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Maintenance Management Systems for Municipal Wastewater Facilities

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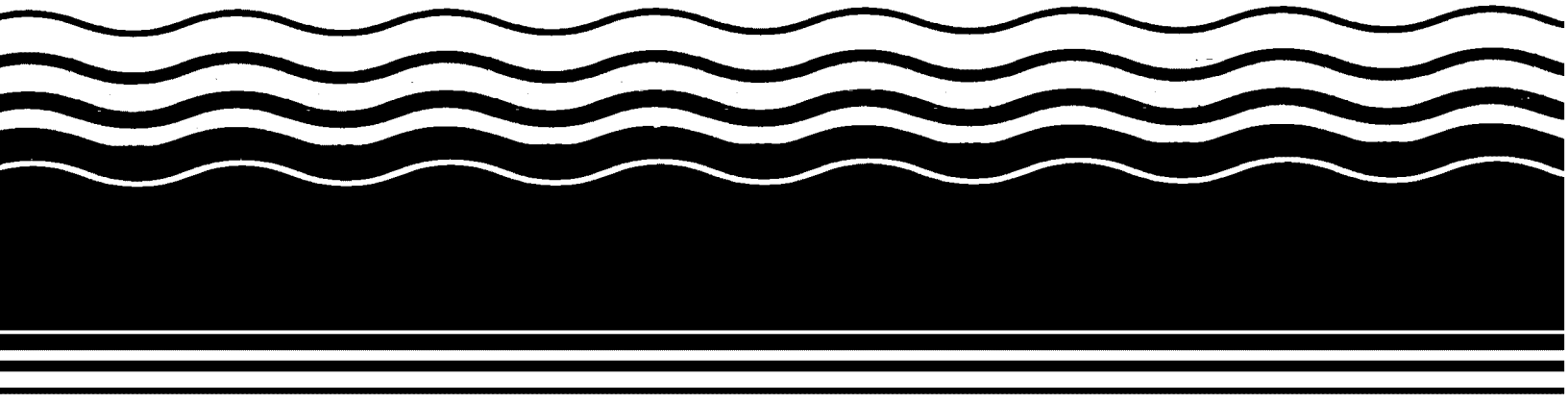

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MAINTENANCE MANAGEMENT SYSTEMS FOR MUNICIPAL WASTEWATER FACILITIES

MUNICIPAL OPERATIONS BRANCH
OFFICE OF WATER PROGRAM OPERATIONS
U. S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D. C. 20460

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ABSTRACT

The Environmental Protection Agency (EPA) through its operation and maintenance program, Office of Water Programs Operations, has commissioned Wiley & Wilson, Inc., Engineers • Architects • Planners, Lynchburg, Virginia to develop recommendations for the preparation of maintenance management systems to be used at municipal wastewater treatment facilities. The recommendations are presented in the form of a manual to be used by treatment system management in developing maintenance management systems.

The principal background for this work came from the existing maintenance guidelines as outlined in the Appendix of the "Federal Guidelines For Design, Operation and Maintenance of Wastewater Treatment Facilities", 1970. During the project, information was obtained from persons experienced in maintenance management. Existing maintenance management systems used by wastewater treatment facilities, industry, and the armed forces also were reviewed.

These recommendations cover each of the basic features required in a sound maintenance management system and a separate section of this manual discusses each feature.

These recommendations are not intended as a rigid format; they can be modified to fit the particular case at hand. By following these recommendations, a complete and efficient maintenance management system will be developed.

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SECTION I
CONCLUSIONS

1. A sound maintenance management system will help ensure that a municipal wastewater treatment facility operates efficiently and the effluent limitations, as described in the facility's discharge permit, are being met.

2. A review of municipal wastewater treatment facilities across the country reveals that, although no standard maintenance system is in use, all plants have instituted some form of maintenance. However, many plants haven't undertaken their maintenance in an orderly enough manner that it could be termed a system.

3. The information on maintenance management systems contained in this manual should be helpful to persons developing the maintenance chapter in a treatment facility's Operation and Maintenance Manual. The information should also assist persons revising an existing maintenance program. The manual, however, does not attempt to define ideal maintenance management systems for every size and type municipal wastewater treatment plant.

4. Treatment plant management must give their full support to the maintenance program if it is to be successful. Plant management must convince all maintenance personnel that, by following the maintenance program, both the overall plant operation and the maintenance organization will benefit.

5. A good maintenance management system ensures that necessary preventive maintenance work is performed through proper planning and scheduling, by adequately trained personnel, and by realistic estimates of corrective maintenance requirements.

6. The costs required to maintain a preventive maintenance program are less than the expensive repairs that result from inadequate preventive maintenance.

7. The records of a good maintenance system on equipment, work orders, and storeroom activities contain sufficient cost information to permit control of maintenance expenditures and to allow realistic budget preparation.

8. A maintenance management system should not stand still. It needs to be continuously reviewed and revised to keep up with changing equipment requirements, staff capabilities, and maintenance costs.

9. The attention given to maintenance activities by wastewater treatment management is somewhat less than that given by managers in profit oriented industries.

10. The most important factor in any good maintenance program is the people involved. It is essential to pay attention to the needs of these people. These people's needs include adequate training, proper tools, good working surroundings, competitive salaries and fringe benefits, and adequate opportunity for advancement in both salary and degree of responsibility.

SECTION II
RECOMMENDATIONS

1. Persons preparing the maintenance chapter for a municipal wastewater treatment facility's operation and maintenance manual should review the information on maintenance management systems contained in this manual. This manual contains the necessary information to ensure that consideration is given to each feature required in a sound maintenance management system. Persons revising existing maintenance programs also may find this information helpful.

2. Persons recommending maintenance management systems for municipal wastewater treatment facilities should review thoroughly the requirements for the particular facility under consideration. Obtain information from persons with experience in the maintenance and operation of equipment similar to that in the facility under study. The maintenance program recommended, however, should be tailored to the facility's needs. Also, investigate the use of computers to handle a portion or all of the maintenance system.

3. The maintenance management system of a municipal wastewater treatment facility should be ready for implementation when the plant is started up. All necessary forms should be available and procedures defined. These items, of course, can be revised at some later time, but it is important to have the maintenance program properly initiated to ensure its proper place in overall plant operation.

4. The training of the maintenance staff should receive the same emphasis as the operator training in a municipal wastewater treatment facility. This training is necessary if maintenance skills are to be sharpened and expanded, and should be a combination of formal courses, correspondence courses, and on-the-job training.

5. All corrective maintenance work in a municipal wastewater treatment facility should be initiated by a written work order. Of course, emergency repairs are an exception to this recommendation, but a follow-up work order should be prepared even on these repairs. The work order system provides the necessary control to ensure that corrective maintenance work is not interfering with the preventive maintenance schedule. The system provides a record of maintenance labor and material costs. The work orders also can be used to measure the efficiency of the maintenance staff.

6. Detailed preventive maintenance procedures (or checklists) should be developed for all major equipment items in the municipal wastewater treatment facility. These procedures (or checklists) should be based on individual manufacturer's recommendations and provided to maintenance crews to help ensure preventive maintenance is performed correctly and efficiently.

7. Municipal wastewater treatment management regularly should investigate the performance standards of maintenance labor and use of maintenance manpower. Such investigation will improve the efficiency of their maintenance personnel. Performance usually improves when a minimum level of acceptable work is established and when the activities of the labor force are planned and scheduled for maximum efficiency.

SECTION III
INTRODUCTION

Scope and Purpose

The primary function of municipal wastewater treatment facilities is to collect and treat municipal wastewaters so as to attain an interim national ". . . goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife, and provides for recreation in and on the water." The Federal Water Pollution Control Act Amendments of 1972 stipulate that this is to be accomplished by publicly owned treatment works in a consistent and reliable manner so as to meet effluent limitations based upon secondary treatment or any more stringent applicable limitation, by July 1, 1977, and so as to employ the best practicable waste treatment technology by July 1, 1983. The specific conditions and limitations will be identified in a permit issued to each point source discharge under the "National Pollutant Discharge Elimination System" as established by the Act.

Since the discharge of pollutants in excess of the effluent limitations of discharge permits is prohibited by the Act, it is essential that municipal wastewater plants, from the day of initial operation, effectively treat wastewater in compliance with those limitations. This manual has been prepared to assist in the accomplishment of this objective.

This manual provides guidelines to aid plant management in selecting, instituting, and evaluating various maintenance management systems for municipal wastewater treatment facilities. A maintenance management system encompasses all those policies, plans, and procedures required to adequately maintain a facility.

To obtain data for the manual, a survey of existing manual and automated maintenance systems literature was conducted. Techniques used by the Armed Forces, industries, and existing municipal wastewater treatment systems were reviewed and field surveys of selected facilities also were made. The results of these surveys plus information obtained from persons experienced in maintenance management, and recommendations from Wiley & Wilson's Sanitary Engineering Conceptual Design Team all are incorporated in this manual.

