in which crews routinely repair equipment under urgent conditions and with little time remaining for maintenance to prevent equipment problems.

A self-fulfilling prophecy occurs for the manager who assigns planners to field crews. Supervisors frequently put planners on their tools to pull wrenches instead of plan. Planners plan less work. Less work is assigned. Work that is assigned is more reactive in nature, needing more on the job assistance. An apparent, but false, validation results showing that planners need to be on crews to help.

The problem is not managers, supervisors, or crew members with inadequate organizational discipline or inadequate understanding of the nature of planning. The problem is poor alignment of the company organization with the company vision. Simply removing the planners out from under the crew supervisors allows the planners to perform planning duties. The problem is not having persons who can resist the temptation to use a planner's craft skills. The problem is creating a situation where the temptation exists. The company avoids this situation by removing the planners from direct control of the maintenance crews. Then when the supervisor presumes it necessary to use a planner as a technician on an emergency job, the maintenance manager makes the call, not the supervisor.

If problems do arise where extra craft help is necessary, the supervisor has several options besides using a maintenance planner. The supervisor may assign more capable technicians to difficult jobs. The supervisor may decide overtime work is appropriate. The supervisor may decide to extend the job duration and not complete the job on schedule. The supervisor may decide to take advantage of an existing contract to provide contract labor assistance. The supervisor may decide to contract the job altogether. Perhaps the supervisor could increase productivity by personally supervising the work. The supervisor might request help from another crew. The labor contract might allow the supervisor to use another craft as a helper. For example, an electrician might be an adequate helper for a machinist on a particular task. Supervisors might also contribute their own hands to the execution of the work. Many options besides using the planner exist to expedite pressing field assignments.

Only after considering other avenues of help might the supervisor request using a planner as a technician through the maintenance manager who applied the job pressure in the first place. It is one thing for a manager to say "Fix that pump today!" and another thing for the maintenance manager consciously to redirect other resources to the task. Because a single planner helps leverage 30 technicians into 47, the planner in effect is worth 17 persons. The planner is the last person the manager would want to pull away for a field assignment. Compare the cost of time and a half overtime paid to a mechanic versus 17 times straight time opportunity lost to the company for using a planner on a field assignment. Even triple overtime does not compare to the economic waste of using a planner for execution of work. Pulling a planner for a field assignment must be the absolute last resort for the manager who understands and believes in the leverage of planning. Making the manager involved in each case for such a decision helps prevent such reassignments.

The manager might expect the crew supervisor to complain that management took some of the best technicians from the work force to create the planner positions. The manager must understand that for each technician transformed into a planner, the work force receives the equivalent of 17 technicians in return. It is in everyone's best interest to make planning work. Time spent in explaining the leverage and benefit of planning to supervisors both at these times of questioning and at the outset of initiating planning is time well spent.

Another reason the company organizes planners into a separate group is to facilitate or help the planners become specialized in planning techniques. Planners need to work closely together to ensure proper execution and consistency of planning work itself. There are ample opportunities to conduct planning in different manners. Planners need the reinforcement of each other's help to plan jobs and follow the planning principles in a common fashion. Consider a school musical band with a trumpet section. The first and second trumpet parts follow the melody of the song exactly or very closely. However, the third trumpet part if played alone might not even be recognizable as the song being conducted. The third trumpet player greatly benefits when there are other third trumpet part players. This is especially helpful if the third trumpet player occasionally loses the place in the musical score. Listening to other third trumpets helps the player come back into place. Maintenance planning provides a similar situation. Preparing work to be accomplished in the future while the other technicians on crews scurry after jobs-in-progress is a new experience and is difficult to master alone.

Illustrations

The following illustrations demonstrate this principle of planning. The first section shows problems occurring as a result of not following the principle. The second section shows success through application of the principle.

Not This Way. Maintenance Manager Scott Smith walked over to the office of the mechanical crew supervisor. Each crew had its own planner who had a partitioned section of the supervisor's office with a desk and computer. Smith did not expect to see the planner necessarily because he knew that planners had to travel quite a bit to go to all the jobs for scoping. So it was not unexpected that the planner was not at the desk. The crew supervisor was not there either, which was appropriate, because Smith likewise expected supervisors to spend time in the field with their crews. However, on the way back to the front office, Smith happened to pass the fuel oil transfer pumps and saw the mechanical crew planner on a scaffolding assisting another mechanic hoist a valve into place. After questioning the planner, it appeared that the crew supervisor wanted to have the valve job completed today. He directed the planner to help the mechanic who was having trouble managing the bulky valve alone. Smith could understand that the planner was under the direction of the supervisor, but Smith had begun to notice an uncomfortable trend. At least half of the time when he saw a planner, the planner would be working on a crew. This probably contributed to the indicator Smith tracked showing that the crews spent most labor hours on unplanned work. Last week Smith had even seen one of the planners working as a tool room attendant. The supervisor of the tool room had borrowed the planner from one of the crews because the crew was suddenly short-handed that day. Smith was somewhat reluctant to counsel his supervisor because the supervisors took such great pride in managing their own work. However, in order for planning to work, obviously there had to be some planners doing planning. Smith decided to meet with his supervisors again regarding the matter.

This Way. Maintenance Manager Scott Smith walked over to the office area of the maintenance planners. Each planner had a partitioned office cubicle with a desk and computer. Smith did not expect to see all the planners necessarily because he knew that planners had to travel quite a bit to go to all the jobs for scoping. So it was not unexpected that only two of the four planners were at their desks. One of the planners present appeared to be attaching plan information to a work order and the other planner was going through a file to find equipment clearance information. On the way back to the front office, Smith happened to pass the fuel oil transfer pumps and saw the two mechanics hoisting a valve into place. After questioning the mechanics, it appeared that the job plan was helping them expedite the job. The plan had given the valve weight so that the right straps could be checked out of the tool room before the job started. The plan had also advised the supervisor ahead of time that the job required two persons because of the valve's bulkiness. After talking to the mechanics, Smith started again back to his office. As he was crossing the pump yard he noticed one of the remaining planners carrying a clipboard with a stack of work order forms. This planner claimed to be in route from the power house where three jobs had been scoped and was heading toward the chemical waste treatment system to scope four more work orders. Smith was comfortable that the planners were engaged in planning activities as he wanted. Smith knew that the supervisors also knew the importance of completing the planning. This morning he had turned down a request for a crew supervisor to borrow a planner for a field assignment. After discussing the particular work order, Smith had advised that the crew supervisor would have to extend the schedule for its completion.

Managers need to place maintenance planners out from under the control of crew supervisors to prevent the planners from being assigned field work as technicians. The temptation to use planners as field technicians on current jobs is usually too strong to allow the planners time to do helpful planning for future work. A separation arrangement allows the planners to concentrate on planning future work.

PRINCIPLE 2: FOCUS ON FUTURE WORK

Planning Principle 2 states (Fig. 2.3)

The Planning Department concentrates on future work—work that has not been started—in order to provide the Maintenance Department at least one week of work backlog that is planned, approved, and ready to execute. This backlog allows crews to work primarily on planned work.

Crew supervisors handle the current day's work and problems. Any problems that arise after the commencement of any job are resolved by the craft technicians or supervisors.

After every job completion, feedback is given by the lead technician or supervisor to the Planning Department. The feedback consists of any problems, plan changes, or other helpful information so that future work plans and schedules might be improved. The planners ensure that feedback information gets properly filed to aid future work.

✦Principle 2

Focus on Future Work

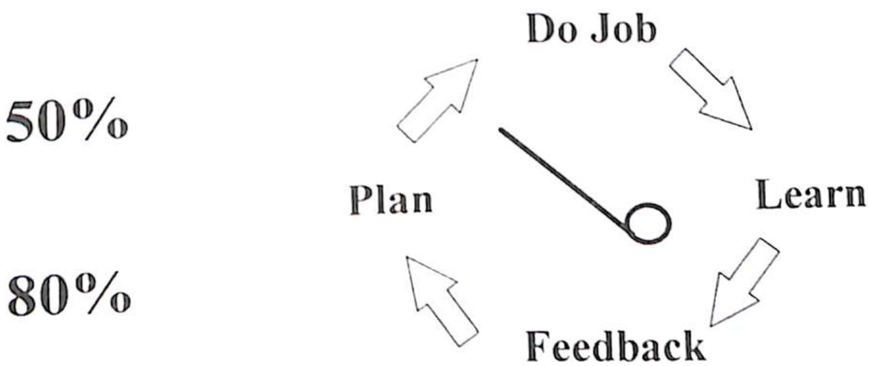

FIGURE 2.3 The snowball of improvement.

The reason the planners need to be separate is they need to focus on future work. Planners do not become involved in work that is already ongoing. A simple definition of future work is the crew has not yet been assigned to start on the work order. Once a crew has started working on a job and they find out they need more information, they do not come to the planner for assistance, but work it out themselves. Then after the crew successfully completes the current job, feedback to planning helps avoid similar problems in the future.

The problem with the planner having the duty to help technicians find file information for jobs already under way is that the planner soon has no time left to plan or gather job information to help future work. A vicious cycle is then in place. No jobs receive the benefit of advance planning because there is no time to refer to past feedback or otherwise anticipate problems ahead of time. The question at the crossroad is whether planners are really in the business of planning or are they in place to help technicians quickly find information to help resolve problems for work that has already started. The planners are most knowledgeable about the plant technical documents, and jobs that are under way need help fast when problems arise. Nevertheless, this use of planning is almost as short-sighted as using planners as field technicians.

Think of the circle in Fig. 2.3 as a repeated cycle of maintenance over the life of a piece of equipment. Maintenance does a job to maintain the equipment. During the course of the work the field technicians learn about the equipment or task. For example, they may learn that a certain pump bearing can only be removed from the inboard side because of an almost imperceptible taper in the design. The technicians learned this fact from trial and error and spent most of a morning doing it the wrong way. After the job the technicians give feedback on the work order form about the design and delay. Then the next time that particular pump needs maintenance, the planner can refer to the previous problems and the resolution because the planner filed the previous feedback. The planner reports this information as part of the job plan before the crew starts the task. As a result, previously encountered delays might be avoided on the subsequent maintenance operations. In the example of the tapered bearing, the second time the crew replaces the bearing, they should not have to waste time trying to insert the bearing from the wrong side. The crew avoids an entire morning of wasted time. Each time the crew works on a particular piece of equipment, they might learn something new that could help future jobs.

This cycle of maintenance and planning concept carries some important implicit presumptions. The first and most important presumption is that a planner is available to review feedback from previous jobs and otherwise plan for new work. Another presumption is that feedback is not only obtained, but kept after each job. The final presumption is that equipment is worked on repetitively. These presumptions are not taken lightly.

The first presumption is that a planner is not only willing, but available to plan new work. As planning recognizes the need not to be on the tools (Principle 1), they are still frequently hindered from focusing on future work. As the planners leave their tools and arrive in the office to focus on future work, they meet a new challenge. The problem that arises is that if a planner is planning for 20 to 30 technicians, how many of those technicians are going to want some additional information? Probably at least two or three will do so. So these two or three technicians come to the planning office and ask the planner for help; after all, the technician regards the planner as the information finding expert. With this constant interruption, the planner does not have the time for the filing or work necessary to focus on future work. The planner helps with work-in-progress, not future work. Figure 2.4, Chasing Parts, illustrates what happens.

Figure 2.4 presents a variation of the common product life cycle that illustrates the planning effectiveness challenge. As management takes good technicians out of the work force (Principle 1) to be planners, the work force's effectiveness initially suffers. Then as the planners become proficient at finding file information (albeit on work-in-progress), there is overall improvement for the work force. However, the first curved line shows an upper limit to how much help this practice can deliver. The second curved line shows when planners turn away from constantly helping work-in-progress and focus on future work that maintenance effectiveness can improve further. Opportunity

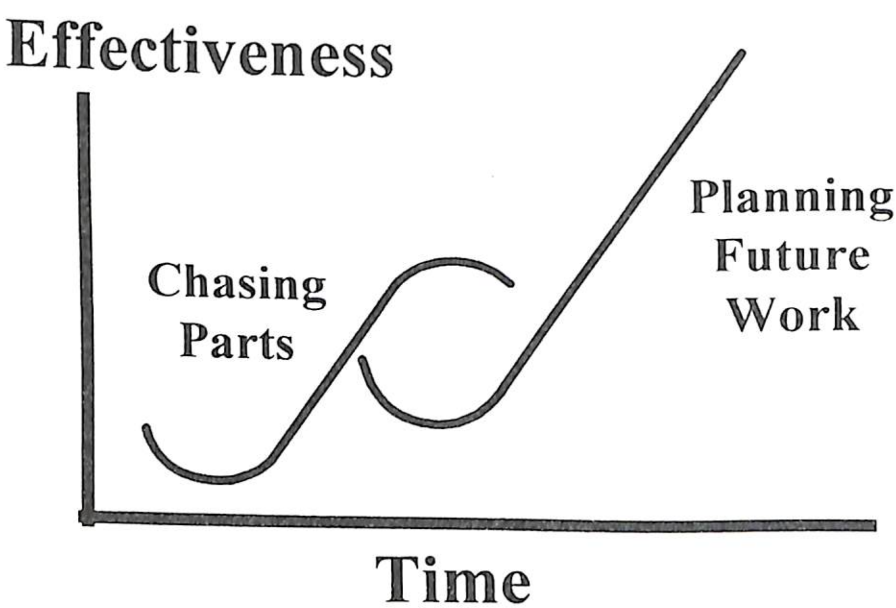

FIGURE 2.4 Chasing parts for today's jobs cannot help as much as focusing on future work in the long run.

for further improvement exists because when the planners only help work-in-progress, they are not helping the crews avoid previously encountered delays. Every job becomes a new job without any history advantage. No wonder so many techs need help with work-in-progress; they have no opportunity to avoid what has happened in the past. It is no wonder the planner cannot focus on future work. Every job in progress runs into problems creating another vicious cycle. The planners become known as "parts chasers" excitedly helping technicians find parts information or solve other problems on most jobs. Every job is urgent once it starts.

This is a very sensitive area for existing planning departments. Management may have started the planning department with the published intent of helping everyone with obtaining information at any time. A planner soon learns the impracticality of planning in advance for 20 persons while at the same time helping with work-in-progress. The best alternative at this point is to try to designate one of the planners for helping all jobs-in-progress to shield the other planners.

It is best to start out with the understanding that "planners will not replace the need for a tech (or supervisor) to find technical information." However, once a technician has found information the planner will save and reissue all job feedback on future work. This arrangement is also necessary for the crew supervisors to maintain their familiarity with the files and also encourages feedback from the technicians. Once technicians have to find technical information for a job, knowing that they will have to find the information again themselves the next time unless the planner can extract the data from the files, encourages feedback.

The future work concept is important. If a crew has already started working on something and they find out they need some more parts, they do not come to the planner to help find those parts. One would think the planner is the one most familiar with the files, parts, and the computer system. One would think the planner is the person to whom to turn. But that is counterproductive overall. Think back to before the company had planning; then the crew supervisors knew how to obtain parts. The crew supervisors knew how to find file information. That previous familiarity should be maintained. Management wants the "added value" of looking at future work. Therefore, after the job starts, the techs or crew supervisors must find any additional information just as they did before planning existed. That lets the planner focus on getting all the jobs planned. Principle 3 does not accept planning being a highly efficient department of persons to help crews look for parts once jobs start. The craftperson who changes the plan or has problems should write that information down after she finishes the job and give it back to planning for filing. The next time that piece of equipment needs work the planner will take the filed information and insert it for an improved job plan.

