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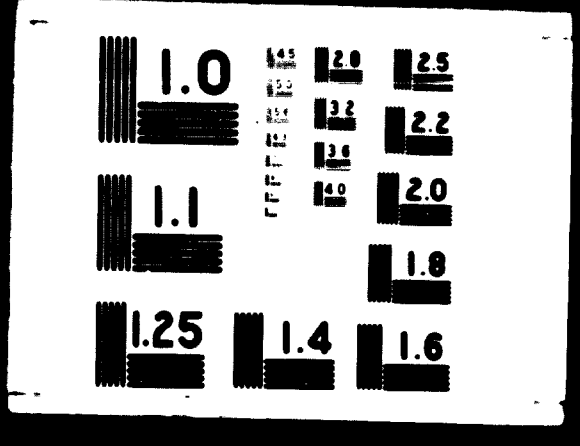

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PREVENTIVE MAINTENANCE: KEY TO IMPROVED PRODUCTIVITY

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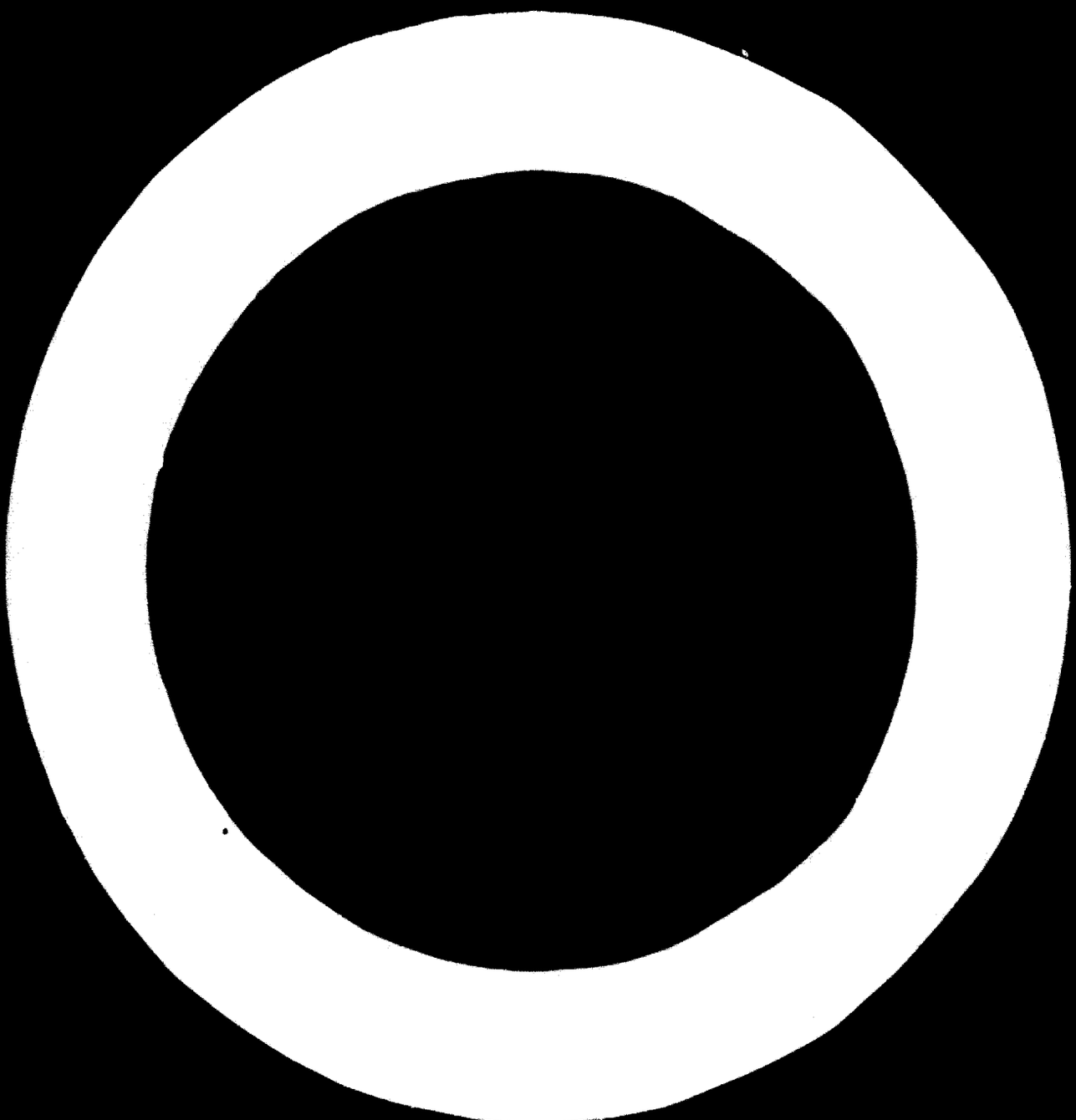
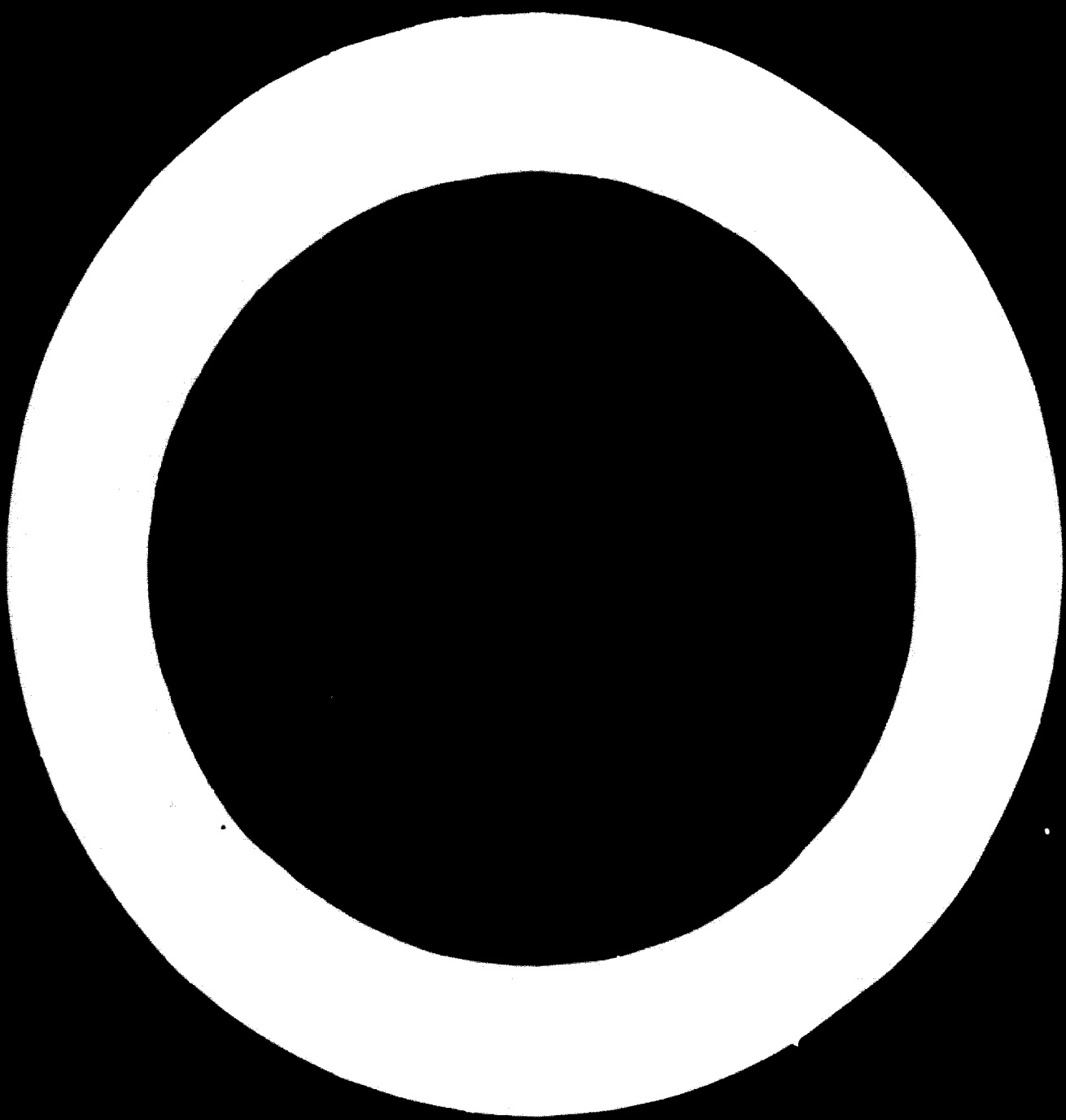