The treatment plant must be recognized as a highly specialized and complex manufacturing facility that must produce an acceptable product or effluent. It is the plant management's responsibility to produce this effluent at the lowest unit cost and at the highest quality possible. One important key to fulfilling this responsibility is a sound maintenance management program.

A good maintenance management system will reduce breakdowns, extend equipment life, and provide for more efficient manpower utilization and performance. The system will

provide data to aid in solving maintenance management problems and develop cost and budget recommendations.

Manual Format

Persons using this manual should be familiar with its organization and the general contents of its major sections, and following basic definitions:

Preventive maintenance is work done to prevent breakdown, reduce wear, improve efficiency, and extend the life of equipment and structures. These are maintenance functions that can be performed while the plant is usually in operation. These tasks would include routine inspection of equipment, lubrication, and minor equipment adjustments.

Corrective maintenance is work required for repairs and nonroutine maintenance functions. These tasks are performed while the plant is in operation or with a minimum of equipment downtime. These tasks would include changing belts and replacing worn bearings and brushes.

Major repairs or alterations are major tasks which generally occur when a unit is out of service. These tasks usually involve large expenditures of money and additional support personnel to aid or accomplish the required task.

Detailed discussions of the basic features of any sound maintenance management system are provided in the following sections:

- Equipment Record System
- Maintenance Planning and Scheduling
- Storeroom and Inventory System
- Maintenance Personnel and Organization
- Cost and Budgets for Maintenance Operations

The following is a brief introduction to each of the five basic features of any sound maintenance management system. A system efficiently using these basic features will provide for economy in maintenance cost and reliability in equipment operations for the maintenance program.

Equipment Record System — The equipment record system contains information on each item of equipment requiring maintenance. This system may be one card on each

item of equipment, a number of cards for each item, or for large plants, a combination of both cards and data maintained on a computer.

The equipment record system provides information on preventive maintenance tasks with their frequencies, corrective maintenance work performed and maintenance cost data. Information used in making cost analyses, preparing maintenance budgets and evaluating maintenance problems will be found in the record system.

Maintenance Planning and Scheduling — The planning and scheduling of maintenance work is an essential ingredient in any good maintenance management system. If planning and scheduling is done properly, the maintenance force will be used in the most efficient manner and the preventive maintenance program will be effective. Tools for planning and scheduling include schedule boards, maintenance work orders, and maintenance labor standards. The key to successful planning and scheduling is a realistic estimate of a facility's corrective and preventive maintenance needs.

Storeroom and Inventory System — The purpose of a good maintenance management system is to ensure the proper operation of the treatment facility. The storeroom and inventory procedures used at the treatment plant can help ensure that the maintenance system's purpose is achieved. A good storeroom procedure will maintain control of items on hand, will recognize when to reorder needed supplies, will facilitate locating items on hand, and will provide for efficient purchasing and receiving of all supplies.

Maintenance Personnel and Organization — Regardless of the care which goes into the selection of an equipment record system or work order system, it is the plant's maintenance staff who is ultimately responsible for ensuring the maintenance management system functions properly. All maintenance tasks within the treatment facility should be analyzed, and properly trained personnel in sufficient numbers should be provided. The maintenance management system should provide adequate staffing, arrange comprehensive maintenance training programs, develop accurate job descriptions for all personnel, and maintain an organizational chart to help define maintenance responsibilities.

Cost and Budgets for Maintenance Operations — Information on plant maintenance cost and the development of a maintenance budget are very important for their incorporation into the plant's total operation and maintenance budget. Before an accurate estimate of maintenance cost can be made or a sound maintenance budget can be prepared, it is necessary to divide the maintenance operations into service categories such as preventive maintenance, corrective maintenance, and major repairs or alterations. With the maintenance operations defined, the information in the equipment card file on work performed, work contracted out, items used from storeroom stock and purchased, and a breakdown of man-hours can be used to develop information on maintenance cost. With allowances for equipment replacement, expansion, and information on maintenance history for the plant, the maintenance budget then can be developed.

The manual section entitled "Correlation of the Basic System Features into A Working Maintenance Management System" provides three examples of how the basic features may be combined to develop a sound system.

Criteria to be used for evaluating proposed or existing maintenance management systems are provided in the manual section entitled "Maintenance Management System Evaluation Guidelines."

SECTION IV
EQUIPMENT RECORD SYSTEM

General

An equipment record system should be developed to maintain information on each item of equipment. The facility owner should be involved in selecting the system to be recommended. The equipment record system should contain information on each item of equipment. This system may be only one card on each type of equipment, a number of cards for each item or for larger plants, a combination of information cards and data maintained on a computer.

In addition to the equipment records, as-built drawings of the facility, construction specifications, construction photos, shop drawings, and manufacturer's catalogs should be maintained in a file for easy access.

The equipment record system will be used as a source of information for developing cost and budgets, and obtaining information to evaluate maintenance problems.

Equipment Numbering System

The first step in selecting an equipment record system is to find an equipment numbering system that best satisfies the needs of the particular treatment facility. Each item of equipment in the plant requiring maintenance should be assigned a number for easy identification and to help ensure all equipment receives proper attention.

One approach is to start numbering the equipment beginning with the point where the wastewater enters the plant and continue to number each item of equipment as the wastewater continues through the plant. Sludge handling equipment is numbered after all wastewater treatment equipment has been numbered.

The consecutive numbering system is not flexible with respect to equipment additions and omissions. Therefore, consideration might be given to alternating equipment numbers (1, 3, 5, 7, 9 etc.) or using an alphabetical suffix (12A, 12B, 12C, etc.) to handle this problem.

A second approach is to number all equipment in a specified area or building with a range of numbers as 100-120 and the equipment in another area 200-230, this system of block numbering for a specified area aids in locating equipment, adding equipment, and setting up numbering system for the equipment card file.

A third approach is to divide the facility into nine stages and assign 1000 numbers to each; the stages may be further broken down to 100 series numbers to identify specific

items and allow for future additional units. For example, the pretreatment stage may be identified as:

3000	Pretreatment Stage	3210	Compressor
3100	Grit Collection	3220	Accessories
3101	Structure	3300	Screens
3110	Mechanism	3301	Structure
3120	Hoist	3310	Bar Screens
3130	Conveyor	3320	Trash Rack
3200	Preaeration	3330	Trash Rack Rake
3201	Structure		

A fourth approach is to use a combination of letters and digits. Each plant building or structure is classified by a capital letter and begins with the influent end of the facility. An example would be as follows:

A - Pump building
B - Grit chamber
. .
. .
. .
. .
. .
H - Sludge disposal

Equipment in each building is numbered in the sequence of flow such as the pump building drainage pumps could be A-1.2.

A simple consecutive numbering system is usually entirely satisfactory for a small plant with a minimum of structures and equipment. A more complicated system that definitely locates, designates function and identifies is justified for a large plant with several buildings and a number of treatment steps.

Equipment Catalog

After each item of equipment has been assigned a number, a catalog should be prepared that lists equipment descriptions, locations and equipment numbers. The catalog will provide a convenient reference for locating equipment and identifying equipment numbers. The catalog may be a small file, a notebook containing this information, or a computer printout bound into a desk reference.

Maintenance Information

The maintenance information maintained in the equipment card or computer files is a vital part of plant maintenance and operation. The maintenance information should

include a list of preventive maintenance functions to be performed and their frequencies. As these preventive maintenance items are performed, they should be recorded with the date the work is accomplished and related cost information. As corrective maintenance work is performed, this information should also be recorded with the date the work is accomplished, cost information, and any pertinent comments.

The following is an outline of the information the equipment cards or computer should contain:

- Description of equipment and equipment number with location in plant.
- *Supplier with address, representative, phone number, date of purchase with cost.
- *Size, model, type, and serial number.
- Electrical and/or mechanical data.
- Inventory of spare parts on hand.
- Preventive maintenance items to be accomplished with their frequency. Space to note when PM was performed, by whom and pertinent comments. Data on man-hours, costs, and materials or supplies consumed.
- Information on corrective maintenance work should be maintained in a manner similar to that outlined above for preventive maintenance.
- A system to compile this information for use in determining cost and for future use in budget development.

*Copies of all purchase orders and invoices should be routed through the maintenance department to ensure all needed equipment data may be obtained for the equipment record system.

The system for retaining equipment data should include procedures and information on how the system is to function and to describe each employee's responsibilities.

Adequate maintenance records assist in equipment evaluation, aid in establishing budgets for manpower and materials, and help ensure an efficient schedule for preventive maintenance functions. Maintenance records also provide plant management with an indication of the efficiency of the maintenance personnel. This allows management to assign

maintenance personnel to jobs for which they are best qualified and to rotate personnel for training and overall experience throughout the facility. Such experience provides for continuity during absences or personnel changes. The information in the equipment record system can help provide answers to the following maintenance related questions:

1. Is the maintenance work on a specific item of equipment excessive in relation to other similar units?

    a. What is the cause?