Management needs to monitor the time planners spend planning future work versus helping jobs-in-progress. If using a timesheet system, management may consider planners using a one time accounting number when planning and another number when providing technical assistance. A balance should be struck between the use of separate numbers legitimizing "chasing parts" and showing that "chasing parts" is not planning.

The second implicit presumption is that feedback will be received and used. Many companies almost hopelessly damage their planning effort with misconceptions regarding this point. These organizations start their planning groups with the expectations that field technicians would never have to look for information and that planners would always plan jobs from scratch. In other words, their concept is that each planner would pick through the technical manuals every time a job came up to support the planner's 20 to 30 technicians. The field technicians thereby never have to find information because the planner always has it ready. This approach fails for two reasons. The first is that a planner cannot keep up with the work load researching each job from scratch. This is why planning organizations have a difficult time in their first 6 months of existence. In effect, every job is being built from square one before the files slowly become builtup and useful. The second reason is that the most valuable information needed on plans is not available from equipment manuals. Information such as potential work permitting problems, the probability that certain parts will be needed, and corrected local inventory stocking numbers are learned from past jobs. A planner must be able to find the helpful feedback on those last three work orders from the last three years to help the crew avoid previous problems. For example, if the planner finds that the last time the crew worked on this job they did not have a certain part, the planner makes sure they have that part this time. Each and every job is on a learning curve. Looking to the files helps achieve that improvement opportunity. The correct concept is that the planner to a large degree is essentially a file clerk for their technician. The planner promises that if the technician reports any information, the planner will have that information available for next time. The field technicians must be willing to research and resolve problems as they come up on jobs in progress and report feedback to their file clerk. The technicians must not have the false impression that because certain information was unknown that the planner failed to adequately plan the job. On the other hand, the planner must understand the importance of saving and referring to this important feedback. The planner does not plan each job from scratch. By using feedback in the plant files, the planner not only has the opportunity of continuously improving job plans, but has time to plan all the work orders.

The last presumption concerns doing work repetitively. Working on equipment repetitively is a reality. One typically thinks of preventive maintenance as the only repetitive work in the plant. Yet the 50% rule says that if a piece of equipment requires work, there is a 50% chance it will require similar, if not the same, work on it again within a year's time. Moreover, the 80% rule says that there is an 80% chance the equipment will be worked on again within a 5-year period. These percentages are not for preventive maintenance. Why are these percentages so high? One reason is "infant mortality." After any work on any equipment, there exists an increased chance of additional maintenance soon being required. Problems from the initial job might include faulty materials or maintenance practices. The feedback from these jobs is especially important for the planner to scrutinize for opportunities to avoid repeated problems. Another reason is that some equipment simply requires more attention than others. Out of 10,000 different pieces of equipment, 300 might continuously need attention while the other 9000 or so never seem to need work. On the other hand, there is a common perception that "Nothing is ever the same" or "It is always something different." These statements reflect a perception that none of the equipment receives repetitive maintenance attention. This perception is false, but understandable. For one thing, the exact same technician might not be involved each time. For another thing, working on a piece of equipment only once or twice a year just does not seem to be very repetitive, especially if the exact same task is not involved. Nonetheless, one must move beyond the horizon of a crew thinking of one week at a time. The 30 plus years of a plant's life mean that the vast majority of maintenance tasks will be executed repetitively. And if the vast majority of jobs are repetitive, each presents the potential opportunity of contributing to increased labor productivity through heeding the lessons of the past. That means there is a tremendous opportunity to improve through avoiding past delays. There is a cycle and a snowball effect. As maintenance crews work jobs, they learn helpful information about delays. Then they give that information to planning as feedback at the end of a job. Planning references this information when the next job comes up for that equipment and the snowball picks up momentum as repeated jobs avoid past delays.

A final comment is appropriate regarding future work. Even without regarding the repetitive nature of maintenance work, there is a serious problem when the plant overfocuses on helping jobs-in-progress. When technicians run into a problem, there is generally a job delay while they resolve the matter. Unless these technicians can quickly move to

Attachment 1a

other work, there will be several technicians standing around wasting time even if the planner rapidly resolves the problem. It is undeniably much better to have the planner anticipate problems ahead of time and spend time resolving them while no one is waiting.

Illustrations

The following illustrations demonstrate this principle of planning. The first section shows problems occurring as a result of not following the principle. The second section shows success through application of the principle.

Not This Way. Sally Johnson was the planner for the mechanical work for Crew A's ten mechanics and ten welders. Since it was Monday, she planned to scope and compile plans for all the jobs that the weekend operating crews had reported. In addition, there were a number of jobs completed last week for which she needed to file the work orders. Before she could complete checking her email, however, two welders came into the office requesting her help to run pick tickets for them to receive a valve out of inventory. Soon after she provided this help, a mechanic called her on the radio for assistance obtaining bearing clearances for the forced draft fans. She knew this would be a problem and she spent the better part of the morning locating and talking to the manufacturer. By midafternoon, the interruptions had kept coming and Johnson still had not scoped the first job. At least she felt a sense of accomplishment that she kept important jobs going through her efforts.

This Way. Sally Johnson was the planner for the mechanical work for Crew A's ten mechanics and ten welders. Since it was Monday, she planned to scope and compile plans for all the jobs that the weekend operating crews had reported. In addition, there were a number of jobs completed last week for which she needed to file the work orders. After checking her email, she began filing. Then as she started to assemble information for the new jobs, she first made a field inspection, then again returned to the files. Good, she thought, here is a list of parts for the air compressor job. That will help the mechanics when they start that job. On about half the jobs, she found useful information from previous work orders. After compiling the information, she finished the required planning by about midafternoon. That left part of the day to talk to one of the plant engineers from whom she had asked some material selection advice. She felt a sense of accomplishment that she was part of a new service for maintenance that boosted productivity and ultimately company profits. She could feel that her efforts were part of a better process than the old "Just work harder" mind set.

As one can see, the repetitive nature of equipment maintenance provides great opportunity for planners to give technicians a head start in avoiding past problems. Technicians need to be mindful to resolve problems without planner assistance and provide feedback on circumstances encountered and information gained. Planners need to be heedful to their task of keeping and utilizing past work order information to improve jobs being planned. To make the cycle of job improvement work through avoiding past delays, planners must be allowed to focus on future work. Nevertheless, past delays can only be avoided if they are remembered, which leads to the next principle.

PRINCIPLE 3: COMPONENT LEVEL FILES

Planning Principle 3 (Fig. 2.5) states

Attachment 1a

The Planning Department maintains a simple, secure file system based on equipment tag numbers. The file system enables planners to utilize equipment data and information learned on previous work to prepare and improve work plans, especially on repetitive maintenance tasks. The majority of maintenance tasks are repetitive over a sufficient period of time. File cost information assists making repair or replace decisions.

Supervisors and plant engineers are trained to access these files to gather information they need with minimal planner assistance.

The concept of component level files or "minifiles" is a vital key for successful planning. Principle 3 dictates that planners do not file on a system level or basis, but on an individual component one. A minifile is a file made exclusively for an individual piece of equipment the first time it is maintained. The term minifile helps convey the understanding that the file does not keep information for multiple pieces of equipment together. Planners make new equipment a minifile when it is purchased. Planners label the file with the exact same component tag number attached to the equipment in the field. Planners consult the minifile for each new job to take advantage of the lessons and information gained on previous jobs. This principle takes advantage of the fact that equipment requires repetitive attention over the life of the plant. In particular, cost information available through the files helps planners and others make important decisions on replacing or modifying troublesome equipment. The files are arranged in a secure fashion to keep data from being taken away unadvisedly and lost, but are arranged simply enough for other plant personnel to be able to access their information. Engineers and supervisors directly use the files for obtaining information for projects or jobs-in-progress rather than interrupt the planners from planning future work.

The crossroads, so to speak, in this instance is whether to file information by systems or by individual equipment. A simple few files make it easy to put certain information in, but later difficult to find and take out that information. A complex, multiple file arrangement would require more time to find the right file in which to put the information. On the other hand, later it would be easier to find the information again. Starting from the extreme, the easiest arrangement into which to place information would be a single repository or file for the whole plant. Planners would have no trouble filing infor-

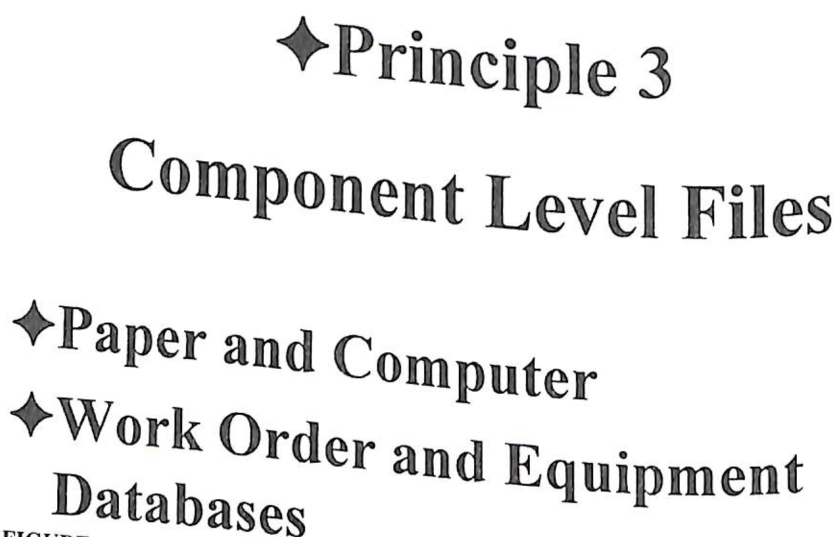

FIGURE 2.5 Filing so that information can be used.

mation because it all goes into one place together. However, later if a planner wanted information saved last year for the clarifier drain valve, it would be impractical to find it amidst the mass of other saved data. Moving to a slightly less simple arrangement, the plant could file information by building or plant area. A planner would file all the waste treatment information together and later might have a less difficult time finding the clarifier drain valve data. Continuing to how many plants do actually file data, a plant could file by equipment system such as the liquid waste system, the high pressure steam turbine system, and the polisher system. This makes the planner have to take a little more care filing the information to place it in the right place. Later the planner has a much easier time finding the information if needed. The next less simple filing system would be filing information by the equipment itself such as the clarifier drain valve. Obviously, the planner would have little trouble later retrieving information, but to begin with the planner would also have to exercise considerable care filing information. The extreme case would be to file information separately even by nearly every discrete subcomponent such as a valve body, a valve actuator, a pump, or a pump bearing. These arrangements become too complicated for filing or retrieving information. Alternately, the plant may file equipment information by manufacturer or vendor. Filing by manufacturer or vendor is common, but generally not favored because manufacturers and vendors change over time for particular pieces of equipment.

Consider a road or street address system in a town or city. Persons might take a multiple lane highway to arrive at the town. They turn off the highway onto a major road to go to the neighborhood. Then they look for particular side streets leading to the street of interest. Once at the specific address of the home of interest, they turn onto a specific narrow driveway. The seekers can locate all of the occupants of this home because they are at a specifically numbered address within the city. One cannot find any of the occupants of the home by simply arriving in the city. Planners likewise cannot find any of the work orders for a piece of equipment if the population of total work orders is significant at all.

Consider a doctor's office. Many physicians have a paper file system directly behind the receptionist. There is a separate paper file for each patient or, at most, family. The physician can easily determine the patient's medical history by looking at the filed information. A patient would also be uncomfortable if the physician did not think any past history was ever important. A patient would also be uncomfortable if the physician filed all history by single neighborhood files. Similarly, planners know that history is important for all equipment and there is not too much trouble in filing by equipment.

The conventional wisdom is threefold for filing. Do not file information that one knows will not be needed in the future. File in fat files what probably will not be needed in the future, but if needed must be found. File in skinny files what will be needed and used in the future.

Maintenance work orders decidedly fall into the last category considering that the majority of equipment maintenance is repetitive over the years.

It turns out that once management takes the planners off their tools (Principle 1) and actually ready to focus on future work (Principle 2), a new situation arises. The files where everything has been put for years are not useful unless information is filed by individual pieces of equipment. Say a planner is planning a job on the polisher cation regeneration valve. According to the 50% rule, there should be at least one or two previous work orders from the past couple of years that would help. The problem is that the plant used a single file to place *all* the work orders from the polishers; there must be 250 work orders. The planner does not have time to dig through them looking for the several cation regeneration valve ones if this situation is the norm encountered for every piece of equipment and job planned.

As planning is implemented, it soon becomes evident that it is not feasible to check individual equipment history and technical information if they are kept in system files.

System files have too much information to allow quick reference for individual equipment. Once the planner receives job feedback for future reference, it cannot go into a system file. A system might have 20 to 100 or more different components alone with multiple work orders for each. When a file is that large, planners cannot practically find information on a single piece of equipment. Therefore planners use a component level file for each piece of equipment. When the planner receives a work order, the planner consults the specific file to find the previous work orders for that equipment. The filing mirrors the obvious work order arrangement. Normally, planners plan work orders for discrete pieces of equipment. It makes sense to file information in the same manner.

Consider a simple, paper file system. This file system is the equipment database complete with work order history for each piece of equipment. With a minifile, the first thing a planner does when a job comes in is go to the minifile, pull it out and find the previous work orders for the equipment. If the planner finds that the last time the crew worked this job they did not have a certain part, the planner makes sure they have that part this time. The job is on a learning curve.

As discussed in the previous principle, many persons think a crew never works on the same thing over again, that it is always something different. Yet in reality they work on the same things over and over again, just not every day. It might be 9 months to over a year before a crew works on it again and even then with a different technician. So persons just have a feeling that they are working on different things all the time. Notwithstanding popular opinion, if a planner can find those last three work orders over the last 3 years, the planner can help the crew avoid previous problems. Furthermore, if a planner can tabulate the previous cost, the planner can make better repair or replace decisions. For example, "The last two times we worked on that, it cost $1000. I know I can buy a completely different valve for $500 that probably will not need as much maintenance." Looking to the files helps the planner reach that improvement opportunity. In addition, since the majority of jobs have been worked on before, most of the jobs currently in the plant would benefit from a planner being able to review past information through an adequate file system. Filing information by the individual equipment allows that opportunity.

Experience has shown that after only 6 months of conscientious feedback and planning, most jobs in the plant receive a benefit from feedback learned on previous jobs.

The next issue concerns how the planners should physically arrange and number the files.

First, an intelligent numbering system of some sort is preferred. Many plants might have the equipment files labeled by the written names of the equipment. For example, one file might have Polisher Cation Regeneration Valve as its label. The plant may order these files within systems alphabetically or by process location. However, using the filing system becomes somewhat cumbersome as the quantity of equipment rises. For one thing, not everyone may refer to the equipment by the same name. On the other hand, a plant-wide coding system allows better file arrangement through intelligent numbering. For example, from the number N01-CP-005, one could tell that the equipment is a valve on the Condensate Polisher system of North Unit #1. This number allows not only a unique, file reference number, but also the grouping of all polisher equipment together. This system is preferred although some thought will have to be spent on developing an appropriate numbering system. Some companies have already tagged their equipment with unique numbers just for the benefit of ensuring maintenance does their work on the correct machines. Planning should use these existing numbers as the basis for the filing system whenever possible. Appendices J and K give practical advice on setting up a numbering and tagging system.

