Total Productive Maintenance—Essential to Maintain Progress

Moving toward equipment quality and performance readiness, an environment where working out problems is more important than organizational status.

Robert W. Hall

A retired railroad track maintenance supervisor, an acquaintance now dead, predicted the demise of the Penn Central Railroad five years before the actual event. He knew nothing of financial reports. He somberly declared his pension check in jeopardy with the observation that the successor to his beloved Pennsylvania Railroad "couldn't even keep their damn weeds cut."

A company in financial trouble often defers maintenance. Managers know better, but put off tomorrow's troubles until—they hope—time and money will arrive to deal with them. But even companies with fat profit margins may not recognize the importance of detailed maintenance to competitive position. Among veteran maintenance personnel, accepted wisdom is that anyone who wishes to know what a company is "really like" should work in maintenance.

Productive maintenance develops knowledge of tooling, equipment, and control systems in the applications for which they are used, seeking not only to keep processes operational, but to make them better. Productive maintenance is essential for improving quality and reducing leadtimes.

Simply paying attention to preventive maintenance can pay off quickly. Early in its JIT journey, the Black & Decker Fayetteville (NC) plant emphasized preventive maintenance on key machines. Operators recorded problems on cards kept at each machine. Maintenance personnel referred to these cards on regular rounds of the shop. Equipment availability (readiness) increased by 10 percent within a few months.

Maintenance is a recently-discovered hot topic, vital to continuous improvement. However, some of the current directions to improve maintenance management do not necessarily lead a company into productive maintenance.

Connection to Productivity and Quality

If equipment is organized as a job shop, maintenance problems are painful only if costly enough to stand out, or if a machine is a "bottleneck." Hooked together in tandem, problems on one machine stop all, so that interest in maintenance is sure to increase. The connection of equipment downtime to overall productivity becomes more obvious.

Maintenance practices also affect quality, sometimes in nonobvious ways. Take the case of press dies standardized in height for quick setup. Dies sharpened after a standard amount of use can be sharpened with a standard cut and restored to height with a standard shim. Standard maintenance = standard setup = standard quality —no fiddling with adjustments to stamp a standard part again.

Maintenance should do more than just avoid production stops and excessive costs. It should enhance and preserve the capability of the total process to make defect-free parts. Many sources of process variation are affected by the maintenance of something other than direct production equipment. Some examples:

1. Variance of power line voltages because of inattention to maintenance of controller units balancing a three-phase power network. (The company had to become concerned for reasons other than maintaining an "economical" balance.)
2. No regular calibration of test equipment for recycled cutting oil.
3. Variance in ambient air temperature due to failure of controls for an overhead door.
4. Contamination of wash water due to installation of dirty pipe.

Maintenance in every part of a production facility improves quality and prevents downtime. Standardization of correct maintenance helps preserve gains in quality.

Total Productive Maintenance (TPM)

Total Productive Maintenance evolved during the 60s and 70s in the Toyota group companies, gradually spreading to many other Japanese companies, but by no means all. TPM is mature in Japanese auto companies and their suppliers, popular in metalworking, but just off to a good start in other industries. Total Productive Maintenance is broad in scope, seeking to:

1. Improve equipment effectiveness in both quality and performance readiness until it becomes technically obsolete. Hence the use of the term "productive" in TPM. A piece of equipment should perform its applied function better at the end of its life than when new.
2. Cover all departments and functions of the company from top management to operators, and all aspects of manufacturing. Hence the term "total" in TPM.