PROGRAMMED MAINTENANCE:
KEY TO INCREASED PRODUCTIVITY



PROGRAMMED MAINTENANCE:
KEY TO IMPROVED PRODUCTIVITY

I - INTRODUCTION

Most industrial, governmental, and social leaders today agree that present conditions in industrialized countries, inadequate as they may seem, are nevertheless great improvements over the previous periods of commercial enterprise and agrarian feudalism. A pertinent illustration of this is a passage from the autobiography of an Englishman whose age was twenty a mere century ago:

"In the middle of the nineteenth century there lived in the parish of Marsham, Norfolk, a couple of poor people by the name of Thomas and Mary Edwards. In was on October 5, 1850 that Mary Edwards bore her last baby boy. At the time of my birth my father was a bullock feeder, working seven days a week, leaving home in the morning before it was light, and not returning in the evening until it was dark. He never saw his children at this time except for a little while on the Sunday, as they were always put to bed during the winter months before his return from work. At this time my father's wage had been reduced to 7s (about $1.40) per week, and had it not been that my mother was able to add a little to her husband's wages by hand-loom weaving, the family would have absolutely starved. I have known my mother to be at the loom sixteen hours of the twenty-four, and for those long hours she would not average more than 4s (about 60¢) a week, and very often less than that.

The cottage in which the child was born was a miserable one of but two bedrooms in which had to sleep father, mother, and six children. The family at this time was in abject poverty. When lying in bed with the infant the mother's only food was onion gruel. As a result of the bad food, or, properly speaking, the want of food, she was only able to feed the child at her breast for a week. After the first week he had to be fed on bread soaked in very poor skimmed milk. As soon as my mother was able to get about again, she had to take herself again to the loom.... Food rose to famine prices.... The only article which did not rise to such a proportionately high figure was meat, but that was an article of food which rarely entered the poor man's home, except a littel piece of pork occasionally which would weigh about 1 1/2 lb., and would have to last a family of nine for a week! At the time of the Crimean war meat never entered my father's house more than once or twice a year.

In order to save the family from actual starvation, my father, night by night, took a few turnips from his master's field. My father used to keep our little boots in the best state of repair he could. My sister and I went to bed early on Saturday nights so that my mother might be able to wash and mend our clothes, and we have them clean and tidy for the Sunday. We had no change of clothes in those days. This work kept my mother up nearly all the Saturday night, but she would be up early on the Sunday morning to get our scanty breakfast ready in time for us to go to Sunday School."