Second, when using a numbering system, the company must make sure to follow through on one action. Not only must they label the files, but it is almost imperative that they hang matching equipment tags on the field equipment. This simple step greatly assists the operators and other writers of work orders tie the equipment number to the work order. This tie helps the planner find the correct equipment files. Some filing programs have failed not because the filing system was somewhat complex, but because there were no corresponding equipment tags.

Third, the planners must set up the files so that the supervisors and plant engineers do not ask the planner to look in the files; they look in the files themselves. The planners intend for these persons still to work with files and information. For this reason, paper files should be open and easy to see with side labels on individual folders. Files that are enclosed within closing file cabinet drawers tend not to be inviting or as user friendly as possible. Large labels should clearly declare the contents of different shelf areas. For this same reason, planning should keep all the files in a common area, not within individual planner cubicles.

Fourth, if other persons have access to the files, management may have some concern for security. Generally, having the file area located so that persons must first pass through the planner area is acceptable. This arrangement strikes a balance between making the files accessible and making the files less prone to wander off by knowing who is there. Supervisors may want to designate that only certain individual technicians may access the files depending on the competence of the technicians in this regard.

The objective of this principle is to create a file system that delivers useful information to the planner and the rest of the plant personnel.

Illustrations

The following illustrations demonstrate this principle of planning. The first section shows problems occurring as a result of not following the principle. The second section shows success through application of the principle.

Not This Way. David needed to plan two jobs. One job required a simple filter change and the other required stopping a drip on the hypochlorite discharge piping. Both jobs were fairly routine. The filter was not on a PM route because varying operating modes caused the filter to plug at different intervals. The operators monitored the pressure differential and wrote a work order whenever the filter was beginning to show signs of clogging. David first skimmed through the thick system files behind his desk for past work orders, FC for Fuel Oil Service System and IR for Intake Chemical Treatment System. He was sure there were at least some for the filter. After several minutes he was able to find one for the filter, but not the piping. David copied down the filter and gasket inventory numbers off the previous work order plan. From his field inspection of the discharge piping, he determined that maintenance needed to cut away and replace the PVC piping. David included PVC piping inventory numbers and a statement to obtain PVC glue from the tool room in the job plan.

As David was finishing up the job plans, Supervisor Juan asked where the equipment information was for the hypochlorite pumps. David explained that all the information from past work orders was together in the system file and waited patiently as Juan shared his cubicle looking through the file.

This Way. David needed to plan two jobs. One job required a simple filter change and the other required stopping a drip on the hypochlorite discharge piping. Both jobs were fairly routine. The filter was not on a PM route because varying operating modes caused the filter to plug at different intervals. The operators monitored the pressure differential and wrote a work order whenever the filter was beginning to show signs of clogging.

The operators had written the equipment tag numbers on the work orders so David was able to walk over to the planner file area and immediately locate the two pertinent file folders, N02-FC-003 and N00-IR-008. (David could have found the specific folders even if the operators had not written the tag numbers on the work orders. The plant schematics, the computer drill down, or a field inspection could have shown him the specific number. He could also have simply looked in the file area under N02-FC for specific folders for fuel oil filters and under N00-IR for specific folders for chemical treatment piping.) As he had suspected there were several work orders for the filter and one for the piping.

David noticed that out of the three times the plant had changed the filter, two times the technician had reported having to redo the job because the assembly had leaked upon pressurization. David decided to change the work plan and include a reminder to tighten the strainer cover in a criss-cross pattern. David also included a step to request the operators to pressure test the line before the technicians packed up and left because of past trouble with the lid. David also copied down the filter and gasket inventory numbers off the previous work order plans. From his field inspection of the discharge piping, he determined that maintenance needed to cut away and replace the PVC piping. David included PVC piping inventory numbers and a statement to obtain PVC glue from the tool room in the job plan. David also noticed that the previous job in the file for this piping had recorded a job delay to wait on the operators to drain the pipe. Apparently the pipe was not self-draining as previously thought. David included a note in the plan for the supervisor to remind operations about the potential clearance problem.

As David was finishing up the job plans, Supervisor Juan asked where the equipment information was for the hypochlorite pumps. David pointed to the file area and explained that any information they had from past work orders was in the N00-IR section in several specific pump files. If Juan could not find what he wanted there, Juan might want to try the O&M manuals on another shelf area in the same room. David asked that if Juan found anything useful, to make David a copy and he would file it in an equipment specific minifile.

Caution on Computerization

A computer certainly gives more capability to the maintenance effort. For instance, a CMMS (Computerized Maintenance Management System) might allow accessing work order information away from the planning shop (by operators, engineers, and managers). It might allow sorting work orders (such as for specific types of outages). A computer might be able instantly to tabulate previous work order histories with costs and even eliminate a paper file system altogether. However, these benefits are not the specific leverage of planning. They are either additional points of leverage or acceleration of the manual planning operation. Planning itself is not the use of a computer. First one must learn to add, subtract, multiply, and divide before employing a calculator. The calculator simply helps the existing process.

Be cautious in thinking that having a computer system is itself planning. Planning multiplies a work force by 157%; it transforms 30 technicians into 47. Is management properly thinking that the computer system may help reach the top of this percentage increase or is management only thinking in terms of replacing two clerks currently entering work orders or typing PMs? Management needs a sense of perspective. Do not be unnecessarily eager to abandon a paper file system.

Figure 2.6 declares that computerizing a poor maintenance process will not help maintenance. This is especially true of the planning process.

Attachment 1a

When Using a Computer

1. If you do not know how to do something without a computer, doing it with a computer will not help.

2. Doing something wrong is faster with a computer.

FIGURE 2.6 First learn planning, then computerize.

As one can see, having unique numbers for equipment and then filing equipment work orders and information by those numbers make it possible for the planner to file and retrieve information as needed. Planners serve as file clerks to a large degree and need an accurate filing process.

PRINCIPLE 4: ESTIMATES BASED ON PLANNER EXPERTISE

Planning Principle 4 (Fig. 2.7) states

Planners use personal experience and file information to develop work plans to avoid anticipated work delays and quality or safety problems.

As a minimum, planners are experienced, top level technicians that are trained in planning techniques.

✦Principle 4

Plans with Estimates Based on Planner Expertise

FIGURE 2.7 Estimates are easy for planners that are accomplished craftpersons.

Principle 4 dictates that the plant must choose from among its best craftpersons to be planners. These planners rely greatly upon their personal skill and experience in addition to file information to develop job plans.

The crossroads that this principle addresses is twofold. First, the plant has to decide what level of skill planning requires. The choices range from using relatively lower paid clerical skill all the way up to higher paid engineering skill. Second, the plant must decide the appropriate method of estimating job time requirements. A wide range of choices also exists for this issue.

It would seem that with the feedback and file system in place, clerks might be utilized as planners. However, as a minimum, planners need to be top level, skilled technicians so that they can best scope a job or inspect the information in a file for its applicability to the current job being planned. One issue at stake is in whether to have (hopefully) good execution on an excellent job scope or have excellent execution of perhaps the wrong job scope. Identifying the correct job scope is of primary importance. One of the best persons to scope a job is the skilled craftperson who has successfully worked the job or ones similar many times in the past. Even if the planner has not worked the particular task, a skilled craftperson can research or make an intelligent estimate for what the task might require. A second issue involves the files. Planners cannot simply be clerks or librarians in this regard, either. Again as a minimum they need to be skilled craftpersons so that when they review information in a file, they can gather all possible help for the current job. They can look and see if a part used on a previous job was a "one in a million" type of part or whether it really needs to be a part used on most future jobs.

Companies have considered apprentices for planner positions. These appointments run into two problems. First, an apprentice rarely has the experience to scope jobs properly simply from a lack of experience. An apprentice has also not had the opportunity to develop a top level of skill. The second problem is that experienced craftpersons receiving a job plan from an apprentice tend to cast doubt not only about the job plan, but management's support of planning as well.

A newly promoted technician rising from the apprentice class has essentially the same weaknesses in the planner position as an apprentice. There is more possibility that an experienced technician may make a good planner, but consider that the planner will be dictating certain job requirements to all of the field technicians. If an existing technician is not a star performer, the technician may not have the skill desired to be scoping all the plant work. The rest of the technicians also have some reason to doubt the specifics of any job plan based upon their perception of the talent of the planner as a technician.

Companies have also used engineers and technologists as planners. However, they typically do not possess the skill to plan most maintenance jobs. Most maintenance jobs consist of routine valve replacements, filter changes, or equipment adjustments that the technical experience of the engineer or technologist does not encompass. Each of these seemingly simple tasks is laden with potential job problems and delays beyond their experience. On the other hand, even if these personnel have actually risen through the ranks of the maintenance force while earning their degrees, they are not cost effective to utilize as planners for routine maintenance. Routine maintenance offers the highest potential for planner contribution to company success because more intricate or unusual maintenance tasks normally already receive help from plant engineering.

Supervisors make excellent choices for maintenance planners because they were typically experienced, top level technicians before promotion. Because planners also must have a high degree of self-initiative, they possess another of the qualities mandatory for supervisors, but possibly lacking in some technicians. Existing company guidelines for selecting supervisors frequently are satisfactory for selecting the best planners. Because companies realize that they must attract the best technicians to make planning work, many companies pay planners at or above the first-line supervisor level. A recent survey indicates this is the case for over half of the electric utilities with maintenance planning. A company might want to consider moving an existing supervisor into a planner role or providing an additional promotion opportunity for its existing technicians. Making the planner position a step toward supervisor may also increase support in maintenance for planning. Another argument for paying planners at the level of supervisors is that the planners deal with the crew supervisors, not the technicians, at a peer level.

Companies not accepting that planners should be supervisor level might have one or two other considerations in mind. The company might feel that responsibility over personnel is more difficult than responsibility over a process. This thought has some merit, but consider that companies typically pay engineers higher than crew supervisors because of market demand. The market might also attract away some of the companies' best technicians if there is not ample room for growth. Paying planners as supervisors offers one solution to keep company strength in technical talent. Another consideration might be that the company does not support planning all the way. The company is keeping open an option to revert the planners back into the work force if planning does not work. The company might also be leaving an avenue to replace one or two planners that do not do well. The company so inclined must be very careful that it is not holding back the support a planning organization must have to succeed. The company might also have a weakness in not being able to remove unqualified supervisors. If the company's strategy does not select the best planners, the company does not follow this principle at the peril of planning.

Appendix M, Setting up a Planning Group, gives more guidance on selecting maintenance planners.

Another issue is the development of time estimates. The opinion of the skilled technician-planner is preferred over strict file information, pigeon holing, or other builtup time estimates.

File information yields historical data about past jobs, but can only offer general guidelines for current estimates. For example, the same job to clean an oil burner gun showed the following actual time requirements. One time the job took one person 20 hours. The next time the job took two persons 4 hours each. The last time took two persons 6 hours each. A planner might be tempted to average the times and plan for two persons at about 7 hours each. However, it is difficult to understand why the past jobs were so different especially if feedback was minimal as in these cases. The longest job might have had an inexperienced technician assigned or the person assigned was given no other jobs or schedule pressure. In the latter case, the person may have simply taken all of two 10-hour days to complete the work. If this was the case the planner might be more inclined to average only the two shorter jobs and plan for two persons at 5 hours each. Alternately why might not the planner insist that the target should be two persons at 4 hours each since that rate had been achieved once? On the other hand, what if the technician feels that from personal experience that, if done properly, the job should take two persons an entire day, 10 hours each?

Perhaps the planner could use the historical time estimates to create job standards for certain repeated tasks. The problem with this approach is first that historical time estimates might not reflect the appropriate time to do the job right. Second, other than for routine PMs, the day-to-day maintenance tasks are typically not repeated often enough or with enough similarity for studied measurements. In addition, management might be reluctant to press for early PM completion where one of the objectives of PM is to take care of all necessary minor adjustments.

Pigeon-holing offers another option for estimating jobs. Pigeon-holing involves estimating a job's time requirements by referring to a table or index of similar jobs and making adjustments for particular job differences. For example, if the job at hand is to rebuild a 25-GPM pump, the planner might refer to a table for pump work. The planner finds a suitable chart showing overhauls for 20-, 50-, 100-, and 200-GPM pumps. The planner figures that a rebuild is probably about the same as an overhaul and adds a little time to the estimate offered for the 20-GPM pump. The problem with this effort is the time consumed finding and using the correct tables even if they are available.

There are industrial engineering estimates available for minute portions of tasks that are generic to many jobs the planner is planning. Times for taking off individual bolts of various sizes, walking certain distances, and particular hand or body motions are given. The planner could build up a time estimate for different maintenance operations using these standards. It is doubtful that the estimates these builtup estimates would yield would be worth the planner's time in creating them.

In certain industries such as maintenance of automobiles, auto shops have available books of standards for almost any maintenance task regarding almost any car. The great numbers of identical cars make these books possible.

The jobs in many industrial plants do not yield themselves as well to such universal standards. These plants use a variety of equipment in a host of different applications. The plants also have unique spatial or geographic layouts and unique maintenance facilities and personnel skills.

The objective in planning is to help boost labor productivity, not create perfect time estimates or meet standards. On the bottom line, maintenance supervisors need estimates to help schedule and control work assignments. In practical application, the estimates that a qualified planner can make based on personal experience supplemented by file information are entirely adequate. The planners' estimates are therefore considered the plant's standards for jobs even though they are not "engineered standards."

This need for an easily determined time estimate that the field technicians will respect is one of the reasons a planner must possess the skills of a top level technician.

Two issues arise after accepting how the planner determines the job estimate. Should the planner plan for a certain skill level and should the planner allow time for delays? The resolution to both of these concerns is that the planner estimates how long the job should take a *good* technician without *unanticipated* delays.

These concerns are discussed briefly here and more thoroughly in the Chap. 5 section on estimating work hours and job duration. First, the planner wants to set a standard for performance through the estimate. The planner does not want to set an ambitious target or goal. The planner wants the standard to be met, but at the same time provide for proper maintenance execution of the work. The planner does this by deciding that every job will be done by a good technician. This methodology encourages most technicians on most jobs although it requires the supervisor to shore up weaker technicians on certain jobs. Second, the planner does not allow extra time for delays that the planner does not expect. This keeps the estimate accurate when the technicians encounter no delays, and provides the supervisor a reference time for controlling the work when unexpected delays do occur. The supervisor can judge the appropriateness of the performance taking into account the specific delays dealt with and the time estimated for the job without those delays. Setting time estimates for jobs not to include extra time for unanticipated delays also sets forth the expectation that maintenance should proceed as expeditiously as possible under normal conditions.

Another issue regarding the expertise of the planner involves skills outside the normal experience of the planner. Some jobs require crafts outside the background of the planner. An example might be a requirement of electrical work on a mostly mechanical job. The mechanical planner has several options. The planner might ask an electrical planner for input. If there is no established planner for electrical work, the planner might also consult an electrical technician or leave it up to the electrical craft supervisor to coordinate the electrical input at the time of work assignment. The planner might also be able to provide basic file information from previous jobs that might be helpful to the electricians. A mechanical planner might even have difficulty planning certain mechanical tasks. Many pieces of equipment have become so specialized that not all technicians within the same craft might be familiar with them. In these cases the planner simply consults with the specialists who have knowledge. The planner attempts to provide useful information regarding scope, schedule, and file data even on these jobs to help the later scheduling and execution efforts. In certain plants planners may become specialists in planning different work and do not attempt to plan all the jobs. Jobs requiring the expertise of another planner are referred appropriately.