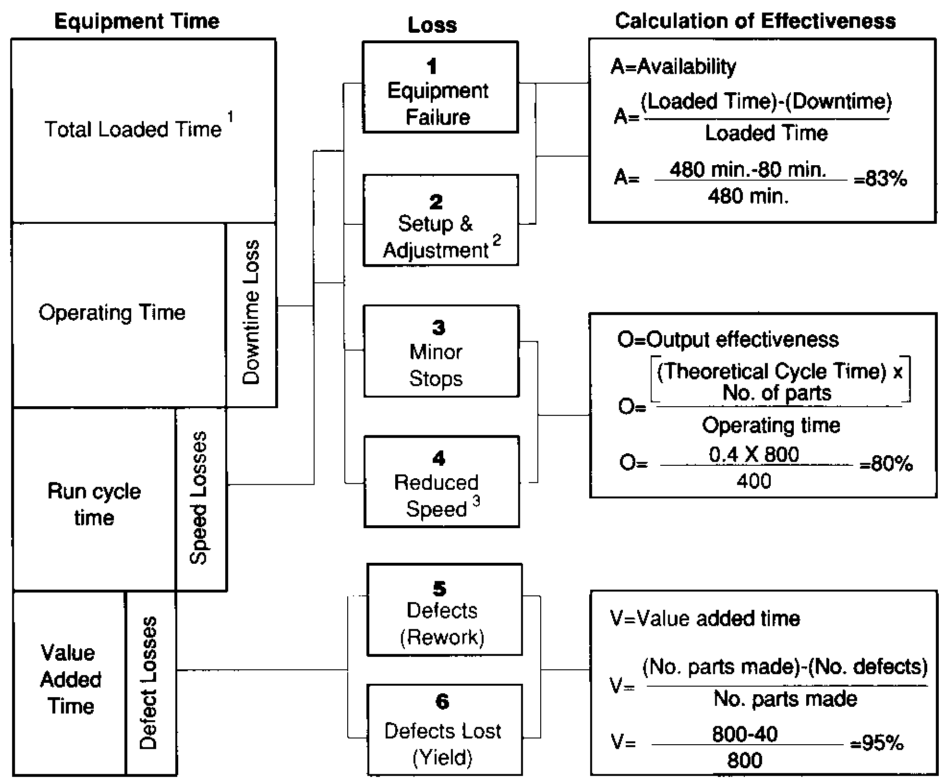
"Total" covers every aspect of maintenance imaginable by a big cause-and-effect diagram of all maintenance activity affecting quality of product or service: all machines, tools, gages, instruments, computers, and vehicles as well as building site equipment.

Deep operator involvement is essential to comprehensive maintenance. "Small group improvement activities" should consider improving maintenance. Operators and supervisors should thoroughly learn the process and equipment so that they can make useful suggestions, some of which they can implement themselves.

TPM fits hand-in-glove with workplace organization (5S) and the ideas of cycle time concept (doing as much as possible by a regular time pattern) and cycle time analysis (studying repeated cycles to discover opportunities for improvement). These methods build on the basic concept of predictive maintenance: repair/replacement prior to a breakdown, or better, prior to a process drifting from its "normal" pattern of variance. Timing may be predicted through experience, technical factors, or quality history.

Reliability analysis to predict mean-time-between-failures is well known, but its complexity prevents extensive use by operators. However, operators or maintenance planners can keep a record of the causes of downtime and chart the repair/replacement cycles in search of patterns. Navistar's foundry in Indianapolis has done this for many years.

Equipment Effectiveness and Six Big Losses



Overall Effectiveness = A x O x V = 83% x 80% x 95% = 63%

[1] Loaded time is not usually all working hours.
[2] Setups are necessary to make what the customer wants, so setup is value added activity. Unnecessary setup and adjustment time within each setup is a waste.
[3] A machine may not be desired to run at its theoretical cycle time. For instance, a machine in a cell may have idle time between cycles to balance with the cycle time of the cell. Others will be operated at speed, but only when parts are demanded.