Admittedly, the conditions described above are very discouraging, but were typical of conditions in Europe a century ago. One only has to look around to see how far Europe has developed in the last one hundred years. Our senor citizens who are living longer, receiving better care and enjoying more material well-being, can tell you how fast that century has passed. But for those who are looking ahead and waiting for such things to come to pass, a century is a very long time indeed!

Generally, a developing country can be defined as one which is striving to reduce the disparity in material well-being between citizens of its land and those of industrialized nations.

Assuming the rate of economic expansion for industrialized nations continues in the future, it can be clearly seen that a developing nation must generate an even greater rate of economic expansion in order to realize its goal. At first glance this may seem an impossible task. But one should recognize that one hundred years ago the entire world still lacked the know-how, the tools, and the harnessed energy to produce and operate the modern day loom with which a single person can outproduce Mrs. Edwards by a factor running into the thousands. Furthermore, detailed information on all aspects of technological development is widely available today.

Recently, an engineer in a modern textile mill declared that the efficiency of the plant machinery was more than 96%. This means that on the average the machines are standing still less than 4% of the time for set-up and maintenance. He said: "To stay alive in this business, one must replace some of the equipment some of the time, but most importantly be sure to keep all the equipment running all the time". That pretty well summarizes the problem to which this article addresses itself.

II - DEFINITION OF THE PROBLEM

Much information is available about technical obsolescence and equipment replacement theory and policies in industrialized nations, and some of the principles are universally applicable. However, due to different relations between available resources, technical obsolescence does not occur as rapidly in developing nations. In developing nations the greater need for long equipment life spans and the urgency to increase productivity places critical responsibility in the area of equipment and facilities maintenance.

Even more information is available about the philosophies, the methods, the systems, and the tools for maintaining industrial equipment and facilities. So much, in fact, and often so general that it is difficult to recognize which information applies to a particular situation. Even after a particular approach has been selected for increasing the effectiveness of a maintenance function, the critical problem still remains of translating this theory into

a practical application which will achieve desired results. The balance of this paper outlines a practical approach for the development and implementation of a program for the improvement of the maintenance function which the author considers particularly suitable for manufacturing plants in countries with relatively short industrial traditions.

III - THE CONCEPT OF PROGRAMMED MAINTENANCE

A well established method of increasing the effectiveness of a maintenance function which has been widely applied in the industrialized countries is based on the concept of Programmed Maintenance. Some experienced consultants whose professional life is devoted to translating theory into practical results have developed a systematic approach to Programmed Maintenance including most importantly the installation of this system. The execution of Programmed Maintenance is a discipline relying largely on the formation of certain habit patterns, and its application is certain to result in worth while benefits in developing nations as well.

In the remaining paragraphs of this section the concept of Programmed Maintenance will be discussed under the following headings:

- Definition
- Objective
- Advantages

DEFINITION

Programmed Maintenance is the performance of maintenance activities according to a predetermined plan. Ideally such a plan takes into account realities such as the fact that a production crane required for a maintenance activity can only be used "off shift". The plan should consider scheduled shutdowns and assign priorities to requests for maintenance work according to importance and urgency.

OBJECTIVE

In an industrial environment, the objective of maintenance is to keep equipment capable of producing acceptable products when needed and at minimum cost. This cost includes the maintenance activities and the loss of production during maintenance work. The specific purpose of Programmed Maintenance is to meet the objective mentioned above with maximum efficiency. This means minimizing the loss of resources through reducing waiting time, waste of material, and duplication of effort.

ADVANTAGES

Although developing and installing a system for Programmed Maintenance is a slow, painstaking process, the advantages of such a system more than offset the initial investment in time and effort. The most important of these advantages are the following:

- Control
- Simplicity
- Applicability
- Effectiveness

(a) Control

In the absence of defined elements of work, it is difficult to determine whether a task is performed correctly or effectively. Attempts to control undefined activities usually deteriorate into debates as to necessity, method, time and place for the task. On the other hand, clearly defined methods make it possible to assign, schedule, and supervise the execution of the work. Standard procedures allow for consistent evaluation and therefore control of performance.

(b) Simplicity

Most tasks can be performed in more than one way. People left alone to perform a given task repeatedly without established work methods and standards will usually go through a period of trial and error in attempting different ways to perform their work in order to determine the most suitable method. But maintenance activities are seldom repetitive in nature, and the same activities are often carried out at relatively long intervals. They are therefore seldom done spontaneously according to the best or quickest method. Judicious programming of maintenance activities makes trial and error unnecessary and therefore simplifies the task of maintenance personnel at all levels.

(c) Applicability

Systematic planning has been applied successfully to virtually all maintenance activities. This includes preventive maintenance routines such as lubrication and inspection as well as construction,

repair, painting, and cleaning.

In developing countries where mechanical orientation and care of equipment may often not be as firmly rooted in workers' attitudes as in countries with a longer industrial tradition, a programmed system of preventive maintenance is bound to pay large dividends.

(d) Effectiveness

Consistent achievement of objectives cannot be realized by accident. It requires thoughtful planning of objectives and controlled execution of activities to reach desired results. The degree of planning and control applied to production processes in the industrialized world and the results obtained attest to the validity of this statement. The same is true for the area of facilities and equipment maintenance. Here, too, results are largely a function of the effort that goes into planning and controlling the activities. Programming the methods and procedures has proven the best way to achieve a high degree of effectiveness in maintenance operations.