Two final issues regarding planner training include maintaining a planner's craft skills and developing skills in specialized planning techniques. First, experience has shown that a planner retains practical knowledge of craft skills even when not applying them in the field. This is because of the close association to the actual maintenance through the planning duties. These planning duties allow the planner continually to develop strategies for jobs and review feedback from actual execution. The planner also spends significant time in the field talking to technicians and supervisors. Second, there are formal courses available for training planners in planning techniques, but on-the-job training provides the most effective training of planners. An experienced planner guides the new planner through the processes. The first planning principle to keep the planners in a separate group together facilitates this learning.

Illustrations

The following illustrations demonstrate this principle of planning. The first section shows problems occurring as a result of not following the principle. The second section shows success through application of the principle.

Not This Way. The planner sat down to estimate ten jobs. Lynn was by classification an apprentice who had completed all of the requirements necessary for promotion to technician and was waiting for a technician job to become available. He had been one of the few persons interested in the job as planner when it became available. The first job was a pump alignment. He had been trained and done several alignments, but never on a pump of this size. He looked in the file and was able to find a previous alignment work order for this very pump. The previous work order had estimated 10 hours for the task and the actual field technician had reported taking 10 hours. Lynn therefore used 10 hours as the job estimate. The second job required rebuilding a fan and there was no previous information available. Fortunately, Lynn had personally been involved in two rebuilds of either this same fan or its redundant spare nearby in the same service. He felt very confident that the job should take two persons a total of two days. However, just in case something came up, Lynn put an extra half day into the estimate. Lynn continued to estimate times for the remainder of the jobs.

Later the mechanical supervisor who was about to assign several of the jobs looked at the pump alignment and fan rebuild work orders. Brittany had not had a chance to see the jobs in the field and was inclined to accept the estimate of the planner who had. Still she wondered why the alignment procedure should take so long.

The technician received the pump alignment work order and knew right away that the alignment would only take 4 or 5 hours. Dana decided she would spend the morning setting up for the job and complete it in the afternoon. That would ensure a quality job. After completing the alignment, she reported to her supervisor an hour before the shift ended. The job had only taken 9 hours instead of the estimated 10.

Meanwhile, Scott and Fred had received the fan rebuild assignment. Surprisingly, the total job lasted exactly two and one half days as estimated even though there had been several unexpected delays. Fred had been temporarily reassigned for several hours at one point. One bearing had also been damaged beyond repair and a new one had been obtained from inventory.

Several days later Lynn received the completed work orders for both jobs for filing. The alignment had only taken 9 hours Lynn observed and the fan rebuild had apparently gone off exactly as planned since no unusual feedback was reported.

This Way. The planner sat down to estimate ten jobs. Lynn had been a certified mechanic with over 15 years of experience. He had competed for the job of planner when it became available since it was a promotion. Lynn had been able to pass the test and interviews successfully. The first job was a pump alignment. He had aligned most of the pumps in the plant in his 15 years including this one. He looked in the file and was able to find a previous alignment work order for this very pump. The previous work order had estimated 10 hours for the task and the actual field technician had reported taking 10 hours. There did not seem to be any unusual reasons the alignment had taken so long for the last person. Lynn thought that most good mechanics ought to be able to align the pump in about 5 hours. Lynn used 5 hours for the estimate. The second job required rebuilding a fan and there was no previous information available. Fortunately, Lynn had personally been involved in two rebuilds of either this same fan or its redundant spare nearby in the same service. He felt very confident that the job should take two persons a total of two days. Lynn used that for the estimate. Lynn continued to estimate times for the remainder of the jobs.

Later the mechanical supervisor who later was about to assign several of the jobs looked at the pump alignment and fan rebuild work orders. Brittany had not had a chance to see the jobs in the field and was inclined to accept the estimate of the planner who had. She had confidence in Lynn's ability to estimate the jobs.

The technician received the pump alignment work order and knew right away that the alignment would take 4 or 5 hours. Dana spent the morning setting up and aligning the pump. No unusual delays came up and she reported to her supervisor an hour after lunch. The job had taken 6 hours instead of the estimated 5.

Meanwhile, Scott and Fred had received the fan rebuild assignment. The total job had run over about a half day because there had been several unexpected delays. Fred had been temporarily reassigned for several hours at one point. One bearing had also been damaged beyond repair and a new one had been obtained from inventory. Scott, the lead technician, carefully explained the delays on the work order after the job was completed.

Several days later Lynn received the completed work orders for both jobs for filing. The alignment had taken an extra hour Lynn observed and the fan rebuild had run into problems according to the feedback. An extra hour shorter or longer was not unusual nor was a problem for most jobs since estimating was not an exact science. The bearing damage was a concern, however, and Lynn knew that it would be advisable either to have the bearing inventory number available or stage the bearing the next time the crew rebuilt the fan.

The experience of the planners makes a big difference in the success of planning. Planners must have the skills of a top level technician to create timely, useful estimates necessary for increasing labor productivity.

This discussion has concentrated chiefly on the general scope and time estimates of the job plans. The following principle addresses the specific content of the job plans regarding maintenance procedures and specific details. Although top level technicians should be utilized for planners, there is still a great reliance on the craft skills. The utilization of superior skilled planners does not mean that unskilled technicians are acceptable in the work force.

PRINCIPLE 5: RECOGNIZE THE SKILL OF THE CRAFTS

Planning Principle 5 (Fig. 2.8) states

> *The Planning Department recognizes the skill of the crafts. In general, the planner's responsibility is "what" and the craft technician's responsibility is "how." The planner determines the scope of the work request including clarification of the originator's intent where necessary. (Work requiring engineering is sent to plant engineering before planning.) The planner then plans the general strategy of the work (such as repair or replace). The craft technicians use their expertise to determine how to make the specified repair or replacement. This arrangement does not preclude the planners from being helpful by attaching procedures from the file for reference.*

This principle dictates that planners count on the work force being sufficiently skilled so that the planners can get all the work planned through putting a minimum level of detail into job plans. Strict adherence to the job plan is not required of technicians as long as feedback is received at job completion.

The crossroads encountered regarding this principle is primarily a choice between producing highly detailed job plans for minimally skilled crafts or producing less detailed job plans for highly trained crafts. An associated issue involves whether all the work should be planned or are there only certain jobs that would benefit from planning.

✦Principle 5

Plans Recognize the

Skill of the Crafts

✦What, Why - Not How

✦Some Standard Plans

✦Some Engineering?

✦Coordination of Engineering

FIGURE 2.8 The planning department's guidelines on level of detail.

Another issue is whether strict adherence to a job plan by the technicians is required. The resolution of these questions regards considering the company's desire for productivity and quality.

Planning promotes productivity by examining work for potential delays and scheduling work. Planning and scheduling more work increases labor productivity. Nearly all work has potential for delays and benefits from learning from past history, and so most work merits planning attention. The plant has better control over work that is scheduled, and so most work merits some schedule control. The objective of the plant is to complete work. To assist the plant in completing work, planners need to plan most of the plant's work. First, planners have to be careful not to put so much detail in a plan that they cannot get around to planning all the work. A general strategy for 100% of the work hours is preferable to developing a detailed plan for only 20% of the work hours. How much detail should planners put into plans? If there is a procedure already in the file or the persons who worked on the equipment previously wrote down some things that are important, the planner will include those items in the work package. If no file information exists, planners do not spend a lot of time developing a procedure. The planners must respect that the craftpersons know how to work on something. The planner is in a sense developing a "performance spec." That is, the plan describes the intent of what needs to be done, not necessarily how best to accomplish it.

In addition, there are frequently different ways to do the same job, and the plant generally wants the technician to do the job in the way in which the technician is most familiar. Classical industrial engineering seems to hold another view, namely that there is one best way to perform each job. However, engineered standards help productivity for jobs that are repeated twice per day, not twice per year or less. In other words, planning seeks more to avoid past delays and provide scope and scheduling assistance than to minutely examine each welder's technique on any individual job. In addition, individuals generally have perfected their individual methods of accomplishing routine tasks. Requiring a technician to perform a particular task in a way less familiar, though not necessarily superior, may lead to lower quality simply from unfamiliarity. It is the supervisor's job to help promote good work practices, not the planner's job to dictate consistency among equally valid work practices.

In addition, continual iterations back through planning to approve every modification to the plan is a deterrent to productivity. It is also unfair to both groups to consider that the planner who has not taken the time to disassemble a device to have perfect knowledge. Vital information might only be practical for the field tech to discover and handle.

On the other hand, there may be a procedure already in the file or persons who worked on the equipment previously recorded information that was important. The planner would include those filed items in the planned package. In addition certain tasks such as a large pump overhaul may benefit from the planner having a "standard plan." This plan would describe steps and procedures unique to certain equipment and not likely to be subject to individual preference.

Planning concentrates on adding value. Before there was a planning function in existence, the technicians had to decide how to accomplish the work requests. Planning does not take over this function, but rather adds a new function of value. The planners give the tech a head start from scoping the field situation and reviewing the history file review, and planners give the supervisor information for scheduling control.

Therefore the planners must count on the skill of the crafts. Supervisors must shore up technicians with deficient skills rather than have the planners planning jobs for a lower skill level.

Even when including a minimum of detail, the planner must be cognizant to include certain information. First, a planner should include information as to why the planner chose a certain job strategy, especially when the file history helped make the decision. For example, "This valve is being replaced since patching it in the past has not worked well" (the planner knows the file history). The technician needs this information to avoid making unwise field decisions. A planner at one company reviewed the history file and recommended a valve be replaced because of past unsuccessful repair attempts. The planner did not mention the history leading to the replacement decision on the job plan. Consequently, when the technician finished the job, he returned the completed work order with the following feedback, "I saved the company money by repairing the valve instead of replacing it." Second, the planner should include known legal or regulatory requirements if adherence to a particular procedure is necessary and not commonly known by technicians.

The company is also interested in quality of maintenance. Responsibility and satisfaction through ownership contribute to quality. There are different schools of thought for ownership of work orders.

One school believes that technicians must execute the job precisely as planned for two reasons. One reason is that the planner had access to the necessary information including specifications, history, and engineering to develop the proper job plan. Any deviations from the job plan must be approved by planning before execution, and recommended changes that appear during the job execution must also be immediately coordinated with planning for approval. A second reason is that restricting execution to the plan ensures reliable history records without having to count on accurate job feedback. One can recognize this school by work order forms or computer systems that have limited or no space for reporting job feedback. An example of an area where this may be appropriate would be an automobile repair shop. One would like to approve any work done to one's car before it is begun. This type of arrangement normally has a larger planning staff because of the iterations sometimes necessary before a job can commence. So in the first school where the planning department essentially owns all jobs throughout the work process, a more substantial planning investment is required and less emphasis is placed on technician competency for determining the job scope and procedure for execution. Better history records are thought to come from less dependency on field feedback.

On the other hand, this book follows another school of thought. While a methodology of strict adherence to job plans may be necessary for some industries (nuclear power comes to mind), it could be counterproductive. In the first place, planners do not possess the time to develop a detailed step-by-step procedure for every job. In addition, even if they did, field technicians may have an equally valid way to execute the job in which they are more comfortable. In the second place, technicians are skilled, knowledgeable, and empowered. This is the type of employee a company desires to develop if it has not already. The company expects the technician to know the proper method to execute most of the routine, day-to-day maintenance operations, which is the focus for improving productivity. If technicians have questions or problems, they can contact their supervisors or they themselves can access the equipment files. The best planning practice prefers that 30 technicians do a little hunting around rather than a single planner continuously helping jobs-in-progress or trying to plan for every conceivable contingency on every future job. The technician giving feedback helps the planner anticipate probable specific delays to avoid on repeated specific jobs. The first school of thought keeps ownership in the hands of the planners for control of the work. On the other hand, the second school of thought keeps moving ownership of the job to the current holder of the work order. This second school is the accepted model for this book. When the job is being planned, the planner owns and controls the work order. Later, after assignment, the field technician owns the work order and is responsible for it. When the job is being planned, the planner uses field scoping, file information, and per-

Attachment 1a

sonal experience to develop a good general job scope for the right job avoiding past or other anticipated delays. Planning has given the technician a head start. Scheduling has given the technician a time requirement. When the technicians receive the work order in the field, it is their job. They own it. The technician is part of a team in the process, however, and this process requires good feedback for file history to help future work. In the second school adopted by this book where the ownership actually passes to the field technicians, a leaner planning effort requires more competent and empowered field technicians. A higher reliance is made on receiving good feedback to make history records accurate and allow avoiding future job delays.

This arrangement could be a stumbling block for the planning group that feels they "own" all the jobs from start to finish and are responsible for making sure the crews execute the jobs properly. Explicit advice is necessary to these planners to reorient their thinking to the team concept.

Keep in mind that the skill of the technicians does not mean that anything will do. The principle requires that skilled technicians will know what standards to follow for their craft specialty. This may involve their being able to follow a provided technical manual correctly. A certified welder will know how to perform weld heat treatment. A skilled mechanic will be able to follow and perhaps improve upon a guide to rebuild a boiler feed pump. The planner may have to provide particular standards for particular jobs such as unusual safety precautions or machine tolerances. Warren Riggs and Harrington of Eastman Kodak (1995) correctly note that empowerment is in direct conflict to standards and that some jobs require standards.

After planning the job, the planner no longer owns the job. The planner gives the technician a head start on the job, but the technician now owns the job. After beginning the job, the technicians are free to accomplish the job scope as they see fit. They may have a closer intimacy with the job than the planner had time to develop. The technicians must give feedback on any job changes or delays encountered so that future plans can benefit.

Once planning accepts this principle, planned coverage can take a big leap as shown in Fig. 2.9. Planned coverage is the percentage of all work hours spent on planned jobs. 100% planned coverage would indicate that the company spends all labor hours on work

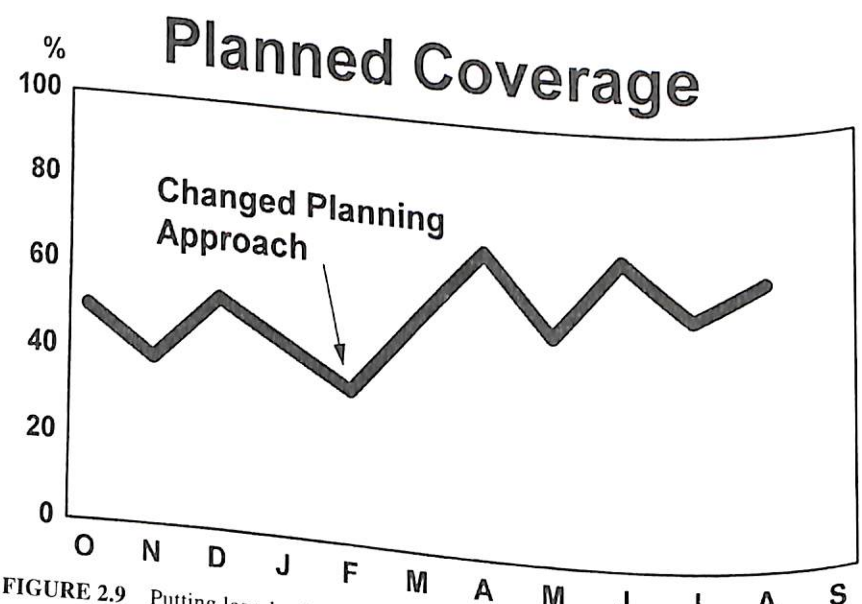

FIGURE 2.9 Putting less detail on plans.

assignments only on planned jobs. 50% planned coverage would indicate that the company spends half of the labor hours on planned work. This company was able to move from work crews spending only about 45% of their work hours on planned work to about 65% of the work. The company made the improvement simply by changing its approach to allow more dependency of the skill of the technicians. Planners were able to plan more work for the crews by spending less time specifying unnecessary details. Craft satisfaction with the work plans also increased as technicians felt more responsible for determining particular craft operations. Not only were planners planning more of the work, but they were no longer insulting the technicians.