Fig. 1. *This interpretation of the Japanese TPM explanation shows the six big losses associated with equipment and tooling. It reflects the need for detailed study of machine problems. An overall effectiveness measure must be tailored to fit individual machines and processes.*

Japanese manufacturers use control charts to identify the onset of process irregularity before catastrophic failure makes something obvious. For example, Tokai Rika plotted a chart on rolling an indentation in the body of a cigarette lighter for automobiles. A sample size of four was plotted daily on a chart spanning several years. Over time they noted that the process began to drift slightly every four months because of wear on a positioning collar. Their Cpk was so high there was never any danger of an actual defect.[1]

Fig. 1 is liberally interpreted from the Japanese explanation of TPM. It shows the six big losses associated with equipment and tooling. It also illustrates that machine problems must be studied in organized detail to be overcome — more than just tracing the causes of "dead stop" downtime. Any overall effectiveness measure must be developed to fit individual machines and processes. It is impossible to devise a general measure of machine effectiveness which properly takes all factors into account in every case. The measure shown is filled with interpretive possibilities and still doesn't account for operating methods or operator efficiency. ▷

Twelve-Step TPM Program

Step	Notes
1. Announcement of TPM by top management.[1]	As with anything, this is necessary if the effort is to be serious.
2. Education on TPM.[1]	Detail for leaders. Some for everyone.
3. Organize for TPM.[1]	Teams and working groups, cross-functional as for JIT/TQC implementation.
4. Set goals and policies.[1]	Benchmarking excellent operations elsewhere is helpful.
5. Formulate master plan.[1]	Overall project activity schedule. Milestones applied to goals.
6. Kickoff.	Invite customers and affiliated companies. Now "everybody knows" and there is no backing down.
7. Improve effectiveness on each piece of equipment.[2]	Work on model equipment first, so "followers" learn from that. Effectiveness rating is developed from detail on each item of equipment.
8. Promote PM by individual operators.[2]	The maintenance department trains and backs up. Judge performance and award certificates.
9. Develop planned maintenance by the maintenance personnel.[2]	Study equipment. Develop timing for fixed-cycle and predictive work by maintenance. Refine systems for MRO, tooling work, equipment records, and visibility methods.
10. Advanced training, based on acquired skill and knowledge.[2]	Organize what has been learned internally and elsewhere and use it to prepare people for a "second push" (Step 11).
11. Develop system for long-run management of equipment.[2]	Study ways tp revise equipment to improve quality and prevent maintenance problems. Categorize criteria for buying or designing new equipment with next generation of technology. Try to optimize life cycle cost of equipment designs and modifications.
12. Establishment of TPM.	Review and set higher goals. Prepare for competition to receive PM prize.[3]

[1] **The preparation phase** lasts 3-6 months. Japanese like to have everyone beyond the "awareness stage" by Kickoff. They should be willing to learn new skills and accept more responsibility.

[2] **The implementation steps** take two to three years. This is the heart of what is to be accomplished, namely raising the educational and skill level of the entire working organization to a higher level.

[3] Each fall the Japan Institute of Plant Engineers awards about ten PM Prizes to competing companies which have reached the twelfth stage with good results. Automotive and metalworking companies dominate the competition. TPM originated in the Toyota group from which many of the practices have spread to other industries even if they do not pursue them vigorously enough to be strong competitors for the PM Prize.

Fig. 2.

Concentrate on discovering causes for specific machines not being effective and eliminate them. An overall effectiveness measure can only suggest checking specific situations in more detail. However, two kinds of overall measurement may be useful:

1. *Machine availability (or readiness):* The percentage of time equipment is operational whether needed or not, which is a more positive way of putting it than as an out-of-service rate.

   Availability percent = (100 percent) − (Out-of-service percent)

   Availability, or readiness, is preferred over a measure of machine utilization because that may stimulate people to run equipment unnecessarily. However, equipment may be out-of-service for positive reasons as well as negative. Modifications for improvement may be done off-line.
2. *Operating ratio:* The percentage of time equipment operates when on-line:

   $$\text{Operating ratio} = \frac{(\text{On-line time}) - (\text{Downtime})}{\text{On-line time}}$$

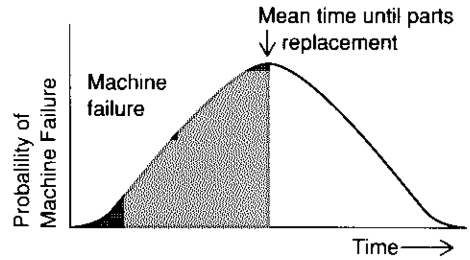
Neither of these measures suggests anything specific to improve. For that, one must seek detailed measures of machine capability: dimensional variances in output, cycle time variations, stops for adjustment, difficulty in setup (setup time variations), defect rates, whether classified as one of the six big losses or not, and so forth. These relate to the uses of a machine, and provide indirect indicators of maintenance among many other clues to various production problems. Such data is best kept by those close to the operation—usually operators themselves.