IV - DEVELOPING AND INSTALLING PROGRAMMED MAINTENANCE

No single method of developing programmed maintenance is applicable to all types of operations. Plants vary widely with regard to production processes, local conditions, and human traditions. A system that does not take into account these different factors will be less than optimal and will fail to achieve

the objectives for which it is created. These objectives must be defined before the programmed maintenance system can be developed and installed. Typically, a list of such objectives includes some or all of the following:

- Consistent estimating
- Improved methods analysis
- Elimation of delays through improved scheduling
- Improved coordination of crafts
- Improved supervisory controls
- Better trained maintenance personnel
- Improved material control
- Better control of maintenance work backlog
- Controlled manning
- Improved productivity
- Better cost control.

A successful approach to the installation of a comprehensive system of programmed maintenance is to conduct the work in separate and distinct phases. An important advantage of this approach is that the attainment of a distant target is divided into manageable pieces, each moving in the direction of the ultimate goal. In addition, progress can be measured more precisely and steps can be delayed at well defined intervals when additional time is required for the installation of a certain phase. These advantages apply universally, but the individual phases and the sequence in which they are installed will vary especially with differences in

personnel qualifications, a factor which will require particular attention in developing countries. In the beginning, therefore, emphasis should be placed on development of the personnel through motivation and training as part of the creation of a basic preventive maintenance system. As a next step a system for programming construction and repairs (including painting, cleaning and miscellaneous duties) should be developed and installed, and finally introduction of labor standards and refinement of the preventive maintenance system should be undertaken. A suggested program is described in more detail in the following chapters. It consists of the following phases:

- Basic preventive maintenance
- Construction and repairs
- Maintenance labor standards
- Refined preventive maintenance
- Miscellaneous programs.

A - BASIC PREVENTIVE MAINTENANCE

A basic preventive maintenance program is organized and carried out in the following steps:

- Personnel Conditioning
- Systems Development
- Personnel Training.

PERSONNEL CONDITIONING

This step deals with the development of certain attitudes among the maintenance personnel.

(a) Motivation

People are deeply committed to their futures. Therefore, an effective way to motivate people is to inform them about the goals they are expected to attain. If these goals can be demonstrated to be desirable and realistic, they will be accepted with positive response. If the information about the goals is left to the grapevine to be communicated, they will be misunderstood and unfavorably received. An effective way to motivate personnel to cooperate in the realization of goals, therefore, is to tell them in clear terms about the goals and the benefits that will accrue.

(b) Indoctrination

There are many examples of popular wisdom which are full of glaring fallacies - racing the engine of a cold car to warm it up - and - automation creates unemployment - are indeed common examples in the industrialized world.

Another case in point is that powerful equipment can survive rugged use even over extended periods of time without special care. People with such convictions may do considerable harm to equipment. It is therefore important to organize an effort to detect and combat such detrimental misconceptions. Imaginative posters or slogans such as those which have promoted safety in

industrialized nations will sometimes bring about favorable changes in these attitides.

SYSTEMS DEVELOPMENT

This step is concerned with developing systems and procedures for carrying out the preventive maintenance function. It consists of the following activities:

(a) Collect and Organize Data

Effective systems and procedures are built on a sound foundation of factual data concerning the equipment and facilities to be maintained and the available and necessary tools and supplies. These data will include manufacturers recommendations regarding equipment limitations, lubrication, adjustments and other operating and maintenance guides. If necessary, equipment manufacturers or previous owners are contacted to obtain missing data. Insurance codes, catalogues and manuals often provide good answers to specific questions concerning the operation and care of equipment. Similar data concerning tools and supplies should be gathered. All data are collected and filed in an organized manner according to plant departments and types of facilities or equipment for easy reference during the next activity.

(b) Analyse and Classify the Data

Relevance of the collected data for the purpose of this phase must be determined through careful analysis. Superfluous information

is identified and segregated. The usefulness of the remaining data can be enhanced by further classification. Grouping equipment according to similar lubrication requirements, for example, will help to determine how many different lubricants should be stored in what quantities and where. Analysis and classification should be made in so much depth that the results are the simplest possible consistent with the requirements. Stocking general purpose items or tools in place of differentiated items simplifies purchasing and storage requirements as well as the task of the craftsman in the use of these items.

(c) Establish Methods and Procedures

The performance of maintenance work consists of carrying out series of tasks arranged in certain sequences. Experience has shown that superior results can be obtained if the tasks and sequences of tasks are always carried out according to the same - preferably the best - method. This is also true for carrying out procedures which are normally not classified as work, but are carried out in connection with it, such as the filling in of time cards. In this step the best methods and procedures for preventive maintenance are established through analyzing the tasks or elements of maintenance work and arranging them in the most effective and economical patterns. The following items are required for basic preventive maintenance:

1. Descriptions of each of the basic tasks such as: "feel if motor overheated" or "fill reservoir to line".

2. Checklists made up of patterns of these tasks for each installation. For a conveyor, for example, the checklist may include the following:

   - watch operation of conveyor
   - check if all rollers turning
   - listen for squeeky rollers
   - shut down conveyor and lock switch
   - feel if motor overheated
   - check oil level in speedreducer
   - check if all roller bolts tight
   - unlock switch and start conveyor

3. Inspection and lubrication routes. These could be colored lines running from one installation to another on a plant layout. They should be determined to maximize the result per unit of distance travelled.

4. Schedules determining the time of execution of the checklists and precedures to initiate these activities. These should be sufficiently flexible to allow for short order rescheduling if an activity cannot be carried out when intended.

5. Procedures for reporting extraordinary conditions or those which the inspecting craftsman cannot correct by himself.

6. Procedures for coordination with production departments including agreements to shut down equipment when required for maintenance activities.