Here is another sensitive area for an existing planning group that management billed as putting total information on every plan. The less skilled technicians may begin complaining when less details start to appear on job plans. Communication and management commitment to the program must focus here on the purpose of planning. One of the problems is that unless they are informed, technicians and supervisors may not understand how helpful a simple job plan is. A simple job plan may have a good job scope, craft identification, and time estimates along with a knowledge of previous job delays to avoid. The supervisor must accept the responsibility to assist weaker technicians on certain jobs.

The crew supervisor still has an option regarding work plans deemed unsatisfactory. The supervisors can return job plans to planning for additional detail or information as long as they have not yet assigned the work. Once the work has been assigned or has commenced, the crew owns it and should resolve problems and give appropriate feedback to improve future planning efforts.

Finally, engineering assistance merits some comment. Planners should plan work within their level of expertise. Planners should recognize, but not become bogged down with, design considerations beyond their expertise. The planner is responsible for coordinating work requested for plant engineering where appropriate. The planner still owns the job at this point and should request a quick turnaround of answers to routine questions. If the questions point to an extended effort on the part of engineering, the planner should take other steps. The planner should formally assign the work order to the engineering group or otherwise request that a project be initiated. A few plants have an engineer assigned under the planning supervisor to provide easy access to engineering support. This engineer would answer uncomplicated questions and coordinate questions requiring more extensive research or determination. Utilize caution when mixing a staff engineer into the production environment of the planning department. The planners must not become staff assistants to the engineer gathering file information. Planners must not become distracted from their planning chores.

Illustrations

The following illustrations demonstrate this principle of planning. The first section shows problems occurring as a result of not following the principle. The second section shows success through application of the principle.

Not This Way. Typically it seemed the crews worked only about one out of five jobs on a planned basis. This distressed Hosea, the supervisor of planning. The problem was not so much that the supervisors did not want the planned work, but that planning simply could not get to the jobs before the crew had run out of planned work. In these cases the crew naturally turned its attention to the unplanned work backlog. There were ample planners. There were five planners for only 100 technicians. The planners were busy as well. The planners continually worked to provide detailed procedures on every plan.

The problem with the crews working unplanned work was that they were simply not able to take advantage of parts lists or other information the planners had available from past work. Supervisors also had inadequate information to control schedules. That brought up another problem. With the planners being so busy, they were not filing all of the completed work orders. So even on planned jobs, the files were not as helpful as they might be.

There were also some indications that particular members of some of the crews thought planning was a "waste of time," in their words. Hosea had talked to one electrician who told him flat out that he did not need to be told how to run a conduit. This electrician had felt irritated at the thought that he had to be baby sat.

One of the planners had also expressed irritation recently, but not for the same reason. This planner was upset that the crew supervisor had not taken the plan's advice to rewind a motor in-house. Instead the supervisor had agreed with the technician to send the motor out to a local motor shop. The planner wanted to know why the supervisor did not understand that in-house work could provide better quality. The planner asked if Hosea would bring the matter to the plant manager to resolve.

This Way. Typically it seemed the crews worked about four out of five jobs on a planned basis. This was acceptable to Hosea, the supervisor of planning. The problem was not so much that the supervisors did not want the planned work, but that sometimes the supervisors directed technicians to unplanned work. The unplanned work was pressing and did not appear to require much planning. Hosea knew that after becoming more used to planning, they would want even more of their jobs reviewed by planners before starting them. There were ample planners. There were five planners for only 100 technicians. The planners were busy as well. The planners continually worked to provide adequate job scopes, time and craft estimates, file parts information, and other notes to help avoid previous job delays. The planners were able to provide planning for all the work orders that the supervisors had not immediately written up and started themselves.

The advantage of the crews working mostly planned work was that they were able to take advantage of parts lists or other information the planners had available from past work. Supervisors also had adequate information to control schedules. The planners were busy, but still filed all of the completed work orders. So to improve all of the planned jobs, the files were becoming ever much more helpful.

There were still a few technicians that did not understand how helpful the scoping and file information were to them or the scheduling information was to their supervisor. Some technicians thought that without a detailed, step-by-step procedure, planning was a waste of time, in their words. Hosea had talked to one electrician who told him he did not receive a diagram on how to run some field conduit. Hosea carefully explained to the technician that the planner had considered this to be a field decision. On the other hand, the planner had reserved 60 feet of conduit to avoid a parts delay, enough to satisfy any layout.

The planners had accepted their roles of giving the technicians a head start and the planner duty carefully to save any feedback on actual job performance. One of the planners had recently received feedback that a plan to rewind a motor in-house had been contracted. The planner made sure to record the contract motor shop's address and warrantee information for the files. The planner also checked with the supervisor to see if future plans should consider such an option or if this was just a one-time event.

Planning provides the what, the technicians provide the how. This ensures that the company best leverages the skill of the technicians. The company wants the technicians to do what they were trained to do. At the same time, this allows the planners to ensure planning all the work so that every job can have the benefit of advance planning. This principle presumes the company invests in the acquisition and training to produce and maintain a staff of skilled technicians. Planning gives skilled technicians a head start.

PRINCIPLE 6: MEASURE PERFORMANCE WITH WORK SAMPLING

Planning Principle 6 states

> *Wrench time is the primary measure of work force efficiency and of planning and scheduling effectiveness. Wrench time is the proportion of available-to-work time during which craft technicians are not being kept from productively working on a job site by delays such as waiting for assignment, clearance, parts, tools, instructions, travel, coordination with other crafts, or equipment information. Work that is planned before assignment reduces unnecessary delays during jobs and work that is scheduled reduces delays between jobs.*

Principle 6 ordains that measuring how much time craft technicians actually spend on the job site versus other activities such as obtaining parts or tools determines the effectiveness of the maintenance planning program. This principle holds that delays are not simply part of a technician's job and should be avoided. Figure 2.10 shows an example of the distribution of technician time. Only category 1 is productive time on the job. All of the other categories identify delay time.

The mind of management must resolve two crossroads considerations. (1) Does management have a specific mission for planning to keep technicians on job sites or does

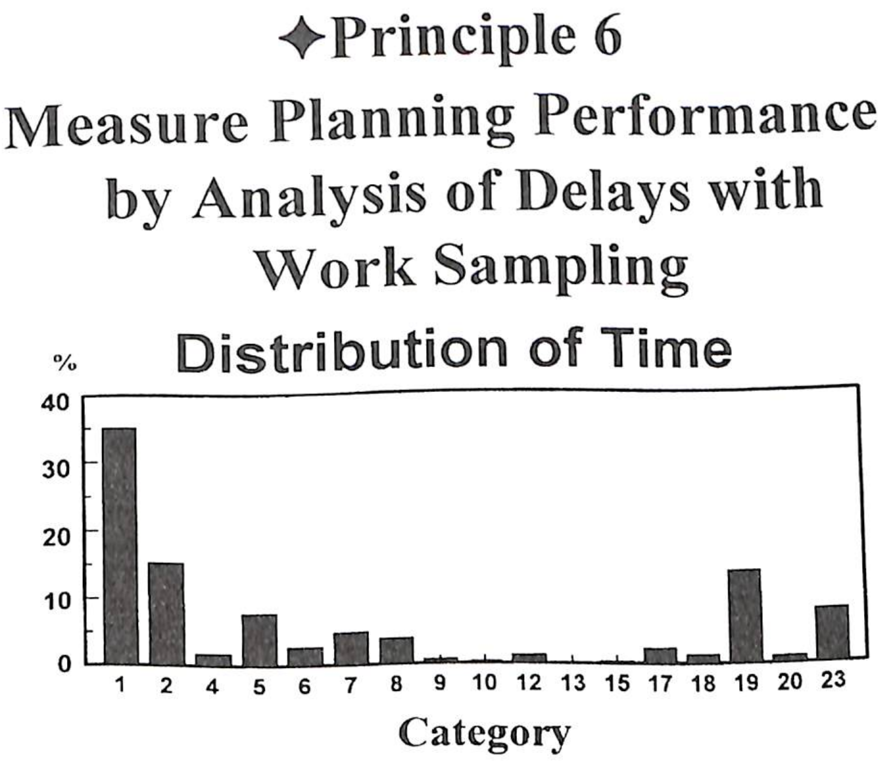

FIGURE 2.10 This company's time on the job is only 35%.

management have a more vague idea of planning somehow contributing to effectiveness? (2) Is working in a delay area such as obtaining parts or tools merely part of the job or is it a delay to be avoided? Does management's strategic vision involve moving technicians out of delay areas and onto job sites or does the vision only have technicians working hard to do everything necessary.

The purpose of planning is to help put everyone on their tools in front of a job instead of traveling, waiting for parts, or otherwise being delayed. The purpose of planning does not include making sure persons are productively working once they are in front of a job and not being delayed. The issue of productively working once on a job is important, but it is not centrally associated with planning (other than the planner setting an informal time standard through the estimate). Nevertheless, consider that whether or not time in front of a job is as productive as possible, simply increasing the proportion of time so spent by a work force should increase the number of jobs completed by maintenance. That improvement is the purpose of planning. Similarly, planning is not concerned with administrative time spent for activities such as training, meetings, or vacation. Planning concerns itself with the time technicians do have available to work under the control of their supervisors.

Work sampling (also known as wrench time) gives this measure of how much planning helps. The time the employees are at their job sites working is called direct or productive work. At issue is not so much the time the technician spends doing productive work. What is actually important is the analysis of the nonproductive time. For example, how much time is spent waiting for parts; how much time for tools; how much time for instruction? If the technician is obtaining a part, instruction, or tools, the job is actually not progressing. Separate studies done over time indicate if planning is becoming better or worse with regard to reducing these delays. Has the time waiting for parts gone down; has time waiting for tools gone down; has time waiting for instruction gone down? Interestingly, measuring the technicians tells about the planning function, not the technicians. The planning tool should have an effect on the technicians.

The interesting thing about this principle is that it does not make planning work per se, it only measures how well planning is working. A company could believe in planning and successfully implement planning according to the other planning principles without ever conducting a wrench time study. Similarly an automobile could function flawlessly without a speedometer. Nonetheless, measuring wrench time does tell directly if the objectives of planning are being met. The objectives of planning are to reduce delay times and put technicians on their tools. Measuring wrench time thus also gives an overall indication of how well the other principles have been implemented or accepted. The other principles must be in place for planning to succeed. Wrench time analysis is an indicator, not the control of planning or the work force. Chapter 10 deals exclusively with the control of planning.

While management might not use wrench time measurement to conduct or control planning, it might use it to demonstrate the need for planning. Maintenance planning effectively helps improve labor productivity exactly because there is such a great misunderstanding of the current level of direct work time. That is why analysts present the results of work sampling studies to management, supervisors, and technicians. The realization that delays consume over 70% of work force time and direct work is less than 30% generates extremely beneficial dialogue toward accepting the concept of planning and productivity improvement. An important issue is that everyone understands that while technicians are being paid by the hour to handle delays, the company is not receiving any benefit from such activities. The company benefits when productive maintenance keeps equipment in service to make a product for market. The company does not benefit from avoidable activities that consume over 70% of its work force labor hours. Such a discussion time is a marvelous opportunity to explain that delays are undesirable.

The technicians view the results of the initial wrench time studies as even more remarkable when they realize that during the course of the study, they had made a special effort to be productive. That means the observation effect of the study showed the results to be even more confirming that at best the productivity had been less than 30%.

Simply conducting a wrench time study to illustrate what planning is all about and why the company employs technicians (to work on equipment) could be worth more than the results of any study itself. The measuring of wrench time does not yield planning improvement, it only quantifies it. A properly structured planning system within a maintenance organization yields the improvement whether or not it is measured.

It is difficult to agree with industry claims that productive time could possibly be so low without the results of a valid study. One supervisor submitted a scenario showing how hard it would be for an employee to try to have such a low wrench time. This supervisor showed a theoretical technician through an average day. The tech first took 30 minutes to start going in the morning. During the course of the day the tech spent 45 minutes receiving instructions from the supervisors and 60 minutes waiting at either the tool room or storeroom. 45 minutes were consumed traveling. The tech took a total of 90 minutes in breaks and 30 extra minutes for lunch. The tech also took 90 minutes for showering and otherwise getting ready to go home at the end of the day. With all this wasted time, the tech had only 210 minutes left out of the 10-hour shift for work. This time arrangement netted the tech a 35% wrench time and 65% delay time. Incredible as it seems, the typical wrench time reported in industry ranges between 25% and 35%. While some employees at each plant are in more productive situations than others, studies show overall productivity measurements are in this range. A few minutes here and there add up to a productivity problem with significant delays.

Wrench time is accurately measured with a properly structured, statistical observation study. The study sets up statistical procedures to ensure proper observation techniques. Generally, a study conducts observations over several weeks or months to ensure a time period representative of the work force's normal activities. An observer has a list of maintenance employees at the plant each day of the study and has a methodology for selecting a sample of employees to locate each half hour or other time period. The first moment the observer locates a selected employee, the observer categorizes the activity as a type of work or delay. The observer does not merely follow an employee around to gain observations. The observer also does not locate jobs instead of persons because some persons may not be even assigned to work. At the end of the study, the study reports the proportions of observations in each category. Appendices G and H present actual work sampling studies conducted at an electric utility.

Other less formal methods of measuring wrench time have been explored. One method has been to have several individuals in the work force carry special scorecards. A clerk pages these individuals at specified random times during the day. When a person's pager goes off, that person records the appropriate category on the scorecard. The problems with this method are several. First, there is not a single person deciding the appropriate category to use. Second, there tends to be great reluctance on the part of any but the most productive employees to participate and carry a scorecard. Third, this method requires extreme integrity on everyone's part instead of on a single observer. Fourth, there is also extreme "observation effect" in that the person being measured is continually aware of the ongoing measurement. As might be expected, studies using this method have recorded average wrench times about 20 to 25% higher than what a normal study would show on the same work force. That means when the actual work force wrench time was probably about 35%, there would be reports of 55 to 60%. On the other hand, studies such as this can often be conducted with good humor and effectiveness, not to find out wrench time, but to help educate the work force of the importance of direct work versus delay activities.

Similarly, efforts to have entire crews where everyone keeps track of their daily time in the different categories have resulted in reported wrench time hardly ever below 80%. These studies with everyone participating even if just to raise awareness are probably not a good idea. They seem to degenerate into a "liars' club," damaging the integrity of everyone and everything, including the wrench time concept. It is about impossible for an individual to keep track of the minute-to-minute delays that impact one's work on a continual basis. This factor combined with the often disbelief that wrench time could be fairly low anyway leads everyone to guess high. Consider this point applicable to work order or time sheet systems that expect everyone accurately to quantify all their delays during a job or time period.

Nearly everyone has apprehensions that conducting a wrench time study could be taken by supervisors and technicians in a mean-spirited way. That does not have to be the case. Communicate the reasons before, during, and after the study. After the study report the results to everyone. It is difficult to imagine too many persons objecting to a program designed to boost productivity only to 55%. Also, after some studies work forces were able to demonstrate the need for new tool boxes, a better storeroom, and even go-carts. During the study consider using a familiar, agreeable person as the observer.