        (1) Is it lack of preventive maintenance?

        (2) Is it wrong application of the equipment?

        (3) Is breakdown result of inherent defect in the equipment?

        (4) Is it due to poor lubrication?

        (5) Was the equipment overloaded?

2. Is this maintenance procedure repetitive?

    a. Can the maintenance procedure be simplified, improved or eliminated?

    b. Are the correct tools available?

    c. Was an experienced craftsman assigned to the job?

    d. Were spare parts required?

        (1) Were the spare parts immediately available from plant inventory?

    e. Can preventive maintenance procedures be established at less cost?

3. Was overtime work required?

4. Is the clerical time required out of proportion to the maintenance work performed?

    a. Is the overhead cost of clerical work justified for this facility?

5. Can the maintenance be done by contract with outside party?

6. Do the maintenance records help in planning maintenance work and scheduling?

    a. Can the cost of time and materials be reduced?

7. Is the data of sufficient volume for the facilities maintenance functions to be processed by computer?

Card File Systems

Various card files are available such as single equipment cards, a three card system, edge-punched cards, and card files which are set upright or are located in a horizontal position and have an edge exposed on which color tabs are placed. These tabs mark the month and week in which preventive maintenance work is to be performed. These card systems are readily available through most office supply agencies and the systems can be adapted to plants based on their individual needs.

The card system will require time to develop and must be done carefully and thoroughly. Preferably it should be started when a new or improved facility goes into operation. The record system will be of little value if it is not kept up to date.

Single Card System

A single card system can be developed using ordinary ruled 5″ x 8″ cards or 8-1/2″ x 11″ cards. This system is adequate for small plants where a single supervisor is responsible for maintenance and record keeping is a duty he must perform by himself. Each item of equipment should have a single card either filed by equipment number or filed alphabetically. The equipment card face should contain the following information:

- Name and location of equipment or structure
- Name of manufacturer, supplier, or builder
- Cost and installation date
- Type, style, model
- Capacity, size, rating
- Serial and code numbers

- Nature and frequency of maintenance

- Proper lubricants, coatings

The backs of the cards are used to record the date the work is performed, the type of work, and initials of the person performing the work. Corrective maintenance tasks may also be noted on the back of the card to provide a complete record of all maintenance work performed on the item of equipment. Figure No. 1 shows the face and back of a sample card from a single card system.

Three Card System

The three card system may be used by large or small facilities. Several types of three card systems are currently available. The following is an outline of the basic information which may be maintained on each of the three cards:

1. The first card has equipment number, description, nameplate data, vendor name, cost information, location, mechanical and/or electrical data on the front of the card. A spare parts list and space for additional information are on the reverse side of the card.

2. The second card contains equipment item, number, preventive maintenance tasks and their frequencies. The card should have a metal tab or some other method to identify when a maintenance task is to be performed.

3. The third card contains item, department, preventive maintenance work performed, with labor hours, labor cost, materials, and total cost. The remaining side contains corrective maintenance work performed with man-hours and cost data as outlined for preventive maintenance. The date is also entered to identify when the work was performed. Some standard cards are color coded in one corner to identify that no work is required or work is required and is being performed on the item.

Edge-Punched Card System

Edge-punched cards offer advantages for all but the smallest installations. The edge-punched card type of record systems are available with either a hand-sorted punched card filing system or electromagnetic filing system. The cards have rows of holes pre-punched along each edge. The face and back of the card are used for a written record of the desired data. Each hole or combination of holes along the edges is assigned a specific meaning.

To designate, for example, a semiannual service, the paper between the edge of the card and the hole marked "semiannual" is removed, thus forming a notch.

JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.

BOARD OF PUBLIC UTILITIES
PREVENTIVE MAINTENANCE PROGRAM

EQUIPMENT		ELECTRICAL EQUIPMENT		
NAME		EQUIPMENT		
SERIAL NO		MAKE		
MACHINE NO.		SERIAL NO		
VENDOR		TYPE		
MODEL		VOLTAGE	AMPS	RPM
BELT SIZE NO.		PHASE	FRAME	H.P.

ITEM NO.	WORK TO BE DONE	FREQUENCY	TIME

SERVICE RECORD

DATE	WORK DONE	SIGNED	DATE	WORK DONE	SIGNED	DATE	WORK DONE	SIGNED

Courtesy of Mr. Marvin J. Miller
Plant Superintendent
Casper Sewage Treatment Plant
Casper, Wyoming

FIGURE NO. 1

Using the hand sorted punch card system to select all "semiannual" cards from a pack of cards, the pack is aligned in a vertical position with the desired hole in the upper edge. As indicated in Figure No. 2, a needle similar to an ice pick is then passed through the hole. Upon fanning out the pack and lifting it with the needle, all cards notched in the selected position drop from the pack, while those not notched remain suspended from the needle. This type of card record system is primarily for use in municipal wastewater treatment systems, but it also has application for remote pump stations and in collection system maintenance.

The following steps outline the procedure to establish an edge-punched card system for preventive maintenance tasks:

- Use the equipment number for the file number for each item.
- List all equipment and structural units with their respective preventive maintenance tasks, frequencies, information on how task is to be accomplished, length of time required to perform task.
- Establish a schedule for the required tasks.
- Transfer information to edge-punched cards.

A complete set of duplicate cards should be made and filed in a protected area. These will make replacement easier if cards are lost or destroyed. Personnel should be discouraged from treating cards as worksheets. Cards should not be permitted outside the office area.

Provisions should be made for collecting cards that contain information on deficiencies discovered during routine maintenance and for cards that cannot be completed after they have been pulled. These cards can be reviewed and personnel assigned to the work remaining.

Anywhere from one to five cards can be prepared for any one item of equipment, depending on the frequencies of maintenance work required. More effort is required to place data on extra cards, but it is felt the ease with which personnel can identify work assigned on a particular day more than compensates for this initial work. Figure No. 3 is a typical card for the weekly frequency group.

In large plants or where the engineering, accounting, and maintenance shops are divided or in widely separated areas or distant locations within the region served by the facility, it may be necessary to duplicate cards and provide all departments with appropriate information. Edge-punched cards offer an infinite variety of services for scheduling and

Courtesy of Journal Water Pollution Control Federation, Vol. 26, p. 1399 (Nov. 1954)

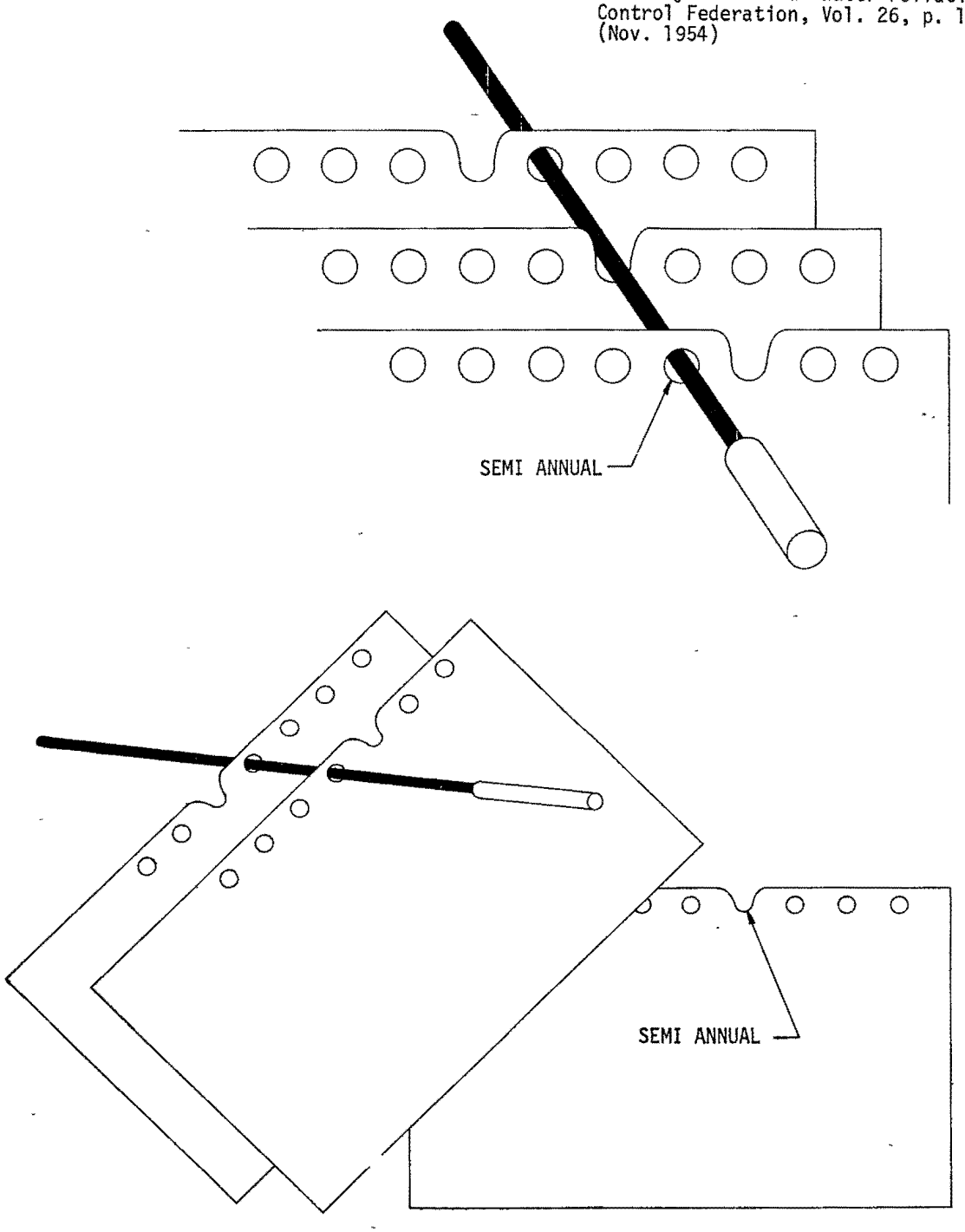


FIGURE 2 PRINCIPLE OF EDGE-PUNCHED CARD RECORD SYSTEM FOR MAINTENANCE PROGRAMS.