Operator involvement is a prominent feature of TPM, and TPM itself is a maintenance emphasis within a broad program of detailed quality improvement. The program cannot be properly executed unless personnel are well-grounded in the attitudes and methods of Total Quality Control. The Japanese twelve-step plan is shown in Fig. 2.

Phases of Machine Maintenance

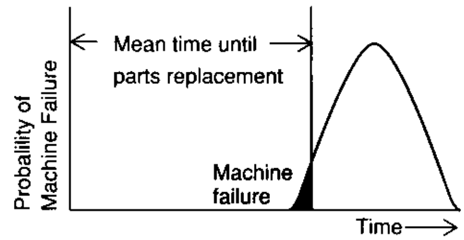
Phase I: Forced Deterioration

- Repair only when broken.
- Standard or correct operating practices either unknown or not practiced.
- Minimum operator responsibility for maintenance or condition.
- Little routine maintenance; no PM.



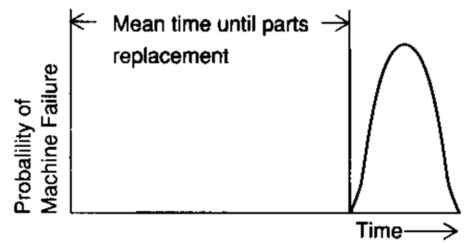
Phase II: Natural Deterioration

- Standard, correct operating practices discovered and used.
- Operator has responsibility for routine PM and condition monitoring.
- No organized effort to restore or improve machine.



Phase III: Restoration and Improvement

- Study operating procedures to refine them. Identify cycles of repair/replacement that will keep the machine at its original capability level.
- Operators are deeply involved both to identify repair cycles and to correct abnormal conditions.
- Work on redesign of the machine.



Phase IV: Condition-Based Repair

- *After* going through Phases I-III, *then* use instruments or sensors to diagnose early deterioration.

This chart comes from page 120 of *The New Manufacturing Challenge* by Kiyoshi Suzaki, 1987 release by The Free Press, which in turn is taken from publications of the Japan Institute of Plant Maintenance.

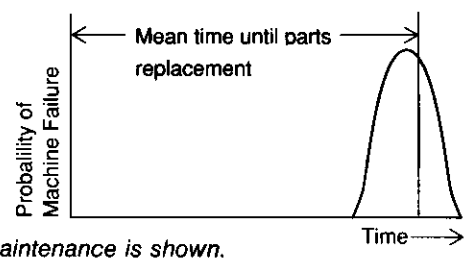


Fig. 3. *Another view of Total Productive Maintenance is shown.*

A review of the implementation steps (7–11) at the heart of TPM shows why it is referred to as Total *Productive* Maintenance. A hidden objective is to make everyone as expert as possible in detailed know how by a systematic program of improvement. TPM is a system for revision of tooling, equipment, and methods within the more general practices of JIT/TQC.

Another view of Total Productive Maintenance is in Fig. 3. Redesigning equipment as in Phase III is widely practiced in the United States, for instance, but usually as a project-by-project approach on selected equipment. TPM is more:

- All operations are covered; all direct production equipment, all plant support equipment.
- The approach is systematic.
- Operators and supervisors must master the equipment. They learn to make simple drawings themselves, and to make simple modifications themselves.
- Very little is contracted out—to contract maintenance companies or to OEM suppliers of machines. TPM is literally a *do-it-yourself program.*

▷

- Thoroughly study equipment, tooling, and process first. Revise it and improve it before Band-Aiding the problems with sensors and other detection devices to warn when a process is beginning to go sour. In other words, don't "high-tech" a bad process—or an undeveloped machine.