PERSONNEL TRAINING

Aside from training programs to improve general craft abilities, proficiency in preventive maintenance requires training of personnel in the specific methods and procedures that were developed in the previous step. The aspects covered by these methods and procedures vary in number and importance between facilities but usually include the following:

(a) Lubrication

Principles, methods and procedures of lubrication, as applicable to the plant in question, are taught, discussed and demonstrated. A basic list of these includes the following topics:

- Objectives of lubrication
- Causes and effects of lubricant breakdown
- Fallacy of overlubrication
- Different lubricants used in the plant and their purposes
- Means of lubricant application and their uses
- Quantities and frequency of lubricant application.

(b) Inspection

At first, preventive maintenance inspections will mainly consist of diagnostic procedures such as those described in the above checklist. The checklists will be used as written programmed instructions. Therefore, no time needs to be lost in learning detailed routines. Training in how to carry out the developed methods and procedures includes interpretation of these standards. In

"feel if motor overheated" for instance interpretation of the term "overheated" is required. Exceptions to such rules, however, must be specifically noted in the instructions. If time and opportunity permits, the actual routines should be carried out in the field during the training under supervision of the instructor.

(c) Correction

Lubrication and inspection routines should include carrying out certain corrective activities. In the beginning, only simple corrective activities will be performed, but later in the program, particularly during the preventive maintenance refinement phase, the scope of these activities will be increased. Preventive maintenance correction includes the following types of activities:

1. Adjustment: this usually consists of turning or moving an object to improve a function, for example advancing an idler sprocket to increase the tension of a drive chain or removing shims from a bearing to reduce excessive clearance. Failure to make adjustments can have grave consequences. Too much adjustment can be equally detrimental. For these reasons maintenance personnel are trained to carry out non-critical adjustments only and to recognize and report the need for critical adjustments to be carried out by specialists.

2. Repair covers a spectrum of widely varying activities from soldering a severed wire to straightening a lineshaft. Personnel are trained to carry out repairs that can be performed with the tools they carry on preventive maintenance inspections. For this reason the proper use of these tools is reviewed. Typical examples of such repairs as straightening a

bent door latch, patching a leaky vacuum line and filing eroded contacts, are treated. Personnel are cautioned against overzealous as well as careless performance of repair both leading to further destruction rather than the intended repair.

3. Replacement of parts depends on the availability of the required spares. Certain parts such as fasteners, gaskets and contacts are relatively inexpensive items of which a small assortment is carried along on preventive maintenance routines. When necessary, replacement of such parts is performed out of this assortment.

   To reduce downtime of equipment in case of breakdown of components, specific spare parts must be purchased and kept in reserve. Such reserves represent an unproductive - though necessary - investment which must be minimized as much as possible. This is facilitated through control of the use of these parts which can only be obtained with formal requisitions, authorized by supervision or - in the case of critical components - by the management. Preventive maintenance personnel are trained to recognize the need for replacement of parts and to perform replacement of inexpensive items.

(d) Reporting

The purpose of preventive maintenance routines is not only to correct small ailments immediately in order to prevent further deterioration and possible serious consequences, but also to diagnose and report unusual conditions which cannot be corrected immediately. During the training of the maintenance personnel, examples of

unusual conditions such as noisy bearings, loss of lubricant or vibrating couplings are discussed, and the procedures for reporting such conditions are explained and practiced.

B - CONSTRUCTION AND REPAIR

The chances for success of programming construction and repair work are dependent on the soundness of certain aspects of the maintenance function. Therefore, investigations - and if necessary changes - of these aspects have to be made. These aspects are:

- Organization structure
- Facilities
- Systems and procedures
- Familiarization and training

ORGANIZATION STRUCTURE

During this step the maintenance organization structure is examined, existing lines of authority and responsibility are reviewed, and necessary new lines are established. Numbers of craftsmen reporting to foremen and of foremen reporting to higher functions are balanced. Staff functions for the administration of preventive maintenance, for training, planning, scheduling and other systems are established. A complete organization chart is developed, showing occupied and vacant positions. Personnel for vacent positions are solicited, tested, and indoctrinated.

FACILITIES

A study is made of the plant layout to determine the locations

of the maintenance workshops relative to the facilities to be maintained. Buildings, tools, and equipment at the disposal of the maintenance department, as well as store rooms and stores of spare parts and supplies are investigated for adequacy. The availability of services from outside sources and the consequences for maintenance equipment requirements are determined. In case that changes in these arrangements are economically justified, they are scheduled for execution at times when the normal processes will be least disturbed.

SYSTEMS AND PROCEDURES

Existing paperwork systems and procedures are reviewed to determine their compatibility with programmed maintenance. Changes that may be required are outlined, and the complications that may result are analyzed. Lacking elements are developed and implemented.

The major systems and procedures required for successful programmed maintenance are described below. They include:

- Work order system
- Material control
- Planning
- Scheduling
- Cost accounting.

(a) Work Order System

A comprehensive work order system consists of a number of forms and specified routines for filling in these forms, routing them and having them initiate certain activities. The following are the

two principal steps:

1. A work request is normally originated by a foreman requesting a maintenance service. It is routed to the planning and scheduling staff which investigate the work and assign a priority class to it. Requests for work which exeed certain cost limits for labor and material are subjected to approval from the maintenance or the plant management.

2. A work order is made out by the planning and scheduling staff. It contains a description of the work and time and place of execution as well as data for cost identification. Together with other documents described below, it is routed to the head of the department which will perform the work and to the requestor. After satisfactory execution of the work, the requestor signs his copy and reroutes it to the planning and scheduling staff for closing of the order.