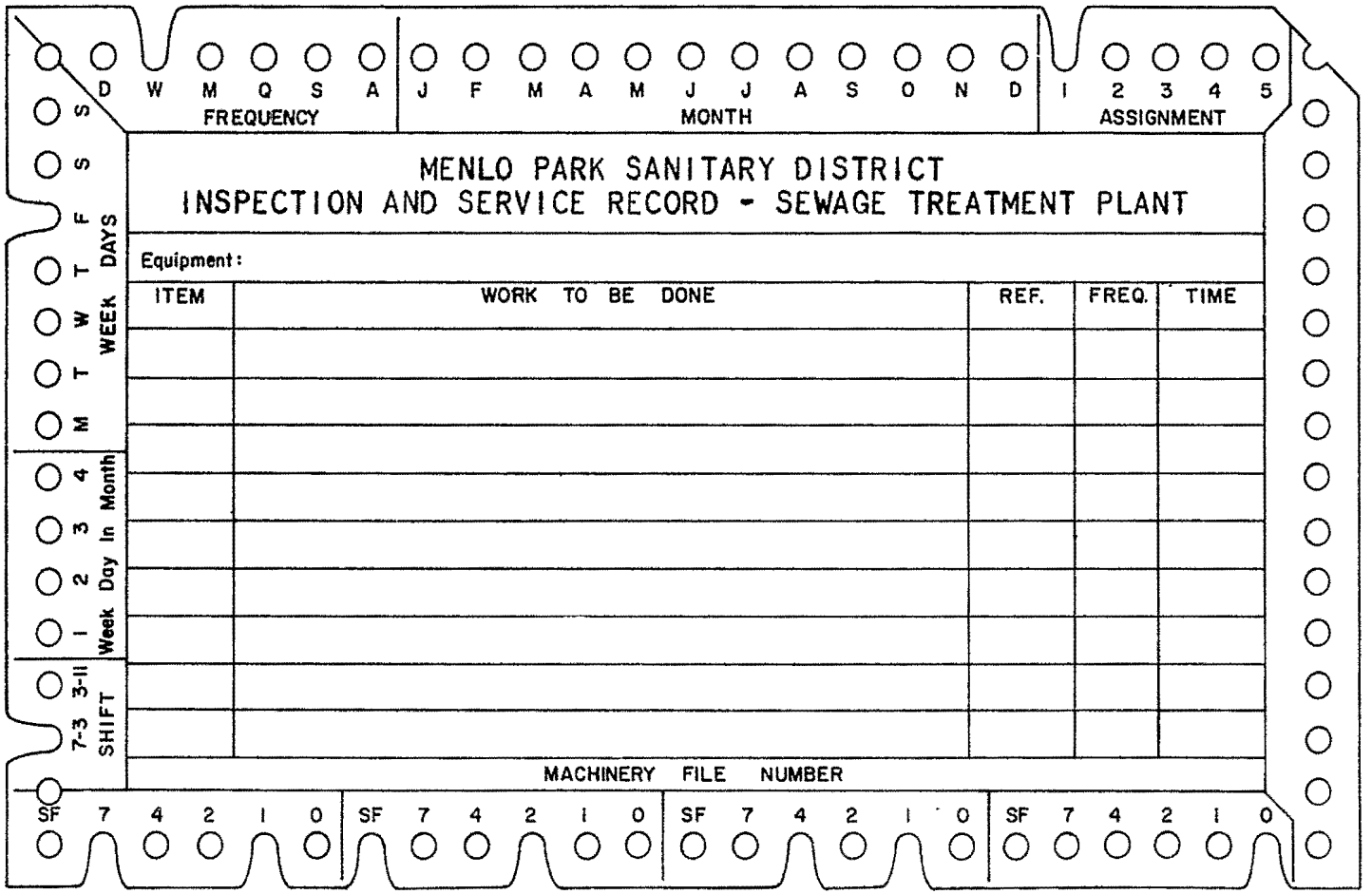


FIGURE NO. 3 SAMPLE CARD FOR THE WEEKLY FREQUENCY GROUP

Courtesy of Journal Water Pollution Control Federation, Vol. 26, p. 1399 (Nov. 1954)

recording information. Edge-punched cards are adaptable to all parts of the wastewater system. Cards which are 8-1/2" x 11" allow for adequate space on the back of cards to record a long life history of the item.

Collection System Maintenance Records

The collection system maintenance records should include information on the collection lines, any force or pressure mains or siphon systems. Any special areas should be reviewed by the preparer of the maintenance system to determine what maintenance information and data should be maintained.

Line cleaning crews should be provided with a record sheet on which is shown a diagram of the work area. Provisions for supplying the following information are also included on the form:

- Distances between manholes
- Depth of manholes
- Condition of manholes and lines
- Unusual conditions (large trees and culverts)

The line cleaning foreman collects these record sheets each day and makes out a daily worksheet. Figure No. 4 is a typical daily worksheet. Items listed on this sheet include:

- Location of work
- Employees used
- Man-hours
- Equipment information

The superintendent and foremen should prepare permanent collection system record cards on a weekly basis. The following information is recorded:

- Location
- Manhole numbers and/or invert elevations and manhole lid elevations where branching occurs

CITY OF BOULDER, COLORADO

Sewer Maintenance Department Date_____

Location:

Men Used	Hours	Account No.	Material Used
Equipment Used	**Hours**	**Account No.**	
			Distance between manholes_____
			Depth of manhole #_____
			Depth of manhole #_____
			Distance between manholes_____
			Depth of manhole #_____
			Depth of manhole #_____
			Distance between manholes_____
			Depth of manhole #_____
			Depth of manhole #_____

GENERAL REMARKS: _____

FIGURE NO. 4

- Pipe size
- Manhole depths
- Distance between manholes
- Manhole condition
- Infiltration estimate
- Line condition

The reverse side of the permanent record card contains provisions for recording:

- Date of emergency call
- Time of call
- Time crew reported to call
- Line condition upon arrival
- Emergency remedy
- Prevention recommendations

Provisions should be made to record emergency calls on a collection system map; after three calls to a given location, the line may be repaired or replaced. The progress of the line preventive maintenance program may also be monitored on a collection system map using colored tape to indicate lines that have been serviced.

Data from the permanent record cards should be compiled into monthly and annual reports. These reports would be helpful in preparing budgets and defending budget requests.

The equipment record systems described for use with a plant's equipment can also be used with the equipment at remote pumping stations in the collection system. Additional information on collection system maintenance records can be found in the Water Pollution Control Federation Manual of Practice No. 7 Sewer Maintenance.

Computerized Maintenance Program

Some facilities may find it economical to computerize their maintenance programs. The decision to use computers in a maintenance program must consider many different factors.

Of course, the availability of a computer is of primary importance. Many cities have their own computers or have access to computer facilities. If the city does not have a computer, a remote terminal in the plant could be used to tie the treatment facility into a computer located in another city. Complete computerized maintenance packages are also offered commercially by a number of companies. These computerized maintenance packages are either adapted to the city's computer or use a remote terminal connected to some other computer where the necessary computer time is purchased.

This section does not give details on the specifics of computerized maintenance programs. Its objective is to discuss the maintenance related services that can be accomplished with computers.

The following description outlines the capabilities and basic features of a single purpose or multipurpose system. The system may be either a maintenance information system or total documented control readout system of scheduling, cost, equipment history, and manpower requirements.

The four basic elements of the most fundamental types of information systems are:

- Input — Method of getting data to process into a computer
- Program — Set of computational procedures for processing input in a specified manner
- File — Mechanism for storing information often used in processing data
- Output Reports — Feedout of information sought from computer processing input or file data

The following is an outline of the type of programs which may be developed:

Single Purpose, Single File System —

This system is a closed system in the sense that only information which is introduced as input may appear in the files or in the reports. The single purpose, single file system is used in conjunction with manual scheduling of maintenance work.