TPM is a people-intensive, low cost method to work through the bugs in processes and equipment, but upgrading the skills of all the workforce does not come without a price tag. Formal skills training is necessary, but worked "the Japanese way," very little overhead need be added. The maintenance department itself becomes the primary skills trainer.

If there are downsides to TPM, the time required to implement is one, and potential problems adopting a radical new technology is another. A few experts can master something new more quickly than if it must be imparted to the masses. TPM is also part of the quality considerations to take into account when designing and developing new products. TPM cannot be quickly grafted onto an existing organization.

Comparing TPM To The American Experience

No American company is known to be practicing TPM in the sense described. Almost all the individual concepts within TPM are known and sometimes practiced in the United States, but no one is known to have "put it all together."

No comprehensive survey of American maintenance practices is known. Maintenance practices can be inferred from conversations, trade press articles, and conference presentations. Background work for this article concentrated on foundries.[2] Because of their harsh environments, something above the normal consciousness of maintenance was expected in foundries. However, there is no reason to believe that the general management practices of foundries differ much from those elsewhere in manufacturing.

American managers are certainly conscious of maintenance costs. Referring to foundries, John Wasem stated the situation: "When management thinks of maintenance-related problems they think of repair cost per ton, excessive overtime hours, excessive equipment downtime, loss of production, high equipment replacement cost, excessive spare parts inventory, and idle maintenance employees."[3]

In other words, managers think of maintenance problems in terms of cost ratios, comparing various categories of maintenance costs with the cost of obvious maintenance failures. Success is low overall cost, and cost-of-quality measures are seldom included.

A common way to evaluate preventive maintenance is also through cost tradeoffs. What is the added cost of PM versus the cost of letting equipment run to breakdown? By the TPM concept, the idea is rather to investigate the production mission and capability of the equipment before digging deeply into long-run cost estimates.

Japanese managers think of "things and conditions" before costs —within reason, of course. By pushing the responsibility for TPM onto the direct workforce, there is little added cost to evaluate early in a TPM program—mostly the cost of developing people for TPM. That cost is accepted without hesitation.

In the American company, operating people think of "things and conditions" while the top management and financial staff think of cost tradeoffs. The burden is to prove cost effectiveness. Under TPM, this burden is more to check whether proposals are cost *in*effective.

American companies also contract more maintenance and rely more on the advice of equipment manufacturers than Japanese TPM companies. TQC wisdom is to thoroughly understand a process for quality reasons. TPM extends this to thoroughly understand the equipment, so managers and workers want to work on it themselves. For instance, an evaluation of an OEM's proposed new equipment might include taking it apart and putting it back together.

Some American companies build a great deal of their own equipment and tooling; others hardly any. The strategy depends upon company expertise and cost tradeoff. According to TQC and TQM, a company should become expert in every production process critical to its quality, possibly including some processes belonging to suppliers and customers. A plant should repair and modify much of its own tooling and equipment in its own shops. Some of it should be designed at the plant. How else can a workforce totally understand the process? This outlook tilts decisions toward doing work yourself unless the economics are prohibitive. (A metalworking company does not service its own computers.)

Survey of Maintenance Practice

About 10 years ago Charles Bimmerle performed one of the few surveys of maintenance practice on 84 foundries in Ohio.[4] Conditions have changed since, but some of the results are still interesting.

Thirty of the 84 foundries conducted PM on over 50 percent of their equipment, but only 10 had written procedures covering that much equipment. Four foundries had PM on more than 75 percent of equipment. One had a very low maintenance cost per ton, and another very high, so the effectiveness of PM appeared to differ greatly. Only 30 foundries involved maintenance in new equipment decisions. The average equipment availability of all the foundries was 91.7 percent, and average maintenance labor productivity was 54 percent (with most estimates based on imprecise standards).

The most interesting result was that *both* equipment availability and maintenance manpower productivity:

- Correlated *positively* with scope of preventive maintenance
- Correlated *negatively* with size of foundry
- Correlated *negatively* with number of maintenance workers.