A further mention of administrative time is appropriate in the discussion of wrench time. The wrench time study observations do not include any employees not available for work. If employees are scheduled for training all day, those employees are not observed. This administrative time is time the company has decided to invest other than for immediate work. On the other hand, consider the implications about wrench time. Consider if employees are only available for work 80% of the time because of administrative time. A wrench time of only 35% is only a measure of the percentage of time available to work that the employee was directly working. The percentage of time paid that the employee was directly working was a mere 28% (35% × 80%). Looking at the cost to the company another way, say that the technician is paid $25 per hour. Because the employee is only working 28% of that time on the average, the company actually pays $89 for work that the employee accomplishes. This is why contracted repair persons charge a seemingly high rate for time spent at the company's location. The work force needs to understand its own high cost to the company and join forces with management to raise productive time and lower the rate of company labor cost. While planning can help with the productive portion of available time, the company cannot take the impact of the other administrative time lightly. The company must balance among providing competitive company benefits, investing in training, and making technicians available to work.

Illustrations

The following illustrations demonstrate this principle of planning. The first section shows problems occurring as a result of not following the principle. The second section shows success through application of the principle.

Not This Way. Management could not understand why reliability continued its slow decline. From discussions with the planning department, nothing seemed to be out of the ordinary. The crew supervisors claimed to have their hands full, but were able to stay on top of things.

This Way. Management could not understand at first why reliability continued its slow decline. From discussions with the planning department, nothing seemed to be out of the ordinary. The crew supervisors claimed to have their hands full, but were able to stay on top of things. However, from observing the general state of the work force, management suspected a lower than desirable productivity. Management had noticed lines at both the tool counters and storerooms. In addition, it appeared that breaks were somewhat excessive. Management decided that direct work time on the jobs needed to be improved and that meant there was a problem with the planning and scheduling process.

Planning has the responsibility to help move personnel onto jobs and out of delay situations. Even without making formal measurements, understanding this concept of wrench time as valuable time and delay time as waste leads to improvement. Properly conducted studies can quantify the direct work time, help educate the work force on the need for improvement, and demonstrate improvements. The wrench time is not so much a measure of the work force's performance, but that of the success of the leverage being employed by the planning process. Planning takes direct aim at reducing the causes of job delays.

SUMMARY

So far the planning effort has mainly focused on making individual jobs ready to go by identifying and planning around potential delays. Consideration of six basic principles greatly boosts the planning program efforts toward success. Each principle resolves a crossroads decision that affects the planning effort. At each crossroads, the company has to make a decision regarding alternate ways to conduct planning. The decision the company makes regarding each situation determines the ultimate success of planning. Each principle presents the recommended solution to the crossroads. While a plant must incorporate or consider all of the planning principles to be successful, ignoring a single one can often spell the ineffectiveness of the entire planning effort.

The principles are having planning in a separate department, focusing on future work, having component level files, using planner expertise to create estimates, recognizing the skill of the crafts, and measuring planning performance with work sampling for technician direct work time. Having planners separate from the control of crew supervisors avoids the temptation of using planners for field work instead of for planning. Planners also need to avoid continually being interrupted to resolve problems for jobs already under way. Planners need to focus on future work not yet begun. Because most jobs are repetitive, file history can help technicians avoid previous problems encountered. Only when planning keeps a separate file for each piece of equipment is it practical to retrieve information when needed. Planners must possess the experience of top level technicians in order to scope jobs, utilize files, and estimate times adequately. Engineered standards or other sophisticated time estimating techniques are unnecessary to accomplish the specific objectives of maintenance planning. At the same time, craft technicians must also demonstrate considerable skill during job execution. Planners count on technician skill and the planners focus on providing adequate job scopes rather than on providing an abundance of job procedure details. During actual job execution, technicians decide how best to accomplish job scopes and later give adequate feedback for planner files. Finally, wrench time measures whether the objectives of planning are being met, that of reducing job delays.

So utilizing planned work packages increases the maintenance department's ability to complete work orders effectively, efficiently, and safely. With maintenance planning based on the six planning principles, will the planning effort "work"?

Here is what one utility discovered. They had only a marginal planning program. The planning department consisted of apprentices tasked with developing very detailed job plans on lower priority work orders. The crews worked very few of the planned jobs and primarily worked only on unplanned higher priority work as soon as operations wrote the work orders. With only this planning program under way, management commissioned a work sampling study. Wrench time was only 37% and an analysis of the delay areas indicated that the plant could do a better job with parts and tools. This was either symptomatic of tools and parts availability problems or planning problems, or both.

Considering this and other information, the company placed a renewed emphasis on planning. Management replaced the apprentices with technicians for planners. (However, there was no compensation program to make planner pay competitive. In fact, because the plant did not allow planners to work much overtime, the real pay of planners ended up lower than that for most field technicians.) The company also purchased separate hand tools for each craftperson to reduce sharing problems. The company also virtually doubled the number of parts categories carried by the storeroom to reduce ordering needs. A follow-up work sampling study revealed that wrench time was still at only 37%.

Since analysis of the last wrench time study showed travel time was at 22%, management purchased bicycles and golf carts to help reduce travel time. At the same time, however, management overhauled the planning program and adopted the six planning principles. The company took the planners out from under the control of the crews. The company encouraged the technicians not to seek planner assistance for problems on jobs already started. The company adopted an equipment numbering system to begin creating specific equipment files and filing by system ceased. The company again replaced the planning personnel. This time management selected technicians who had all passed the supervisors test, but were yet not promoted due to a lack of positions. These new planners began to rely on the skill of the crafts and focused more on providing good job scopes and estimates rather than on providing detailed job plans. With these principles in place, certainly planning would succeed. The third wrench study revealed only a 35% wrench time. See Fig. 2.11. How surprising since analysis showed travel time had dropped to 15%.

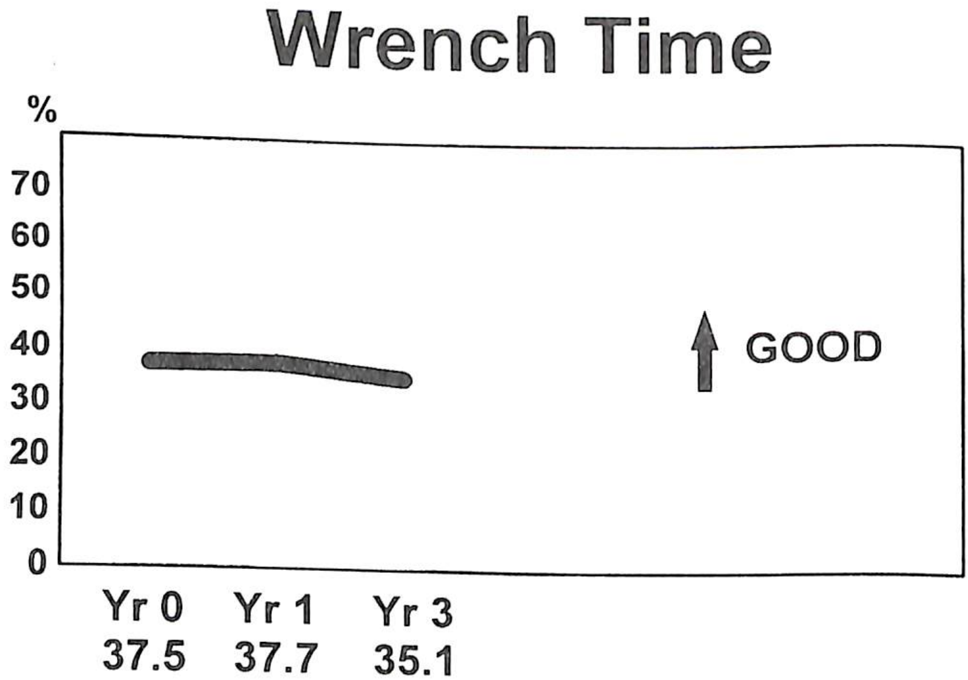

FIGURE 2.11 Different studies over time.

The analysis of this last study revealed a very interesting phenomenon. Large delay times did not exist for parts, tools, instructions, or travel categories. Those were the areas that planning on individual jobs might help to avoid. Large delay times did exist for excessive startup, break, lunch, and shutdown categories. Despite these delay times, to their credit, the technicians had consistently been able to complete all the work assigned them.

Even so, a review of the wrench time for each hour of the day indicated a scenario of how technicians completed their work. When receiving their work for the day, the technicians would scope out the jobs and begin work intermingled with social time and some parts gathering. Then after lunch an incredible burst of activity would see all the work completed where upon the technicians could ease up until the end of the day. Over the years, supervisors had apparently become accustomed to how much work the crews could execute during a day and continued to assign that amount of work every day. The only problem was that now with several systems in place to allow doing more work, supervisors needed to assign more work. Obviously, management needed to consider scheduling of planned work in the planning picture. Maintenance needed some methodology to ensure assigning enough work. This leads to the next chapter on scheduling principles.

CHAPTER 3
SCHEDULING PRINCIPLES

Effective scheduling is inherent in effective planning. This chapter explains the reason why routine maintenance needs scheduling and then presents the principles of effective scheduling. Together, these principles create a framework for successful scheduling of planned maintenance work. Each principle sets guidelines on how maintenance should handle a different portion of the scheduling process.

Just as for planning, six principles greatly contribute to the overall success of scheduling. First, planners plan jobs for the lowest required skill levels. Second, the entire plant must respect the importance of schedules and job priorities. Third, crew supervisors forecast available work hours one week ahead by the highest skills available. Fourth, the schedule assigns planned work for every forecasted work hour available. And sixth, schedule compliance joins wrench time to provide the measure of scheduling effectiveness. Figure 3.1 shows the entire text of these principles.

WHY MAINTENANCE DOES NOT ASSIGN ENOUGH WORK

Aids such as planning good job scopes and having parts identified and ready make it easier to complete maintenance jobs but do not ensure that more work will be done. Adopting all six planning principles from Chap. 2 does not ensure that more work will be done. The reason why is because these aids and principles make it easier to complete individual jobs. That is, each job assigned should be easier to complete than it would have been without such help. If a particular job that used to take about six hours now takes four hours, that does not mean more work was done. Why? The simple reason is that still only a single job was done. Figure 3.2 explains that productivity cannot increase if supervisors do not assign additional work.

Supervisors are typically responsible for assigning individual work orders to technicians, and there are a number of reasons why supervisors might usually assign an insufficient amount of work. In concert, these factors perpetuate a powerful culture to maintain the status quo. This is not a problem of the personalities of the supervisors. It is a system problem encouraged by how plant management has arranged the processes of maintenance.

First, crew supervisors develop a feel for how much work persons should complete in a day. During the past years that seasoned supervisors, no planning function existed. The plant also may not have had an adequate storeroom, tools, or other resources now becoming available. It used to take all day for a few technicians to complete one or two work assignments. The technicians had to work hard and stay busy rounding up parts and tools. Frequently they had to clarify instructions and job scopes during job execution. They persevered and completed their one or two jobs.

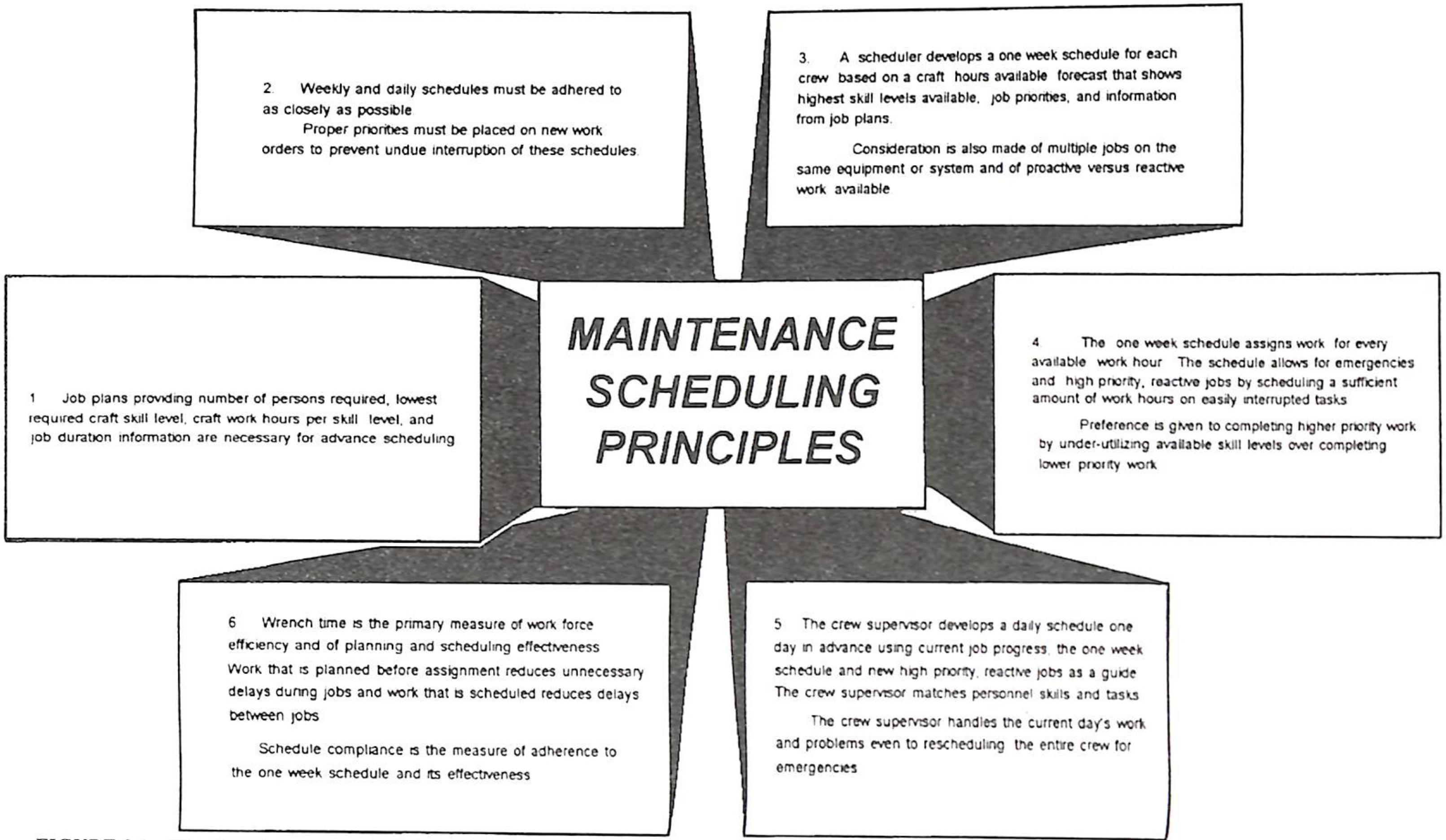

FIGURE 3.1 The six maintenance scheduling principles.

Wrench Time Cannot Improve If Crews Are Not Given More Work

FIGURE 3.2 The reason planning includes scheduling.

Now, however, with it easier to complete those one or two jobs, the maintenance supervisors may not be assigning more work. Habits are hard to change.

Perhaps the supervisors do assign more work. Perhaps they assign two or three jobs to the two technicians. The supervisors would thus feel very supportive of the company mission. But why two or three jobs? Why not four or five?

Now shift to explore another phenomenon. Consider a scheduled outage such as a major overhaul, sometimes called a turnaround. A maintenance schedule dictates the completion of certain jobs, often at certain times. This is true even for many short unscheduled outages for emergency repair. Everyone also shares a sense of urgency. The maintenance group completes a lot of work. Schedule pressure drives the outage. A consideration for doing quality work and doing the work right may alter the schedule, but the maintenance group still completes a lot of work in a short amount of time. However, that is not the phenomenon being considered here. After the outage, the crew supervisors know that they have just accomplished a lot. They have restored production capacity to full availability, and it is time to relax. What? The phenomenon encountered is that the supervisors may think they are rewarding their crews by not pushing for completing a lot of work every day. The supervisor thinks, "How could I expect to work my crew like dogs around the clock during such a critical time and then 'press them' the next day?" The supervisor may feel the outage where everyone works so hard justifies not working so hard later.