(b) Material Control

Starting the execution of a job before the required materials are on hand results in undesirable delays and loss of time. The planning and scheduling staff therefore determine what materials are required and initiate the ordering as well as the reservation procedures. For this purpose they make use of a standard form, the material requisition. Material requisitions are routed to the stores which determine if the material is available or not. In the former case stores reserve the material and notify the planning and scheduling staff. In the latter case they route the requisition to the purchasing department. Copies of the material requi-

sitions accompany the work orders to be used as stores receipts for withdrawal of the material from stores. Before scheduling a job for execution the planning and scheduling staff make sure that all required materials are available in the correct quantities and correspond to the proper specifications.

(c) Planning

This activity is perhaps the most important phase in programming construction and repair. Together with scheduling it constitutes an organized approach to the problem of applying the resources available for maintenance in the most effective and economical manner. Effective planning is carried out in the following steps:

1. A work analysis is performed after receipt of the work request. The planners contact the requestor, examine the work site and collect all information needed for the execution of the work. They secure the necessary drawings and prepare the required sketches and diagrams. The planners also determine the required crafts personnel and special equipment. These data are recorded on a standard form or planning sheet. Drawings, sketches, and diagrams as well as the planning sheet accompany the work order.

2. The craft estimate is the most essential dimension of work programming. The time estimate makes it possible to plan beyond the present or the immediate future. Due to the many variables involved, it is difficult for an individual to make accurate time estimates for construction and repair. Techniques for averaging several individual estimates for the same job should be used by the planners to obtain more reliable results. Schedules can only be reliable when they are based on accurate time estimates.

3. Job manning is determined next. Careful determination of the sizes of crews performing construction and repair contributes to efficient use of maintenance resources. The most economical crew size is usually determined by the characteristics of the job. Because of personnel scarcity, the need to meet deadlines, or in the interest of safety, it is frequently impossible to operate with ideal crew sizes. The planners determine the most favorable crew sizes consistent with conditions prevailing at the time the work is to be carried out.

4. Coordination is necessary when a job is carried out by more than one craft. Frequently the work of one craft must be finished before another can start. When this transition does not occur smoothly, job completion is unnecessarily delayed or craft time is lost in waiting. When the start of a job is dependent on shutting down a production installation, either production time or craft time can be lost by poor timing. The planners therefore assist in follow-up on the schedule to reduce delays and loss of craft time as much as possible.

(d) Scheduling

This step is the synthesis of the previous activities carried out by the planning and scheduling staff. It is the final act in the actual programming process. Several times a week the planning and scheduling staff review the progress of the work in execution, deleting completed jobs from and adding new jobs to the schedule. Every time there is a major change in the situation of a maintenance department a new schedule is prepared. This is entered on a standard form, the department schedule. This form is routed to the

heads of the departments which will execute the work shown on the schedule. In scheduling work for execution, the planning and scheduling staff must take proper account of the following items:

- Priority of the work
- Availability of creft personnel
- Special equipment and materials
- Craft time estimates
- Job manning requirements
- Coordination with production, outside firms and between crafts.

Critical projects such as revisions carried out during standstill of production processes are scheduled with great care to keep lost production at an absolute minimum. GANTT charts are prepared in advance and discussed with the supervisors of the groups which will execute the work. Particular surveillance of jobs on critical paths is provided during the execution of the work. After completion of the work, the planning and scheduling staffs and the supervisor review exceptional or unexpected circumstances that may have affected the work. Planning data and estimates which are found to differ from reality are so noted and corrected on the forms before these are filed for future reference.

(e) Cost Accounting

A reliable index of maintenance performance is cost. Total maintenance cost figures are only meaningful in comparison with other operations data such as production output, production costs, power consumption etc. These comparisons should be made at regular intervals to recognize respective trends. In addition, analyses of the distribution of maintenance costs will show more exactly where the effort at improvement should be concentrated.

A system that both accounts for maintenance expenditures and provides an effective management tool consists of the following major elements:

1. Cost distribution requires identification of the various plant areas or departments, installations within these areas and, if necessary, installation components. Codes are given to each area, installation, and component. The degree of detail of the coding and the type of code depends on the specific needs. As a further step, characters can be assigned for identification of the various maintenance departments, crafts, or groups performing the work.
2. Cost reporting covers both labor and materials. In the beginning, the maintenance supervisors are responsible for charging labor hours to the corresponding area, installation and component codes. Later on in the program, the craftsmen should carry out this responsibility. Labor hours are reported daily by way of a standard time card on which the date, the equipment code, the time worked and the clock numbers of the workers are filled in. Material costs are reported and charged to the corresponding codes by recording them on the material requisitions.

FAMILIARIZATION AND TRAINING

After all forms and procedures for the programming of construction and repair have been developed, the various levels of the maintenance organization are familiarized with the system. A proven way is the use of graphic portfolios containing enlarged samples of the forms and diagrams of the organization structure and of the various procedures. Planners and schedulers are trained in methods

of analysing work content and work requirements, of averaging labor estimates, and in the application of GANTT charts. Supervisors and craftsmen are instructed in the proper use of the work request, work order, planning sheet, material requisition, time card, and department schedule.

C - MAINTENANCE LABOR STANDARDS

As programmed maintenance progresses in actual application, a need for improving the labor estimates will be felt. At this stage the systematic, programmed approach has become an accepted way of life, and the maintenance organization should be ready to establish a more accurate basis for planning and scheduling as well as for measuring performance of the crafts. This can be achieved through the introduction of engineered maintenance labor standards. This refinement can be implemented without changing the systems which were installed in the previous stages. In the subsequent paragraphs, the following aspects of engineered maintenance labor standards will be discussed:

- Definition
- Purpose
- Advantages
- Application
- Training.