Despite a more formal effort in managing with maintenance work, the larger foundries had poorer maintenance, although a PM program helped. This *may* be explainable by the functional organization of foundry management.

Bimmerle found that foundry maintenance variously reported to manufacturing, engineering, operations, plant managers, and in two cases, to the president. Casual observation of manufacturing organizations indicates that maintenance is a box at any elevation, but generally in the far western portion of the organization chart, an afterthought when filling out the squares.

Wherever placed, maintenance is usually seen as a collection of separate skills. Even with no jurisdictional disputes between different craft unions, coordination between the specialties is not simple. Few people can diagnose and repair an electromechanical marvel all by themselves. Technically comprehensive maintenance becomes messy when split among three or four different skills.

More and more new automated equipment comes with built-in diagnostic instrumentation. Equipment designed and developed for TPM should favor "KISS" methodology. Study the equipment and the process, and resist creating computer diagnostics for problems that should not exist. Avoid trying to cut through basic process and organizational problems with technology alone.

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Plant size can exacerbate the organizational and productivity problems of maintenance. Despite pagers and golf carts, much time is wasted running from place to place. Concentrated maintenance attention is one argument for separating a plant into departments each having similar equipment, the opposite of cell manufacturing and layout for flow and flexibility.

Mixed equipment and processes in one area calls for coverage by a diversely skilled maintenance team, with the operators being part of the team. This makes sense with cell manufacturing and flow layouts even if plants do not practice TPM in the full sense. *The problem of maintenance organization and skill development at the plant level is a small version of the problems of functional organization throughout a large manufacturing company.* Current approaches to developing maintenance management reflect the larger thrashing in American companies attempting to make functional organizations perform in place of teams.

Companies redraw organization charts constantly. A decentralized organization structure may be helpful, but success depends on management leadership and attitude— toward maintenance or anything else. The Walt Disney organization is an American example of the right management attitude (see box on following page).

Current Directions in Maintenance Management

Preventive maintenance by operators as well as maintenance personnel is increasingly evident, but much PM is just an oiler running a check-and-lube route. These routes are assigned to the lowest-skill, least experienced personnel in maintenance. They struggle to find all the grease fittings and frequently work without written procedures.

Maintenance software packages are proliferating. These differ in their capabilities, but many companies reorganizing maintenance are guided by them. A listing of the usual software capabilities provides a reasonable overview of current thinking:

- Equipment identification by company number for:
  - –Equipment files and histories
  - –Spare parts lists
  - –Downtime records
  - –Specifications; references to drawings
  - –Cost histories
- Work orders and work order records:
  - –Work order initiation and approval procedures
  - –Record of job man hours and materials costs
  - –Work order reporting systems
  - –Work order priority systems
- Schedules and capacities:
  - –Weekly schedules based on capacity by craft
  - –Work standards
  - –Measurement and control of backlogs
- Maintenance, repair and operational inventory (MRO):
  - –Item masters showing where used and sources of parts
  - –Warehouse inventory levels and transaction system
  - –Purchase request system
- Preventive maintenance:
  - –Generation of worksheets and checklists
  - –Schedules and reporting systems.

Companies reorganizing maintenance must develop system discipline. Just pulling together all the equipment files to reference by a software system is a chore. Little questions arise. For instance, how many manuals are on hand for a given piece of equipment? Who has them? Are they current? Who should have a copy? Where should they be kept? In which system files should manuals be referenced?

Equipment drawings are another messy area to manage. Some originate with the OEM manufacturing the equipment. Some are modifications to the original. Unless all are identified with the company's number for the equipment, just finding a correct drawing can be exasperating.

Parts inventory for a piece of equipment runs about 15 percent of the capital cost. After the depreciation schedule has finished, the major investment in equipment may be the complement of spare parts. The software packages provide transaction-driven MRO systems. The transaction discipline is no different from that of other inventory systems.