In addition, many supervisors feel that the company really does not have quite enough persons during an outage, but that during a regular, nonoutage work day it is a little overstaffed. The supervisor reasons incorrectly that the company has to carry extra persons so it can be ready for the outages. This reasoning is faulty because there is much work that needs to be done on a normal work day for the competitive company. Outages exhaust maintenance personnel because crews work hard, but they always need to work hard to be competitive. One reason they can still work hard without an outage is that normally there should not be an inordinate amount of overtime when there is not an outage situation. Maintenance personnel can work hard for 40 hours each week without being too exhausted.

The crew supervisor may also feel that there is not enough work for the crews on nonoutage days because they are only working on the urgent or high visibility jobs. They may be ignoring the lower priority jobs to prevent future failures. The crews keep somewhat busy fixing those things that break or fail. The high priority jobs give an enormous sense of satisfaction because technicians can directly relate their completion to plant availability. The lower priority jobs' link to availability is less clear. Extra time exists (remember they can now do a 6-hour job in 4 hours) for performing other maintenance jobs to head off failures. Supervisors just do not seem to assign those lower priority tasks. To make this situation even worse, crews try to make the backlog of satisfying jobs last so they do not run out of work.

A related practice is a technician receiving a single job assignment at a time with the understanding to come back for a second job when he or she finishes the first. Three things occur. First, the technician feels that the first job is *the* job for the day unless it is very obvious it should only take an hour or two. So nearly every job becomes an 8- or 10-hour job depending not on the job details but on the hourly shift duration. Second, the psychology of the arrangement encourages the technician to presume the next job is somehow a worse job. The fear of the unknown gives appreciation for the current job. "Why rush through it to go to the next job? In fact, I bet the next job is the worst job in the plant, shoveling out the boiler." Third, if the technician does return for the next job, the crew supervisor "cherry picks" through the backlogged work orders in the order of what is urgent and not necessarily by what is serious. If there is nothing urgent in the backlog, the supervisor may well assign the technician to help someone else on an urgent job currently in progress.

Similar to the manner in which many jobs are assigned or executed as 8- or 10-hour jobs, the practice of assigning two persons to each and every job may exist. True, many jobs require the safety consideration of an extra set of hands, but this practice could become a bad habit. Supervisors as well as planners may always assign two persons, needed or not.

Many of the circumstances just noted support a powerful counterproductive culture of peer pressure. Ample reason exists for not productively completing jobs quickly. Very little reason apparently presents itself otherwise. To try to counter this, many facilities do not even write on the technicians' copy of the work orders how many hours the jobs should take. These facilities fear the technicians will slow down if they know they can beat the time estimate. This is not a recommended practice. The technicians are part of the team and the time estimates help them understand the expectations of the job plan. Maintenance management needs a tool that helps supervisors know how much work to assign.

Thus planning is a maintenance manager's valuable tool. Having the estimates of how long a job should take and the number of persons of each skill required is a simple, overwhelming powerful addition to the situation. If a job plan expressly requires a single welder for only 4 hours, two persons for the entire day is obviously not acceptable. A planned estimate may have reduced a task otherwise consuming two persons, 10 hours each, to a 4-hour task. Real labor savings are available to assign elsewhere. Planning has introduced an element of accountability. This is not to say that the crew supervisors were intentionally mismanaging their resources, but planning provides a helpful tool to counteract the natural tendencies.

On the other hand, remember that only a single job has been completed. Even with individual jobs having time and personnel estimates, the proper application of planning provides an allocation of work for a period for the entire crew. This establishes crew accountability in the form of a check and balance system. The principles of scheduling implement this reasoning. Therefore, planning's primary task is not to provide advance information on parts and tools. The most vital application of planning gives the manager the necessary tool to manage how much work an entire maintenance crew should accomplish.

The utility at the end of Chap. 2 had planning without scheduling. Wrench time studies indicated that planning had freed time from earlier delay areas, but overall productive time did not increase. This was because the maintenance group did not assign more work.

Modern maintenance planning considers advance scheduling as an intricate part of planning. Scheduling is necessary for maintenance improvement. The basics of scheduling are centered on giving enough work to the crews to fill up the crews' forecast of work hours available.

ADVANCE SCHEDULING IS AN ALLOCATION

The basics of scheduling involve giving enough work to employees to fill up a forecast of crew work hours available whether for a day or a week. *Advance scheduling* is actually more of an *allocation* of work and not a detailed *schedule* of exact personnel and time assignments (see Fig. 3.3).

Advance scheduling enough work for an entire week *sets goals* for maximum utilization of available craft hours. It helps ensure assignment of a *sufficient amount* of work. Advance scheduling also helps ensure that *sufficient proactive work* to prevent breakdowns is assigned along with reactive work. It also allows more time to coordinate resources such as *intercraft notification* and *staging* of parts. There is also more time to coordinate doing all the work on a system once the operations group clears the system for maintenance.

The planning department can make the advance schedule. Creating the advance schedule in the planning department involves the serious responsibility of selecting the optimum mix of work for the best interest of both the short- and long-term operation of the plant. The scheduler might consult with an operations coordinator to achieve this optimum mix. The craft crews have the responsibility to execute and complete the preselected work. This arrangement changes the perceived status quo of the decision previously made by the maintenance crew supervisor about what work maintenance should be performed. Now the scheduler decides what work maintenance should be performed, and the crew supervisor is responsible only for performing it. The crew supervisors see this check and balance system as an unnecessary loss of their control. However, the plant priority system that sets priorities for individual work orders remains the primary driver regarding the order in which crews begin different jobs. The schedule has merely provided the supervisors a service by reviewing the entire plant backlog of work and selecting enough work orders for the crews for the coming week. The supervisor no longer has to pick through an entire plant backlog each time to select individual work orders. The supervisor now has a small week's worth of backlog from which to choose.

The vision of planning is simply to increase labor productivity. The mission of planning is to prepare the jobs to increase labor productivity. The mission of scheduling is to allocate the jobs necessary for completion. Scheduling forms an integral part of planning.

✦Advance Schedule - Why?

✦Sets Goals

✦Ensures a Sufficient Amount of Work

✦Staging

✦Intercraft Coordination

✦Ensures Sufficient Proactive Work

FIGURE 3.3 Reasons why advance scheduling helps.

Just as outages benefit from having set schedules, routine maintenance benefits as well. The following principles provide a framework to accomplish effective scheduling.

PRINCIPLE 1: PLAN FOR LOWEST REQUIRED SKILL LEVEL

Scheduling Principle 1 (Fig. 3.4) states

> *Job plans providing number of persons required, lowest required craft skill level, craft work hours per skill level, and job duration information are necessary for advance scheduling.*

Maintenance cannot schedule work without some idea of the number of persons and time frames required. Maintenance job plans provide this information in a manner that allows the efficient scheduling of work.

Maintenance job plans first tell what craft specialties are required. Does a particular job require a welder, a painter, or both? Does the job require mechanics or machinists? Does the job require two mechanics or just one? Does the job require three helpers to assist a certified electrician? How many persons are required?

Consider a job that required a certified welder, but the job plan did not specify the number of persons or craft at all. The supervisor would be limited to assigning persons based solely on an interpretation of the job description. The supervisor might err in sending two mechanics to perform the work. In this case, both mechanics would later return to the supervisor explaining their need for welding assistance. Similarly, if a job requires a highly skilled, certified welder, the job plan cannot specify a mechanic with light structural welding abilities. The supervisor needs the information to assign enough welding expertise to the work order.

On the other hand, the essential part of Principle 1 is that job plans identify the lowest skill necessary to complete the work. By identifying the lowest skill necessary, the crew supervisor has even more capability when assigning individuals to execute each

✦Scheduling Principle 1

Plans with <u>Lowest</u>

Required Skill Level

✦Identify Skills

✦# Persons, # Work Hours, Duration

FIGURE 3.4 Scheduling requires job plan information.

job plan. For example, the job plan should specify one mechanic and one helper if a job requires two persons, but only one needs to be a skilled mechanic. The job plan should not specify two mechanics in this case. The correct specification allows the supervisor who has only a single mechanic to assign the work, presuming the supervisor has other personnel that could be helpers. If the plan incorrectly required two mechanics, the supervisor could assign the work. Consider a job that requires only light structural welding. The plan should not specify a highly skilled, certified welder. Specifying too high of a skill would severely restrict the supervisor who may see a backlog of mostly certified welding jobs but who may have only one certified welder. The supervisor may have several mechanics that were trained to do light welding. Job plans must specify the lowest qualified skill level to give the supervisors the most flexibility.

Another consideration is if a job could be done equally well with different combinations of persons and hours. Perhaps one person could do the job in 10 hours where two persons would require only 5 hours each. How should the planner plan the job? In these circumstances, the planner does not need to go to great lengths to determine the absolute optimum strategy. The planner's feel for the crew supervisor's preferences usually guide these decisions. The supervisor may normally work technicians in pairs or as individuals. However, the planner should not plan the job example just discussed for two persons with 10 hours each.

Job plans also specify the work hours for each craft skill and the total job duration hours. Work hours are not the same thing as job duration hours. Work hours normally differ from job duration hours for a job. Work hours are the individual labor hours required by each technician. Job duration is the straight calendar time the technicians work on the equipment. Each is necessary for scheduling. Consider a job requiring one mechanic and one helper for 5 hours each to rebuild a pump. The job duration is 5 hours, but the work hours total 10 hours. If the job plan called for an additional 5 hours afterward for painting the equipment, the work hours would total 15. There would be 5 hours each for the mechanic, the helper, and the painter. The job duration would be 10 hours since the painter would have to work after the pump was rebuilt.

The schedulers and crew supervisors need to know how many persons each work order requires and for how many hours each. The job plan specification of persons, craft skills, and labor hours gives this information. The schedulers and crew supervisors also need to know when to send or expect back the appropriate persons on each job. The job plan specification of job duration gives this information.

The operations group also needs to know the duration that equipment will be unavailable for production. The additional time necessary for the operations group to clear up or prepare a piece of equipment for maintenance activities or restore it to service are not included in the time estimates for individual jobs. The estimates are primarily for the use of the maintenance group to schedule maintenance resources. The operations group does their own allocation and arrangement of personnel. Advance coordination keeps technicians from sitting around waiting for the operations group to ready equipment.

For outages, the overall outage schedule addresses where the operations group requires time to prepare and restore equipment, but the estimates for individual job plans do not include this information.

Planners should avoid two common traps when estimating the job requirements on plans. One is always assigning two persons. The other trap is setting the time by using half or whole increments of a shift. First, some situations do require two persons for safety reasons or to handle certain job peculiarities. Even work not inherently dangerous might justify needing two persons if located in the midst of an industrial setting away from other personnel. Two persons may also save the overall job time. For example, two technicians might be able to do a certain job spending 2 hours each, whereas a single technician would take 10 hours. However, planners err when they always presume two technicians must work together. Hanging an office bulletin board or repacking certain valves might be jobs for which one person should be planned. Consider also having single technicians carry a communication radio for job safety in some cases. Second, planners make a mistake if they always round off work hours to shift increments. For example, one might see most jobs requiring either 4 or 8 hours for crews that happen to work 8-hour shifts. Likewise, one might see most jobs requiring either 5 or 10 hours for crews that happen to work 10-hour shifts. This practice damages the scheduling effort. Many jobs require only a couple of hours and many jobs do not require an entire shift to complete. Consider a 2-hour job and a 6-hour job. Both of these jobs could be completed in a single 8-hour day. However, maintenance would incorrectly assign them if one job had been planned for 4 hours and the other for 8. In correct practice, planners plan jobs for their true expected time requirements. Then actual scheduling is able to fit jobs together to improve overall productivity.

Planners also frequently need to address other situations peculiar to specific jobs. These are not usually too difficult to handle. Perhaps insulation has to be removed and replaced. Perhaps the operations group could restore the pump to service before painting if painting could be done on-line. The important point to note is that both job duration and work hour estimates are necessary for scheduling work. The job plans provide this information.

One question that companies ask is whether plans or schedules consider a high or low wrench time. Usually, job plans and schedules account for technicians having a high wrench time. Job plans do this because the plan time estimates do not allow for unanticipated delays. Moreover, the job plan attempts to avoid or minimize anticipated job delays that the planner feels could occur during individual jobs. Similarly, the weekly schedule attempts to minimize delays that could occur between individual jobs such as excessive idle time, break time, or assignment time. The weekly schedule does this by providing enough work that is ready to go so that crews do not have to waste time receiving new assignments. Because these planning and scheduling efforts aim to reduce delays, they also aim for relatively high wrench time. Remember that high wrench time consists of having technicians on jobs doing productive work rather than being in delay situations.

Illustrations

The following illustrations demonstrate this principle of scheduling. The first section shows problems occurring as a result of not following the principle. The second section shows success through application of the principle.

Not This Way. Paul planned five jobs during the morning before break. Each job required two technicians. The first job required replacing a high pressure steam valve and needed two certified welders for 10 hours each, an entire day. The second also required two certified welders to construct a work bench for the maintenance shop. Paul planned it to take 5 hours for each. The third job was a simple request to move several barrels of waste oil. He planned this job to take two mechanics with a forklift and barrel attachment only 2 hours. The fourth job required replacing a check valve. This was planned to take two certified welders 5 hours. The fifth job required working on a leaking critical control valve. Paul planned this job to require two mechanics an entire day. Before taking his break, Paul figured that he had already planned 64 labor hours' worth of work for the crew.

Later the crew supervisor began to assign work orders to various members of the crew. James had two certified welders, three mechanics, an electrician, and three mechanical apprentices. In addition to the other jobs available to work for the next day, the backlog included the five jobs Paul had planned. There was a significant quantity of mechanic work and, as usual, more work requiring certified welders than the crew had available. Frequently, James had to second-guess the planner and use the apprentice mechanics for some of the mechanic work.

This Way. Paul planned five jobs during the morning before break. Most of the jobs required two technicians. The first job required replacing a high pressure steam valve and needed one certified welder and a helper for 6 hours. The second also required welding to construct a work bench for the maintenance shop. Since mechanics could handle light structural welding, Paul planned it to take one mechanic and a helper 4 hours. The third job was a simple request to move several barrels of waste oil. He planned this job to take one helper alone with a forklift and barrel attachment only 2 hours. The fourth job required replacing a high pressure check valve. This was planned to take a certified welder and a helper 3 hours. The fifth job required working on a leaking critical control valve. Paul planned this job to require one mechanic and a helper 8 hours. Before taking his break, Paul figured that he had already planned 44 labor hours' worth of work for the crew.

Later the crew supervisor began to assign work orders to various members of the crew. James had two certified welders, three mechanics, an electrician, and three mechanical apprentices. In addition to the other jobs available to work for the next day, the backlog included the five jobs Paul had planned. James usually had confidence in the planner's estimate of skill required and knew when apprentices could be sent on jobs as helpers. Dana first assigned the certified welder and an apprentice to replace both the high pressure steam valve and the check valve in 1 day. Dana assigned a mechanic and an apprentice to the light structural welding for the work bench to help maintain the mechanic's welding skills. After assigning all the other work, there simply was no electrical work. Although not usually done, Dana decided to use the electrician as the helper to a mechanic on the critical leaking control valve.