DEFINITION

Engineered maintenance labor standards are a collection of descriptions of elementary work processes, carried out during

construction and maintenance of industrial installations. To each process a time value for its execution under average conditions by average craftsmen is attached. These work processes and time values can be established through a variety of methods such as work analyses, time studies, Methods-Time-Measurement studies (M.T.M.), or work sampling studies.

Because of the large variety of crafts, materials, and circumstances involved in maintenance activities, it is not economical for most firms to develop their own maintenance standards. Therefore, A.T. Kearney & Co. has developed standards which apply irrespective of type of industry and of plant characteristics. For this approach, maintenance work is divided into direct and auxiliary work. Direct work consists of those elements that can still be indentified after a job is completed. Auxiliary work consists of elements which are not apparent after the work has been done. Among these are planning, travel, obtaining materials, and miscellaneous get-ready and clean-up work by the craftsmen.

OBJECTIVES

While it is fairly easy to estimate the cost of materials, the amount of time required to perform a given task is a more complex problem. The labor estimates which are used in the early stages of the program are based on the judgment of the person making the estimate. Obviously, personal experience, knowledge, and ability of the estimator will determine the quality of these estimates. Although this has the advantage of being a quick and inexpensive

approach, the disadvantages are numerous and include the following:

- Estimates are usually inconsistent and inaccurate
- Estimates vary in accuracy between different estimators
- Methods comparisons are difficult
- Training of estimators is difficult
- Verification is almost impossible

It is therefore apparent that to obtain refined programming and control, more accurate job times must be developed for maintenance work. This is accomplished through the use of engineered labor standards which are applied to the various maintenance tasks to establish reliable execution times for each of these. In this way, a trained and experienced planner is capable of planning the work for 10 to 20 craftsmen.

An important additional application of engineered standards is craft performance evaluation. Comparison of standard hours with hours worked on individual jobs by craft group or department allows calculation and control of effectiveness figures and trends and the identification of trouble areas.

ADVANTAGES

The advantages of applying engineered standards to maintenance work are numerous and include the following:

- Accurate and reliable predetermination of craft times
- Consistent estimating based on common standards
- Determination of the best work method
- Improved scheduling and prompter completion of the work

- Performance rating through comparison with proven standards in industrialized nations
- Objective analysis of contractor performance
- Improved coordination between crafts and elimination of delays
- Improved supervisory control.

APPLICATION

The standards contained in the "Simplified Maintenance Standards" handbook developed by A.T. Kearney & Co. have been used to cover up to 80% of the maintenance activities in industrial plants. The remaining 20% can be covered to a large extent with other A.T. Kearney & Co. standards such as

- Tool Room Standard Data
- Lubrication Standard Data
- Janitorial Standard Data.

TRAINING

Judicious application of engineered labor standards to maintenance work requires thorough training of the planners and schedulers. Experience in the industrialized nations has shown that formal training of planners and schedulers usually takes five to six weeks of class room work on a full-time basis. Upon completion of the training they spend another three to four weeks preparing standards for actual repetitive work in the plant under close supervision of an experienced consultant.

D - REFINED PREVENTIVE MAINTENANCE

After all previous phases have been implemented and are operating satisfactorily, the time has come for further improvement. For this purpose, the operation and results of the basic preventive maintenance effort are examined. Problem areas are identified and investigated in depth. Opportunities for refinement are examined and promising alternatives are implemented. These may include:

- Equipment history records
- Equipment cost records
- Systems to locate and eliminate sources of component failure

E - ADDITIONAL PROGRAMS

A successful installation of Programmed Maintenance as outlined in the above approach can be supported by additional programs and systems which may include the following:

- Long-range facility improvement
- Capital equipment replacement
- Materials handling standards
- Spare parts management
- Stores control
- Incentive payment
- Network planning
- Project control
- Value analysis
- Supervisory development and incentives
- office clerical standards.

V - CONCLUSIONS

Assuming that the essential programs and the necessary support systems have been implemented, an evaluation of the original objectives can be expected to show the following results:

1. Consistent Estimating. Since all maintenance planners are using the same standard data for estimating job content, the man-hours allocated to various maintenance jobs will be consistent. Proposed expenditures can be evaluated with more reliability. Performance by individuals or by craft can be measured accurately and consistently.

2. Methods Analysis. One of the maintenance planner's major functions is to evaluate a job before it is started. Alternate methods of installation can be properly weighed and compared. Decisions can be made as to whether jobs should be contracted, prefabricated, or performed by maintenance personnel with assurance of obtaining predicted results. A need for improved facilities can often more easily be justified because handicaps which exist from a physical facility standpoint must be allowed for in planning the labor content of a job.

3. Elimination of Delays through Improved Scheduling. Since the time duration of a job can be predicted, the maintenance planner and the supervisor are aware of the starting and finishing points of each job. This should eliminate delays brought about by improper estimating and should result in reduced labor costs through improved effectiveness.

4. Coordination of Crafts. In the event that two or more crafts are involved in a particular job, it is necessary to coordinate the start and completion times of each craft to preclude a craft arriving at the scene too soon or too late. Determination of labor content for each craft will provide for proper coordination between supervisors, since the planners can advise them in advance with regard to their particular assignments.

5. Improved Supervisory Controls. Since most of the paperwork involved in maintenance is done by planners, the supervisors have additional time for directing personnel. Supervisors are selected for job knowledge and ability to control personnel. Time spent on paperwork detracts from these important responsibilities.