Examples:

- Equipment numbering, descriptions and nameplate data
- Materials and spare parts inventories

- Maintenance histories
- Standing work orders

Multipurpose, Single File System —

This system does not require data to be introduced each time a different program is executed. The system is built around central computer files. An example is a perpetual inyentory file of the material and spare parts system.

Multifile, Multipurpose System —

This system is based on communications between multipurpose, single file systems. The goal of this system is to develop a closed-loop maintenance control system that would permit one reporting plan to furnish a total documented control readout of scheduling, cost, equipment history, and manpower requirements.

The system is based on total plant rather than the area approach. The first step in developing the system is to establish PM requirements on each piece of equipment. This is done considering the following equipment parameters:

- Number of hours operated
- Severity of use
- Condition and age

A program coordinator must be responsible for programming each piece of equipment into the system. He must also perform the following tasks:

- Ensure cards are properly printed
- Fieldcheck the system
- Monitor printouts
- Coordinate with key maintenance personnel

The PM time estimates and cost information are input to the computer to determine budget expenditures in relation to services performed. The system would provide the following functions:

- Schedules work
- Verifies completion of PM functions
- Prints out maintenance costs in labor and parts
- Stores current information on materials and spare parts
- Maintains information on work order backlog
- Records available resources (craftsmen, mobile equipment, etc.)

Work order cards are prepared in advance by data processing and distributed to the maintenance section. Upon completion of the work, the work order is returned to be recorded. Cards are reviewed and sent to data processing where data is placed into the equipment maintenance record. Work orders fall into three categories:

- Long form (three sections: Scheduled Repair, Service, and Project)
- Emergency repair
- PM work order

This system is equipped with query-response capabilities which enable a program in one system to ask questions and receive answers from files in adjacent systems.

Emergency work cannot be planned, but once the emergency is apparent, the system can plan it quickly with minimum disruption to scheduled work. An extension of this system may be an aperture card file that handles photographic information and may be retrieved on demand and copies furnished to appropriate personnel on an on-time-and-destroy basis.

Persons developing a computerized maintenance program must choose a program that satisfies the needs of the facility in question. A computerized system that is too sophisticated for the facility will mean the time spent in gathering input data is excessive in relation to the benefits received from the computer maintained data. The facility that requires a fully computerized maintenance program and is trying to use a combination manual-computer system is also in trouble.

Two factors of increasing importance which will make investigating maintenance by computer an important future consideration are:

- Economics
- Availability of manpower

Figure No. 5 is an example of the flow chart for a closed system computer maintenance program.

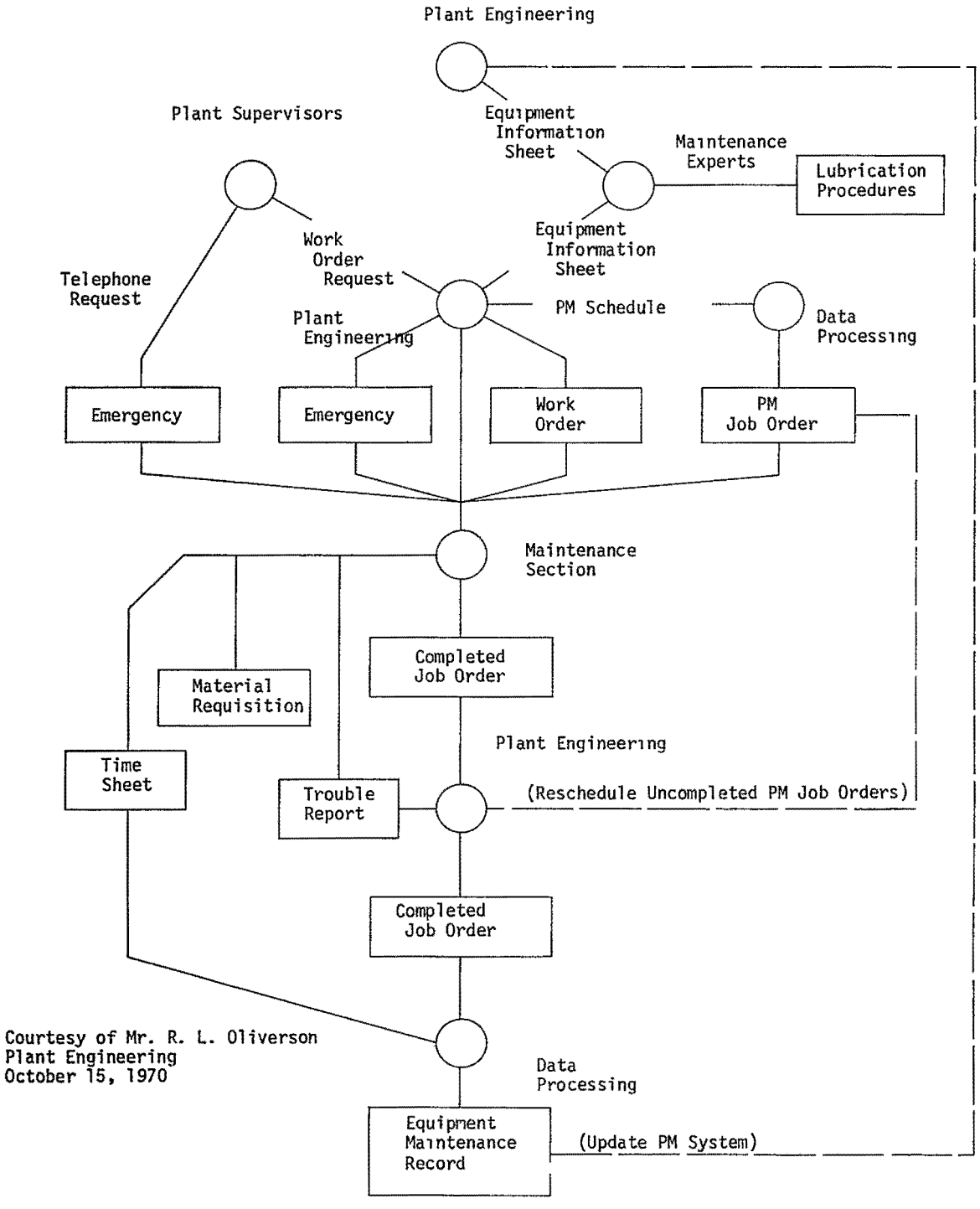


FIGURE NO. 5 CLOSED SYSTEM COMPUTER MAINTENANCE PROGRAM

SECTION V
MAINTENANCE PLANNING & SCHEDULING

General

Wastewater treatment facilities do not observe holidays and vacation shutdowns. The facilities do experience variations in flows and maintenance work loads. Under these conditions it is imperative that maintenance be planned and scheduled so that there is no idle time or peak work load period. Maintenance scheduling will vary with the size and complexity of the facility and with the type of personnel available. However, proper management will provide a maintenance plan no matter what the facility size.

All maintenance work must be scheduled just as the facility's operating routine is scheduled. Preventive maintenance should not be a haphazard procedure to be done if time permits — "or if it rains". Indoor and outdoor maintenance should be scheduled to take advantage of open or inclement weather, low load or flow periods, and other variable conditions beyond the control of the operating staff.

In planning and scheduling maintenance tasks, the Program Evaluation and Review Technique (PERT) and Critical Path Method (CPM) can be used effectively. These techniques will aid in scheduling interrelated tasks. It is beyond the scope of this manual to adequately cover PERT and CPM. For additional information, refer to Project Management with CPM and PERT by J. J. Moder and C. R. Phillips, Reinhold Publishing Corp. This reference lists other sources of additional information.

Some maintenance tasks must be scheduled for the once-a-year opportunity when the plant load normally is at its lowest because of industrial or institutional variation or the weather. This may be the time to drain, check, repair, and paint clarifier and certain underwater items of equipment.

There are seasonal items to be scheduled such as:

1. Lawn and landscaping work
2. Snow removal
3. Exterior painting
4. Road and walkway repairs

There are perennial items which may occur either annually or as often as every 4 or 5 years, such as:

1. Roofing

2. Paving & road repairs

3. Fencing

4. Insulating

5. Electrical system upgrading

6. Plumbing revisions

Plant management should also review job tasks and possible emergency conditions which plant personnel cannot handle due to either a lack of skills or proper equipment. These tasks should be reviewed and advanced arrangements made with contractors or a repair service to handle these tasks and to be available to aid facility personnel in handling emergency problems.

In emergency conditions involving key units, these units should not be shut down unless there is a need prior to the start of work. Before initiating work, the sequence of steps to complete the task should be developed. Proper planning and scheduling will ensure that sufficient personnel, proper equipment and parts will be available in the work area to accomplish the task and minimize the actual downtime for the item of equipment. Once work has started, there should be no interruption that would cause any delays in placing the unit back in service.