As one can see, the planning function gives the crew supervisor or scheduler the craft skill and time requirements for scheduling work. A job plan tells how many persons the job requires and the minimum skill level. By not unduly restricting the skill requirements, the planner increases the maintenance crew's flexibility for using different persons for the work.

PRINCIPLE 2: SCHEDULES AND JOB PRIORITIES ARE IMPORTANT

Scheduling Principle 2 (Fig. 3.5) states

> *Weekly and daily schedules must be adhered to as closely as possible. Proper priorities must be placed on new work orders to prevent undue interruption of these schedules.*

The originator of a work order first picks an appropriate priority for the work based on established plant guidelines for setting work order priorities. Depending on the particular plant, the priority may then be reviewed and adjusted by the originator's

Attachment 1a

✦Scheduling Principle 2

Schedules Are Important

Job Priorities Are Important

FIGURE 3.5 Two essentials that management cannot overlook.

supervisor, an operations coordinator, planners that code work orders, and at a daily meeting of plant managers or supervisors. The resulting priority should reflect not only the work's level of importance for achieving the plant's objectives but its importance relative to other backlogged work. Therefore, the plant priority system should play a large role in creating the schedule of the work the maintenance group will assign and complete. Management must treat the proper use of the priority system as a serious matter. The plant must expect maintenance crews to work on the jobs that the priority system through the schedule dictated. Management must treat working on scheduled work as a serious matter.

It might seem unnecessary to mention that schedules and job priorities are important, but they cannot be overlooked nor presumed. This is a common area of failure in maintenance management. Advance scheduling enough work for an entire week sets goals for maximum utilization of available craft hours. It helps ensure that a sufficient amount of work is assigned. Together with the priority system, it also helps ensure that the right work is assigned.

A significant source of inefficiency in the maintenance group is the interruption of low priority jobs when more urgent jobs arise. If a true emergency arises, it is always appropriate to delay another job. However, the maintenance group should recognize that interruptions on any particular job add extra time putting away tools, securing the job site, and later refamiliarizing oneself with the job. An urgent job that is not an emergency should be worked as the next job rather than interrupt any job-in-progress. A nonurgent job should wait until the next day or week altogether so that the job can be scheduled into the overall priority of importance for the plant. Later, parts and tools might be staged to make executing the job more productive at a more appropriate time.

Jobs with priorities falsely set too high improperly interrupt work or cause work to begin without proper preparation. The end result is that the maintenance group completes less work overall. Then a vicious cycle begins. Higher priority work must interrupt lower priority work because there is not enough productivity to complete all the work plus the interruptions. Quite possibly, the maintenance group could complete all the work with more organizational discipline in setting initial job priorities. This would lower the incidence of job interruptions and lowered productivity. Management commitment is important in this area. Conscientious management attention to enforcing adherence to the priority system helps maintenance.

If everyone assigned a high priority to their work just to ensure its completion, then improperly prioritized jobs would also make it hard to recognize true instances of when schedules or work should be interrupted. They might delay starting true high priority jobs even if they did not interrupt them.

In addition, inadequate confidence that crews will execute scheduled jobs hurts the staging program. Staging, as discussed in Chap. 6, helps increase crew productivity by having a job's planned parts and tools ready to go. They are already withdrawn from inventory or storage and ready for the technician to utilize. Planning stages the material before the anticipated execution of the job begins. Technicians avoid delay areas that they might otherwise encounter if they had to gather the parts themselves. Inadequate confidence that crews will execute scheduled jobs may discourage planners from staging parts. On the other hand, if planning continued to stage parts, the staging area might become overflowing with staged parts for jobs that did not start. In this case, the storeroom might run into stockouts for other jobs that maintenance chose instead to start. The stockouts might occur because of parts that were withdrawn for staging. These circumstances significantly diminish the great potential for staged parts to expedite jobs.

Illustrations

The following illustrations demonstrate this principle of scheduling. The first section shows problems occurring as a result of not following the principle. The second section shows success through application of the principle.

Not This Way. Mike finished his operator rounds and wrote work orders for problems he had noticed. Although most were not yet serious, Mike wanted to make sure maintenance completed them. Therefore he set a priority of 1 on the most important ones and 2 on the rest.

Nearly all the jobs in the maintenance backlog had been prioritized as 1's or 2's. They were either urgent or serious. This made it difficult for the crew supervisor to select which jobs maintenance should work the next day. Abby selected all twelve priority-1 jobs and three priority-2 jobs to assign.

Near the beginning of the next day, the plant manager asked that Abby immediately assign a few technicians to correct a dripping flange on the installed backup feed pump. Abby interrupted two technicians on one of the priority-2 jobs. These technicians first hastily put their ongoing job in a state where they could leave it. Then with the operations group clearing the pump and themselves having to find suitable gasket material, they worked the rest of the day to replace the flange gasket and correct the leak.

This Way. Mike finished his operator rounds and wrote work orders for the problems he had noticed. Most were not yet serious and Mike set a priority of 3 or 4 on them. He set a priority of 2 on a couple of serious ones.

Mike's supervisor afterwards had Mike change the priority of both of the serious work orders. They changed one to priority 1 (urgent) and the other to priority 3 (routine production).

The backlog had work orders with a variety of priorities. Priorities ranged from 1 (urgent) to 4 (routine nonproduction). This made it fairly easy for the crew supervisor to select which jobs maintenance should work the next day. Abby selected all five priority-1 jobs and eight priority-2 jobs to assign. She also assigned two priority-3 jobs.

Near the beginning of the next day, the plant manager wrote a priority-2 work order for Abby's crew to correct a dripping flange on the installed backup feed pump. Planning went ahead to plan and stage the gasket material. Abby included the flange job with the assignments she was making for the next day. She was also able to assign most of the backlog priority-4 work orders as well. Abby requested the operations group to clear the pump in time for her crew to begin work on it the next morning.

The next morning two of the assigned technicians picked up the staged gasket material and began the flange work order. They completed it within a couple of hours and began another job.

Attachment 1a

Maintenance should avoid interrupting scheduled jobs or jobs-in-progress. Maintenance should also place great importance on the plant following the plant priority system.

PRINCIPLE 3: SCHEDULE FROM FORECAST OF HIGHEST SKILLS AVAILABLE

Scheduling Principle 3 (Fig. 3.6) states

> *A scheduler develops a one week schedule for each crew based on a craft hours available forecast that shows highest skill levels available, job priorities, and information from job plans. Consideration is also made of multiple jobs on the same equipment or system and of proactive versus reactive work available.*

The first two principles set the prerequisites of scheduling. These next three principles introduce the concepts of the foundations of the advance scheduling process.

Principle 3 establishes a 1-week period as the advance schedule of allocation of work time frame. It also presumes that a person apart from the crew supervisor will be the scheduler. The scheduler selects the week's worth of work from the overall plant backlog. The scheduler uses a forecast of the maximum capabilities of the crew for the coming week. The scheduler also uses priority and job plan information. The scheduling process also looks at performing all the work available for a system once maintenance begins work on that system. This includes proactive work.

✦Scheduling Principle 3

Schedule from Forecast of Highest Skills Available

- **✦One Week**
- **✦Consider Multiple Jobs on Same System**
- **✦Consider Proactive Work**

FIGURE 3.6 The basics of the advance schedule.

First, the advance schedule selects a 1-week period for making an advance allocation of the work. Advance allocation means the schedule will select all the work that the crew should be able to finish in a single week. The schedule selects the work from the overall plant backlog. The scheduler does not assign the work orders to individual crew members. The scheduler also does not set specific hours or even certain days on which the work on each work order should start or end. The scheduler merely specifies a block of work as a list or package of work orders. *Advance scheduling* is an allocation of work for maintenance and not a detailed schedule of exact personnel and time slots.

A 1-week period strikes a balance between creating set goals and allowing for gradually changing plant needs. On one hand, a 1-week period is long enough to allow establishing a set block of work for a crew goal. This set block of work also allows planners enough time to stage parts for scheduled work. On the other hand, the plant is constantly writing new plant work orders. The new work orders gradually change the relative importance of all the work in the plant backlog. A 1-week period is short enough for the schedule normally not to need significant alteration due to this new work identification. This may be less true in a plant with more than a moderate amount of reactive work. These plants may normally experience a significant deviation from the set schedule. The 1-week schedule also covers a short enough time period to allow supervisors enough certainty in knowing which of their individual crew members will be available for work.

In addition, a curious phenomenon appears regarding the accuracy of job estimates for individual work orders. Experience has shown that job estimates for individual work orders may be off plus or minus as much as 100%. That means that on average, a job planned for 5 labor hours has as much chance of being accomplished in 1 or 2 hours as it might in 10 hours. This is especially true of the smaller work orders that make up the bulk of many maintenance operations. Does this mean that planner estimates are worthless? No, on the contrary, the planner estimates are very accurate overall as the work horizon widens out to as much as a week. Over a week's worth of crew labor, the overall estimate planned hours becomes extremely accurate, only off as much as 5% or less. That means that practically as many jobs run over as under due to the myriad of special circumstances surrounding individual work orders assigned to individual technicians on individual days. This confirms that a week is the appropriate allotted time period for advance scheduling. Remember that the objective of scheduling is not to produce accurate time estimates. It is to accomplish more work by reducing delays.

The scheduler publishes this schedule to give to maintenance crews, the operations group, and management. The crews receive the schedule as allocations of goals for the coming week. Supervisors of different maintenance crafts receive the schedules to have an idea of upcoming coordination needs. The operations group receives the schedules to have an idea of what equipment will eventually need clearing. The operations group may also be able to give the maintenance group timely advice of maintenance redirection needed. The operations group as well as management receives the schedule as an indication that maintenance is making progress on work orders. Many times, areas apart from the maintenance group see it as a "black hole" into which work orders enter, but never emerge. Tangible proof of work order schedules increases cooperation from the operations group.

Second, having a person separate from the crew supervisor allows a system of checks and balances. A person separate from the crew determines how much work the crew should be able to accomplish. The question is not necessarily: Which work orders should be done? The plant priority system drives that. The question is: How many work orders should the crew complete? The scheduler is best included as part of the planning department because this person uses planning as well as crew information. Many times it is appropriate for a supervisor of a planning group to perform the duties of scheduler. This allows the planning supervisor routinely to review job plans.

Third, the scheduler receives a labor forecast for each crew supervisor. This forecast tells how many labor hours each crew has for the next week. The scheduler needs this information. The scheduler intends to allocate hours of planned backlog on the basis of the labor hours available for each crew. The crew supervisors are in the best position to forecast the available labor hours on their crews. The crew supervisor may tell the scheduler that the crew will have 1000 labor hours for the next week. The scheduler then has a basis for knowing how many hours of planned work to allocate.

Fourth, the crew supervisor must make the labor hour forecast in terms of the highest skills available. By identifying the highest skills available, the scheduler has more latitude when actually determining which job plans could be executed the next week. Highest skills available means that if a crew has two certified machinists and seven mechanics available for the next week, the supervisor would not just forecast that the crew has nine persons or nine mechanics. The latter forecast would reduce the flexibility of the scheduler who would not be able to assign any complex machining jobs. The scheduler has more flexibility when knowing that there are two certified machinists. The scheduler can then assign complex machining jobs. The scheduler might also decide to assign routine mechanic jobs to the machinists. There is more freedom in what jobs can be assigned.

Fifth, the scheduler will use information from the individual job plans and a feel for the overall priority of plant systems. The scheduler looks at the priorities of the backlogged work to help select jobs. The scheduler looks at the labor hours planned to select enough jobs. Chapter 6 will discuss the actual steps the scheduler follows in this process.

Sixth, the scheduler also considers plant equipment and systems when selecting work. When selecting work for an entire week, the scheduler is able to group work orders for the same equipment. The scheduler may override some individual work order priorities to accomplish this. For example, a priority-2 and priority-3 work order may be both assigned because they are on the same piece of equipment. This might be preferred over assigning two priority-2 work orders on two separate pieces of equipment. Schedulers can also exercise flexibility by initiating certain PM work orders early to take advantage of equipment downtime for other work. This allows improved overall efficiency because the operations group can clear the equipment a single time and the maintenance crew can work on a number of jobs together.

Finally, it is easier for the scheduler to include preventive maintenance or other work to head off failures on a weekly basis. On a daily basis, there is often sufficient justification to put off these seemingly lower priority work orders. On the other hand, when combining a week's worth of work, it becomes clear that PM cannot be delayed. The weekly schedule includes this type of work to encourage the supervisor not to put it off forever, 1 day at a time.

Illustrations

The following illustrations demonstrate this principle of scheduling. The first section shows problems occurring as a result of not following the principle. The second section shows success through application of the principle.

Not This Way. As maintenance manager, George felt that maintenance could increase its productivity. Lately, he had seen more and more technicians heading home early. This was a problem since reliability seemed to be slipping at the plant. He knew that there was a considerable backlog of work, but the supervisors had assured him that they were assigning as much work as the technicians could handle. George was also concerned that supervisors had a habit of putting off PM work orders.

George felt that advance scheduling of some sort was the answer, but the last attempt had been disastrous. Planning had first scheduled hour by hour what work maintenance should accomplish for an entire week. However, by the end of the very first day, the schedule was in shambles. Half of the scheduled jobs could not start at their target times because other jobs had run over their expected completion times. By the middle of the second day, the actual work-in-progress bore no resemblance whatsoever to what the advance schedule had predicted. At this point, the plant had abandoned the concept and gone back to assigning work 1 day at a time. George felt that now was the time to implement a gate carding procedure to make sure employees worked their entire shifts.

This Way. As maintenance manager, George felt that maintenance was increasing its productivity. Reliability seemed to be gaining at the plant. He knew that there was a manageable backlog of work and the scheduling process was helping the supervisors to assign as much work as the technicians could handle. George was also pleased that supervisors were not putting off PM work orders.

George felt that advance scheduling had been a great success. Planning had first developed a list of all the work orders that maintenance should accomplish for an entire week. The amount of work was determined by the labor hours that the crews would have for the week. At the end of the week, George discussed with each supervisor the results of what had actually been accomplished. Although no crew had completed all the allocated work, most crews had finished more work than they had thought possible. By the end of the second month, crews had a firm idea of the amount of work they were responsible for and were becoming more productive. As a result, maintenance crews were executing more work and the plant was increasing its reliability.

The proper period for an advance schedule is normally a single week. This time frame allows setting a goal that can stay relatively fixed as the plant continues to identify more work. The week's worth of work is not an hour-by-hour schedule of work orders, but a bulk allocation. The crew labor forecast is an important part of the scheduling process. Not only should the supervisors forecast how many labor hours are available, but how many in each specialty.

The following principle discusses two concepts relating how the scheduler compares the labor hours available with the planned hours in the backlog.

PRINCIPLE 4: SCHEDULE FOR EVERY WORK HOUR AVAILABLE

Scheduling Principle 4 (Fig. 3.7) states

The one week schedule assigns work for every available work hour. The schedule allows for emergencies and high priority, reactive jobs by scheduling a sufficient amount of work hours on easily interrupted tasks. Preference is given to completing higher priority work by under-utilizing available skill levels over completing lower priority work.

Principle 4 brings the previous scheduling principles together. The first part of this principle is that the scheduler assigns work plans for the crew to execute during the following week for 100% of the forecasted hours. This means that if a crew had 1000 labor hours available, the scheduler would give the crew 1000 hours worth of work to do.

Overassigning and underassigning work are also common in industry. However, each causes unique problems that could be avoided.