Another significant item is the fact that, since jobs are consistently estimated, supervisors have an additional control tool for use in directing people. Accountability for improper performance can be assigned if supervisors are provided with realistic estimates of labor time for particular assignments.

6. Training. The introduction of Programmed Maintenance results in training of maintenance personnel at all levels. The planners and schedulers who can ultimately become craft supervisors receive valuable training as preparation for future promotions.

Through application of engineered labor standards, inadequate training of craftsmen is also brought to light. This becomes evident when estimates are not met by craftsmen due to unfamiliarity with the assignment, inexperience, or insufficient qualifications.

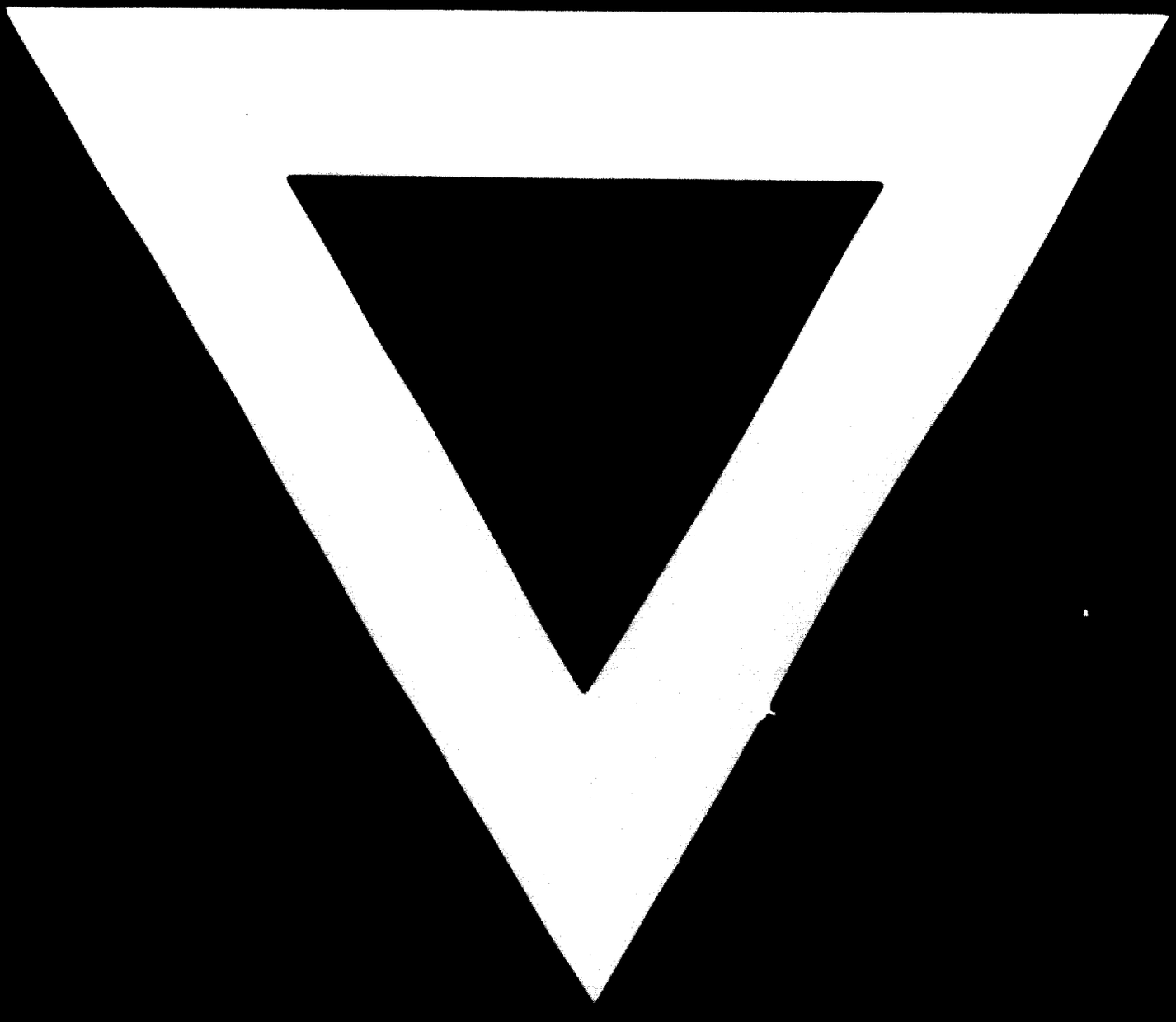
7. Materials Control. The maintenance planner, in addition to controlling labor content, also contributes to control of materials. Jobs are not scheduled for execution unless the material is available and on hand. Material costs are reported in addition to labor costs on each job. The use of alternate materials can be evaluated in terms of the respective labor costs.

8. Work backlog control. Since the labor content of the backlog of maintenance work is accurately determined, the work backlog of each craft can be controlled. Through application of standards, backlogs can be managed and schedules be adjusted as required.

9. Controlled Manning. If proper data are available to supervision and management, better decisions can be made to level fluctuations in maintenance labor requirements. Personnel additions, transfers, or replacements can be planned, and the volume of work done by outside contractors can be reduced.

10. Improved Productivity. Since some of the maintenance resources have been made available for organized, programmed preventive activities, equipment breakdowns occur less frequently. In the event that breakdowns do occur, spare part availability and programmed repair reduce the downtime substantially. Improved equipment condition improves product quality and reduces reject quantities. These factors all add up to improved productivity.

11. Cost Control. Finally, Programmed Maintenance results in better maintenance cost control. Management will be able to compare acutal to standard maintenance cost and will, therefore, be in a position to accurately evaluate, forecast, and control maintenance expenditures.



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