In planning and scheduling preventive and corrective maintenance tasks, the facility may use a schedule chart board, work order system, daily or weekly worksheets, and general priority schedule sheets to forward information to the maintenance staff on what task are to be accomplished, the dates and priorities. A backlog develops when scheduled work isn't accomplished. This work backlog should be reviewed and the more critical tasks assigned the highest priority. The daily or weekly worksheets are a listing of maintenance tasks to be accomplished. Examples of these sheets are shown in Figures No. 6 and 7. The general priority schedule sheet may list tasks and priorities as shown in Figure No. 8.

Proper planning and scheduling will help in establishing standard operating procedures (SOP's) for the treatment facility. The SOP's ensure that the facility is operated in an efficient manner by placing as many operations as possible on a routine basis. Routine preventive maintenance tasks, such as checking oil levels and visual inspections for noise or excessive heat which are performed by the operators, should be included in the SOP's.

DAILY ROUTINE

NOTE:

1. SAFETY FIRST SHALL BE STRICTLY OBSERVED.
2. WORK AREAS SHALL BE KEPT CLEAN AT ALL TIMES. (WASHED & DISINFECTED)
3. ANYTHING UNUSUAL SHOULD BE REPORTED.

Wailoa and Pua Pump Stations

1. Make visual inspection
2. Check pump packing
3. Check sump pump-oil
4. Check flo-matcher water level and temperature
5. Alternate variable speed motors manually
6. Bleed air receiver tank(s)

Sub Stations

Hilo

1. Clean grating (Hose down)
2. Visual check: Pump packing-sump pump

Peninsula

1. Bleed compressor tank
2. Check sump pump

Keaukaha

1. Bleed compressor tank
2. Check sump pump

Treatment Plant

Grit Chamber

1. Grind rags and wash down
2. Visual inspect sprayer nozzles
3. Remove grit once a week

Clarifier

1. Hose down as required scum pit
2. Hose down
3. Pump out

Sludge Pump Building

1. Check sump pump
2. Visual check
3. Check sludge pump-oil level

Courtesy of Mr. Harold Sugiyama
Bureau of Sewers & Sanitation
Hilo Sewage Treatment Plant
Hilo, Hawaii

FIGURE NO. 6

ROUTINE DUTIES — TO BE SCHEDULED BY FOREMAN

Weekly

Grit Chamber

Remove sediments and floating solids

Sludge Centrifuge Building

1. Check centrifuge torque converter oil level
2. Remove sludge (Run centrifuge with water if sludge is not removed)

Monthly

Sludge Pump Building

1. Grease air compressor bearings
2. Clean air filter

Wailoa Pump Station

1. Check compressor oil level
2. Clean air filter

General Duties

January and July

Pua Station

Grease—all bearings

1. Electric motor bearing
2. Drive shaft bearing
3. Pump bearing
4. Change packing as required (complete)
5. Exercise all valves — grease shaft
6. Wash floors as required

Sludge Centrifuge Building

Grease all bearings

February and August

Wailoa Pump Station

Grease all bearings

1. Electric motor
2. Pump drive shaft
3. Pump
4. Change packing as required (complete)
5. Exercise all valves — grease shaft
6. Wash floors as required

Courtesy of Mr. Harold Sugiyama
Bureau of Sewers & Sanitation
Hilo Sewage Treatment Plant
Hilo, Hawaii

FIGURE NO. 7

Form 1

MAINTENANCE SECTION GENERAL PRIORITY SCHEDULE

ORDER DATE	PRIORITY	JOB DESCRIPTION	COMPLETION DATE

Courtesy of Mr. L. W. Ketcham
Plant Superintendent
Central Treatment Plant
Tacoma, Washington

NOTE: The Maintenance Section will generally pursue the highest priority assignment unless specifically instructed otherwise by a supervisor. When conditions are not favorable to work on a higher assignment they may drop back to the next lower one.

SUPERVISOR, TREATMENT PLANTS

FIGURE NO. 8

Schedule Chart Board

A maintenance plan involves time, personnel, equipment, schedules, costs and work orders. A schedule chart with subjects, personnel and time is a convenient aid to reduce impulse searches for work for idle personnel. A schedule chart board may be divided into weekly, monthly, and yearly sections so that the entire range of maintenance functions can be observed. Color tabs and labels can be coded to account for all personnel and their duties at a specific point in time. The removal of the tag from the schedule chart board indicates the work is underway or has been completed. The chart board can reduce the time required to instruct or search for personnel to perform maintenance functions. The board also provides a graphic indication of progress and manpower usage and of tasks that are running behind. The size, method of use and detail of the schedule chart board depend upon the facility's scheduling requirements.

In small plants, the superintendent or chief operator must consider using all three operating shifts to accomplish required maintenance activities. This requires proper planning, scheduling and controlling of the activities of the operators and all outside repair services performing maintenance tasks.

Work Order System

A work order system should be used to initiate all preventive maintenance and corrective maintenance tasks. There are two basic types of work orders. The first type is a standard work order and generally covers repetitive work to be done in a given area, such as a preventive maintenance task. The second type work orders are written job orders. They may originate in the area where the work is to be performed and constitute the authority to carry out specific corrective maintenance tasks. They can also be originated by the maintenance supervisor to perform corrective maintenance tasks identified either by verbal reports or conditions noted where performing preventive maintenance tasks. The following are the basic features a good work order system should contain:

1. The work order form should contain the following minimum information: date; work order number; location of work to be performed; nature of problem; the work required; the desired timing for accomplishing the job, such as emergency, as soon as possible, when convenient, or during equipment shutdown; space to write information on actual work accomplished and comments; and space for supervisory signature.

2. The work order becomes a record of repairs and a history of the equipment requiring repair. It also provides a method for comparing similar items of equipment with respect to their maintenance requirements.

3. The work order establishes a comparative guide for the cost of repetitive repairs; the cost of similar jobs can be checked for cost overruns.

4. The work order should not be financed from petty cash but included in budget considerations.

5. The work order should be a guide for cost and materials expended.

6. The work order should define the work to be performed, the materials required, and the schedule to be followed for a particular job.

7. Only special emergency work should be performed without first preparing a work order. For emergency repairs, a work order should be filed to complete the maintenance records.

8. The cause of the needed repair should be reported on the work order.

9. The work order should be a complete record of the repair service.

10. The work order should be signed only by authorized persons.

11. The work order system should help to reduce equipment downtime.

12. The work order records whether the repair could have been avoided with adequate preventive maintenance.

13. The work order should be used whenever a repair requires new parts, equipment shutdown, or outside repair service. Routine maintenance below a preestablished time limit does not have to be placed on work orders.

14. With the work completed, the work order should be used to note the task on the equipment record for the particular item of equipment. The task description, work order number, and the cost data with date should be noted in the record system. The work order number will provide access to locating the work order should the need arise.

15. The work orders should be filed by work order number and kept as a history record of work performed.

Figures No. 9, 10, 11, 12, and 13 are example work order forms which can be developed and used. Figures No. 9 and 10 are the type of forms which a small facility may find

WORK ORDER

WORK ORDER NO. _____ DATE: _____

WORK TO BE PERFORMED:

MATERIALS REQUIRED:

WORK PERFORMED BY:

1. _____ _____ HOURS

2. _____ _____ HOURS

3. _____ _____ HOURS

4. _____ _____ HOURS

WORK COMPLETED:

SIGNED: _____

DATE: _____

COMMENTS:

FIGURE NO. 9 SAMPLE WORK ORDER

MAINTENANCE WORK ORDER

ELECTRICAL:	MECHANICAL:	OTHER:	DATE:
REPORTED BY:			BUILDING:
ATTENTION OF:			EQUIP. NO.
			JOB ORDER NO.:

COMPLAINT:

WORK DONE:

WORK ASSIGNED BY:	DATE STARTED:
WORK ASSIGNED TO:	DATE FINISHED:

FIGURE NO. 10

Courtesy of Mr. Carl M. Schwing
Charles County Community College
LaPlata, Maryland

Work Order

Location	Order No.	Date

Requested By (Phone)	Priority	☐ Emergency ☐ Action ☐ Hold

Description of Work	Job Estimate Labor $_____ Material$_____

Work Accomplished & Comments	☐ Drawings Attached ☐ Survey Required

Approved By	Title	Date

Completed By	Date of Completion

Remarks	Job Cost Labor $_____ Material$_____

FIGURE NO. 11

Date _____

Work Order No. _____

Location	Requested By: (Phone)	Priority:

Equipment Name	No.

☐ Inspect ☐ Replace ☐ Service

☐ Repair ☐ Overhaul ☐ Paint

Work Description

Work Performed/Comments

Job Estimate

Labor $_____

Material $_____

Maintenance Superintendent

Work Record

Personnel Assigned	Manhours	Date	Work Done	Parts & Materials
Total.				