Job orders are another anchor of these maintenance systems, pegs on which to hang cost and time reporting, and the basis of control. PM ▷

Disney World Maintenance

Maintenance is critical to theme parks, and at Disney World it gets high profile attention from management although most of it is kept hidden from guests. What a guest is most likely to see, and remark on, is the cleanliness. A fallen gum wrapper is immediately whisked up by the closest Disney employee—of any rank.

Although Disney World has a $20 million maintenance manpower budget, 2000 full-time maintenance workers and a maintenance software package second to none, that spirit is the key to breaking down the fences between functional turfs. This spirit comes from the Walt Disney management principles which the master himself enunciated in 1966:

1. Quality will win out.
2. Give the public everything you can give them.
3. Keep the place clean.
4. Keep the place friendly.

The last principle translated to employment atmosphere means to take your job seriously but don't take yourself seriously. Have fun at work.

The Disney maintenance force is represented by ten craft unions. The potential for turf squabbles is ever present, but the means for keeping it in check is that *executives establish pride in the work itself and set examples.* The executive snapping up a gum wrapper is part of that. Pride is cultivated, starting with signs in maintenance saying that under this roof are the finest craftsmen in the world. Shoddy work is not part of anyone's expectations.

Essential to this pride is a sense of the importance of any work, including the smallest details. For instance, the gold inlay on the manes of carrousel horses is not false; it is the 24-carat real thing. A guest will probably never know. The workers do. In the Disney setting, this carries the motivation behind the scenes.

The operational readiness rate of Disney equipment is 99.4 percent, and they target still better. The biggest Pareto items causing downtime are weather-related , so improving this performance requires improved weather-proofing of equipment designs.

The computer system is Disney-conceived and Disney-programmed. The on-line system handles a 24 month history on 38,000 items of equipment. There are 60,000 variable-time job orders per month in addition to the 130,000 fixed-time PMs on the schedule. The program does a failure-code analysis to assist with predictive maintenance.

Other programs are used for special projects. For instance, Disney has a huge number of two-way radios on-site. Radio failures and repairs are being simulated to better establish maintenance cycles for radios, and to determine how many radio maintenance locations should be on the premises.

Disney redesigns troublesome parts. They are on their sixth or seventh generation of soft-drink dispenser heads to stretch the times between failures. An ordinary commercial design has a failure rate of "500 percent per year or more"under the special stress of Disney World use.

Most routine maintenance takes place at night. The day shift mans underground shops near equipment for which they are responsible. Unless there is an emergency, these shops are busy making spare parts or revised parts. A great deal of Disney equipment uses unique design parts.

Disney provides a generous budget for maintenance. A manufacturer of cost competitive products is apt to feel that they cannot afford to copy Disney. They probably cannot afford the same elegance of system and the "imagineering talent," but everyone can afford the Disney management attitude. That costs nothing but the effort to develop it, which is considerable.

by a maintenance person may or may not require a job order. If not, the PM is seen by transaction systems as an unwritten job order.

Software modules to schedule maintenance turn attention to the accuracy of labor standards. Job order files can be analyzed so that time estimates from this data base are superior to top-of-the-head estimates. Some companies use standard data such as the Universal Maintenance Standards of H.B. Maynard and Company. More accurate standards make more accurate schedules, which reduce the waste of poor planning.

The use of software instigates better organization and control of maintenance work. More accurate standards, equipment records, and inventory data bring a mess under control—an improvement over chaos, but perhaps high-overhead improvement.

Two problems are evident with this approach:

1. The walls between departments are still present, and they may be even stronger if they are "formalized" by a system.
2. The system does little to stimulate *productive* maintenance, that is, the incorporation of maintenance issues into the study of equipment and process for basic improvement.

The vernacular for describing this is: "Many things need to be done, but we can't get around to doing them fast enough." Resources are thought to be inadequate.

The real question to ask is: Of all the resources we have, how many of them are engaged first-hand in actually making process and equipment better as opposed to just administrating themselves? The answer lies in transferring as much maintenance responsibility as possible close to the action.