Work Completed By _____ Date _____

Work Accepted By _____ Date _____

FIGURE NO. 12

SAMPLE: WORK ORDER

WORK ORDER

No. _____

Date _____

Work To Be Performed _____

_____

_____

_____

Location _____

_____

Priority _____ Requested by _____

Labor Estimate $_____ Material Estimate $_____ Phone _____

Record Hours of Labor, Travel Time and Equipment Time Used

Materials Used

Size	Item	Quan.	Unit Price	Total
	Total			

Labor, Truck and Equipment Time

Name	Hours R	Hours O.T.	Rate	Total
Total				

Remarks _____

_____

_____

_____

Work Completed By _____ Date _____

Work Accepted By _____ Date _____

FIGURE NO. 13

sufficient for their needs. Figures No. 11 and 12 are forms which a large facility could use to provide and maintain more information.

Preventive Maintenance

Preventive maintenance requirements must be determined and incorporated in a preventive maintenance program to allow these tasks to be planned and scheduled into the normal flow of work.

Preventive maintenance can be defined as work done to prevent breakdown, reduce wear, improve efficiency, and extend the life of equipment and structures. The greatest reliability and dependability of equipment are experienced only when a well-planned and organized preventive maintenance program is carried out. Another reason for setting up a preventive maintenance program is that emergency repair costs are much higher than the routine repairs that are required to prevent breakdowns.

A good preventive maintenance program consists of three basic parts:

1. A method of periodic inspection, lubrication, adjustment and/or other servicing of machinery, equipment and structures.

2. A record of repairs, alterations and replacements.

3. A method of cost accounting for the different parts of the preventive maintenance program.

All three parts of the preventive maintenance program should be simple, reliable and accurate. A sound preventive maintenance program need not be elaborate to affect reductions in downtime and expensive and untimely repairs and replacements.

The following items will help in establishing an efficient preventive maintenance program:

1. A simple and comprehensive preventive maintenance inspection form.

2. Inspection of equipment and structures on a regularly scheduled basis.

3. Proper servicing of equipment.

4. Accurate recording of work performed.

5. Notification of proper supervisor when repairs are beyond preventive maintenance team capability.

6. Adequate planning and proper assignment of duties.

7. Efficient execution of task.

8. A balanced work load.

9. Complete system of cost accounting.

The following are advantages of establishing a preventive maintenance system in any size treatment facility:

1. More efficient scheduling of personnel time.

2. Better scheduling of parts and material deliveries.

3. Reduction in travel time.

4. Better use of personnel skills.

5. More efficient execution of work orders.

Management must accomplish the following to ensure a successful preventive maintenance program:

1. Determine preventive maintenance needs by inspection.

2. Organize maintenance forces.

3. Schedule and prepare work orders.

4. Record necessary data.

5. Prepare repetitive standards to control costs.

In order to establish a preventive maintenance program, data must be collected on all of the items to be included in the program. Typically the data collected should contain such information as manufacturer, model, type, size, serial number, location and horsepower. Another important step is the formulation of servicing procedures and checklists.

Scheduling is another important part of any preventive maintenance program. Establishing an efficient schedule requires knowledge of servicing procedures and a knowledge

of the function each item of equipment plays in the overall performance of the plant. The following is an outline of the basic steps required to effectively schedule preventive maintenance activities:

Step 1 — List all equipment requiring preventive maintenance. Use equipment catalog for this step.

Step 2 — Determine the preventive maintenance requirements and their respective frequencies for each item of equipment. This information should be in the equipment card or computer file.

Step 3 — Estimate the time and skills required to perform each preventive maintenance task.

Step 4 — List all preventive maintenance tasks in the weekly frequency group. Total the maintenance time requirements and compare this total with the available man-hours in the maintenance work week.

Step 5 — Establish a preventive maintenance schedule for a typical work week. This schedule must be adjusted for corrective maintenance requirements, monthly, quarterly, semiannual, and annual preventive maintenance requirements, and any other items that would take maintenance time away from weekly preventive maintenance activities.

Step 6 — On a yearly calendar select tentative dates for performing all monthly, quarterly, semiannual, and annual maintenance.

Step 7 — The typical work week schedule now becomes the basic maintenance schedule for planning each week's maintenance activities.

Step 8 — Each week the basic schedule is modified as required to handle preventive maintenance tasks other than those in the weekly frequency group. The schedule must also be adjusted for work priority changes due to jobs being carried over from the previous week.

Step 9 — Planning and scheduling preventive maintenance is a continuous function. Planning must take contingencies into account and scheduling must be flexible enough to handle maintenance emergencies.

Step 10 — Using a basic schedule for planning each week's preventive maintenance activities will help ensure the maintenance effort is properly coordinated and directed. Management must emphasize the need for proper scheduling if maintenance objectives are to be realized.

The schedule of inspections on plant equipment is dependent on the following factors:

1. Availability of standby equipment
2. Manufacturer's recommendations
3. Operating conditions
4. Management experience
5. Operating schedule of equipment

An accurate cost accounting system is also necessary to determine the cost of repairs, replacements and preventive maintenance performed on each item of equipment.

The equipment manufacturer's maintenance manual is generally the best maintenance guide for any particular item of equipment. However, the adequacy of the manufacturer's information should be verified. Most equipment is mass produced on a competitive basis and the costs of its maintenance should be consistent with its value, life expectancy, and replacement cost. Equipment should be rated as to its critical position in the plant operating system and its maintenance priority. This information will aid management in determining the maintenance expense which will be consistent with an item's value, life expectancy, and replacement cost. The following is an example of how the equipment may be broken down into categories:

Category A:

Small dollar value items ($25 or less), such as spark plugs, fluorescent lamps, and other similar items, should be replaced at appropriate intervals of operation unless a breakdown will not interfere with normal plant operations.

Category B:

Intermediate value equipment ($25 to $100) justifies preventive maintenance when there are little labor and material costs involved. This includes minor repairs and replacement of parts for lawn movers, fork lifts, small motors and similar items which the operator or maintenance personnel can replace promptly with no major downtime involved.

Category C:

Equipment such as large pump motors and compressors must have adequately scheduled preventive maintenance. The breakdown of a minor part may cause the failure of a major component of the item of equipment. Major components

of equipment are not ordinarily carried in stock, either at the treatment facility or by the manufacturer. For this reason, minor spare parts should be available at the treatment facility for rapid installation. Likewise, proper lubrication and adequate preventive maintenance on this category of equipment must be performed. Maintenance cost records can be used to plot cost curves or make cost analyses. Such curves will show whether repairs are due to poor preventive maintenance, inappropriate equipment, overloading, and will also show the economical point for replacement of the unit.

Unnecessary or too frequent preventive maintenance can be as wasteful as improper maintenance procedures. Treatment system management must determine the optimum preventive maintenance schedule and replacement program.

Preventive Maintenance Servicing Procedure and Checklist

It has been shown that the preparation of a preventive maintenance servicing procedure and checklist for each item of equipment can be of significant value to maintenance personnel in performing difficult maintenance tasks. In preparing such a procedure, only those items applying to the particular item of equipment should be included. Directions appearing on the procedure should never be of a general nature. A preventive maintenance procedure eliminates the wasted time that results when maintenance personnel try to follow poorly prepared maintenance directions. The servicing procedures normally follow the manufacturer's recommended preventive maintenance schedule. Valuable servicing procedures information is also made available through professional organizations and maintenance specialists. A checklist virtually rules out the possibility of personnel accidently overlooking an important preventive maintenance check. The checklist can be modified and added to over the years to make it more complete and functional.

Corrective Maintenance

Planning and scheduling of maintenance work must also make provisions to handle corrective maintenance tasks. Corrective maintenance can be defined as work required for repairs and nonroutine maintenance functions. The maintenance personnel must always be ready to handle these work tasks as equipment failures occur and emergency conditions arise. A review of equipment will aid in determining what failures may occur. A review of these potential failures will aid in determining spare parts and equipment required to correct these problems, should they arise. In planning for corrective maintenance, provisions should be made with outside repair services or contractors for assistance should major problems occur.

Corrective maintenance tasks should not be initiated without a work order unless the problem is an emergency and immediate action is required. Even for emergency work, a work order should be completed. It should identify the work for record purposes even if

the job has been completed. The work order will provide a record of repairs, cost data, and a history of the equipment requiring repairs. The use of the work order should help reduce equipment downtime and should provide information on whether the repairs could have been avoided with adequate preventive maintenance.

Procedures for performing corrective maintenance tasks should follow the manufacturers' recommendations for disassembling and assembling their items of equipment. Manufacturers frequently provide trouble-shooting checklists for use with their equipment. These trouble-shooting guides should be readily available to persons performing corrective maintenance tasks.

Manpower Utilization

As management upgrades its maintenance staff, it must also improve the planning and scheduling of maintenance tasks to obtain maximum manpower utilization.