One way to do this is by breaking off parts of central maintenance, assigning manufacturing engineers and personnel for maintenance of production equipment to general area foremen. Firestone of Canada is one company doing this, so maintenance—and skilled trades in general—are closer to the production processes they serve. The number of maintenance supervisors was also reduced because they now deal with a smaller area and less "bureaucratic paperwork."

Operators, maintenance personnel, and others should form teams to routinely overcome quality or process problems. Soon, working out the problems is more important than organizational status.

The shift toward team organizations should increase the analysis of maintenance methods for improvement the same way production methods are analyzed. Effective maintenance time is increased from the proverbial 50 percent by eliminating many wastes:

- Of unnecessary repair
- Of just visiting a repair site for diagnosis
- Of a false diagnosis
- Of obtaining the correct tools and parts
- Of interruption of one job by an emergency elsewhere.

The operator is closest to the action; the supervisor next closest. The operator should be responsible for basic maintenance and for using correct operating procedures. An operator should know such things as proper warm up time for equipment even if it is turned on automatically before his arrival. The operator's job shifts to managing the process and the area, brain work as much as manual work. Increasing automation should hasten this shift.

Operators and supervisors are the front line of continuous improvement. They should understand gages and instruments and know the process. Not only should they know the PM procedure, they should be able to contribute to improving it. Many are capable of making sketches and fabricating simple improvements themselves if given the opportunity.

However, more is involved in improvement work than that. Over time, experienced operators should learn to:

- Find drawings and manuals
- Make a simple cost estimate
- Request an engineering change
- Initiate a maintenance work order
- Obtain a spare part, at least of the type they can replace themselves.

To managers steeped in functional separation, this sounds crazy. If a mob of untrained operators is suddenly turned loose, a mess is sure to result. Operators must be coached, trained, and examined. By whom? Maintenance. It is not done in a few easy lessons, but by upgrading the operator's skills, maintenance power (and improvement power) is increased many times.

This practice is like day from night compared with a situation in which operators want to work on a machine, but fear being "written up" for a rules violation. Or one in which operators or supervisors know a machine needs work but fear writing a job order because the wrong maintenance person might make conditions worse rather than better. Operators, maintenance personnel, and others should form teams to routinely overcome quality or process problems. Soon, working out the problems is more important than organizational status.

Within this spirit, workers can perform many "trivial" repairs and improvements themselves after appropriate management approval. Approval is necessary to prevent everyone's ideas running into each other, but workers need not be passive blobs. This way of operating is seldom an easy adjustment for managers, but it is possible.

The real question to ask is: Of all the resources we have, how many of them are engaged first-hand in actually making process and equipment better as opposed to just administrating themselves? The answer lies in transferring as much maintenance responsibility as possible close to the action.

[1]This story is presented in detail in a 1984 tape by Dr. Donald J. Wheeler, entitled "A Japanese Control Chart," which I obtained from Harley-Davidson Motor Company, Inc.

[2]Many thanks to Dave Kanicki of the American Foundrymen's Society, to John Wasem, Chairman of the Society's Maintenance Committee, and to Frank Hruska of the Navistar Foundry at Indianapolis, IN.

[3]Wasem, John W., "Maintenance and the Bottom Line," Paper presented at the American Foundrymen's Society 1987 Casting Conference, St. Louis, April 7, 1987.

[4]Bimmerle, Charles F., "Ohio Foundrymen Speak Out on Maintenance," Report circulated to the participating foundries from the American Foundrymen's Society, February, 1978. (Summary of a dissertation at the University of Cincinnati.)

Author:
Dr. Robert W. Hall has taught Operations Management at the Indianapolis Campus of Indiana University for 17 years. His special area is the improvement of industrial management and he has made comparative studies of American and Japanese industrial practices. Dr. Hall is the author of: *Driving the Productivity Machine* (APICS, 1981), *Kawasaki, U.S.A.* (APICS, 1982), *Zero Inventories* (Dow Jones-Irwin, 1983), *Comparison Study of Just-In-Time Production of American and Japanese Manufacturers* (AME, 1985), *Attaining Manufacturing Excellence* (Dow Jones-Irwin, 1987).