Manpower management techniques can often result in substantial savings when applied to maintenance activities. The savings can be realized by continuing to provide the existing level of service, by reducing the maintenance forces, or by keeping the maintenance forces at present levels and increasing the amount of work and service. Any plan designed to improve manpower utilization must have the full support and cooperation of top management. Manpower utilization techniques include:

- The planning of maintenance crew sizes and composition.
- The proper selection of tools and equipment.
- The preplanning of travel routes to work areas.
- The improvement of maintenance techniques.
- Control reports to stimulate the reaching of objectives.

The first step in establishing such a system is to select a method of work measurement. The simplest form of work measurement is estimating how long a given job will take. Estimating, however, is an inconsistent method. Work measurement based on predetermined time standards and detailed operational standard time data is more reliable. Standard time data exists for operation such as:

- Using tools

- Handling parts
- Lubricating
- Moving about the job
- Climbing ladders
- Assembling and disassembling
- Rigging
- Making adjustments

Many of these operations are applicable to the daily maintenance tasks performed within a municipal wastewater treatment system.

A job analysis must be conducted for each maintenance task. The job analysis describes the following:

- The recommended method broken down into step by step procedures.
- The number of men required to perform each step.

A time range is developed for use with maintenance work. This time range is necessary because of the variability of conditions surrounding maintenance work. The standard time used when planning maintenance jobs is the average of the range.

Manpower utilization studies often reveal that the majority of jobs can be performed most economically with a reduced crew size. To compensate for unscheduled absenteeism, provisions should be made for transferring men from a manpower pool.

Crew manpower savings can be made:

1. by having crews report directly to job sites, and
2. by paying an equipment operator overtime to pick up equipment prior to starting time and to return the equipment to a central yard after quitting time.

Travel time can be a big nonproductive cost. In the case of specialized crews, travel is an important cost factor. To help alleviate the travel problem, the following should be considered:

- Arrange crew sizes on a day-by-day basis to match the work requirements.
- Eliminate the specialized crew concept to allow jobs in many categories to be handled by a single crew. Work is provided in a more concentrated geographical area and travel time reduced.
- Permit a backlog of noncritical jobs.

Prior to initiating a plan to improve manpower utilization, a standard must be established. This standard serves as a base from which the new plan may be evaluated. Reports should be provided to key personnel so the progress of the plan can be monitored. The parameters covered by these reports should include:

- Plan coverage
- Plan performance
- Travel
- Manning

The planners developing the work assignments for the maintenance crews must consider the following:

- Job priority
- Time job should take
- Availability of equipment
- Crew size
- Routing for minimum travel time

Maintenance Labor Standards

In conjunction with manpower utilization, maintenance labor standards should be developed. Maintenance labor standards can be helpful in preparing accurate work estimates. These work estimates are essential in the planning and scheduling of maintenance work. A labor standard can be defined as the sum of a group of elemental time values. The values which are used are the times required to perform defined elements of work in a specific maintenance job. Maintenance labor standards can increase efficiency in scheduling, manpower utilization, and productivity. The average level of effectiveness of maintenance crews can be as low as 30-40 percent. Through careful organization, accurate measurement and rigid control, the level of effectiveness of maintenance crews can be raised to an effective work time of 80% or approximately 6.4 hours for an eight hour shift.

Maintenance labor standards are most frequently applied to repetitive jobs. A well designed work order system is essential to applying work measurement techniques to maintenance jobs. From a maintenance measuring standpoint, the job order should contain the following minimum information: date; location of work to be performed; nature of the problem; what work is required; the desired timing for accomplishing the job, such as emergency, as-soon-as-possible, when convenient, or during equipment shutdown; work accomplished; man-hours; and supervisor signature. The work orders provide information on the man-hours required to perform certain maintenance tasks A review of these man-hours can be used to develop maintenance labor standards. The labor standards will provide a task description and give the man-hours required to perform the task.

Many organizations currently employing some form of maintenance labor standards developed their standards internally. Maintenance Labor Standards have been developed by the Armed Forces for many tasks; the Navy has Engineered Performance Standard Public Works Maintenance, a guide which covers a broad range of maintenance tasks and which can be used as an aid in developing standards. Outside consulting services can be used to establish or to aid in establishing maintenance labor standards. The most common way of setting standards is through supervisor estimates; this method, however, is probably the least effective way to establish labor standards. Advantages can be gained by using a responsible person in the maintenance planning area who is familiar with all facets of the trade being studied and who has the ability to estimate all maintenance jobs. Obviously, not many individuals can meet all of these requirements. This points out the need for a training program for estimators. There are four basic types of systems that can be used for measuring maintenance performance: historical performance; statistical; checker; and analyst. When initiating a maintenance performance measuring system, jobs of more than eight man-hours are used and 50-60% of all work will be covered. Gradually the program should be expanded to include jobs of less than eight hours and cover 85-90% of all work. Jobs of less than two man-hours generally are not measured.

A sound and economical approach to maintenance Labor Standards has been developed in a technique commonly called Universal Maintenance Standards (UMS). UMS was developed specifically to solve the work measurement problems of nonrepetitive jobs in maintenance operations.

If the normal techniques of time study, standard data, and historical records are too exact for your plant, then Universal Maintenance Standards should be considered. These standards are based upon a range of time. For example, a mechanic will not accept as fact that a standard for replacing valve in a line is 28-1/2 minutes. They will agree that such a job can be performed in, say, between 20 and 40 minutes. Thus, we can follow this principle to set in advance a reliable standard based upon sound engineering data, and the standard will be correct a high percentage of the time.

This concept can best be described as establishing time slots for which a time range in hours has been established for each slot. For example:

Slot 1,	.15 — .25	Average .20
Slot 2,	.25 — .50	Average .40
Slot 3,	.50 — .90	Average .70
Slot 4,	.90 — 1.50	Average 1.20
Slot 5,	1.50 — 2.50	Average 2.00

Slots can be developed for as many time ranges as are required.

The job of the analyst is to take work orders and place them in the proper slot. This procedure is followed until every maintenance job has been slotted, and, as a result, universal maintenance standards have been developed.

These standards can then be used in the conventional manner to schedule work and control maintenance productivity.

The supervisor plays a major role in any maintenance measurement system. He must report to the job estimator any unforeseen deviations in the planned job. He must also ensure methods improvements are promptly measured and the new values included in the standards manual. The tradesmen must also receive training in the philosophy and techniques of measurement of maintenance performance. Measurement in no way detracts from the tradesmen's skills; in fact, it emphasizes their effective use. Remember: to apply measurement without reporting results to those participating impairs human relations.

Some type of maintenance labor standards have been in use by some organizations for over twenty years. There appears to be no consensus on the subject of labor standards among maintenance management people in industry. However, management must surely look to maintenance if it is to reduce costs in the future.

SECTION VI
STOREROOM AND INVENTORY SYSTEM

Central Storeroom

A central storeroom for spare parts, equipment, special tools, and supplies should be established. This will ensure these items are available for the repairs and maintenance work required to keep the plant operating efficiently.

The inventory of supplies, materials, equipment, special tools, parts, and space required for storage will be determined by the overall characteristics of the wastewater treatment system. The treatment system may include the following:

1. Collection lines
2. Trunk sewers and interceptors
3. Pumping stations and force mains
4. Treatment facilities

For the purpose of developing a maintenance inventory, the treatment system may be divided into the following categories. These categories will ensure supplies used for maintenance work can be readily identified.

1. Construction
2. Maintenance
3. Operation

The necessary inventory and purchase order scheduling will vary with the categories and combinations of treatment system features cited above. The question of inventory amount should be answered by the facility management and should be determined from the nature of the equipment on hand and the sources of supply. A review of the equipment and the manufacturer's recommendations will aid in determining what spare parts and miscellaneous supplies should be maintained. Spare pumping and compressor capacity equal to that required by the largest unit should be provided. An intermediate sized spare unit for lower demands should also be provided. Failure to carry an inventory of items which are used on a routine basis can be considered poor management. Conversely, maintaining a supply of readily available and/or seldom used items is wasteful. The delivery time required for items such as valves, bearings, or other wearing parts, must

be considered when deciding what items should be carried in an inventory. Maintenance paint supplies should be ordered as needed. The paint should be used promptly and not kept in stock to age. Special coatings may have to be ordered in advance of their anticipated use.

The more often an item is used or replaced, the more important a supply inventory becomes. Certain items can be bought cheaper in quantity lots; by sharing orders with other departments, a savings can be realized.

Storeroom System

The storage area may be only a small room with the plant operator having the key and a log book in which to record items and their uses. As the plant size and complexity increase, the quantity of materials will require a storeroom and storeroom clerk to maintain it. A system for arranging items in the storeroom should be established to aid in locating items. This system should ensure that all storage compartments are properly labeled and that item location is correctly identified in the storeroom catalog.

For a large storeroom, an accounting system should be established to maintain information on items purchased, stock on hand, cost, and supplier. The accounting system also should provide a checkout procedure to identify the use and location of special tools and equipment. This will aid in locating equipment needed for emergency jobs or needed for reassignment to jobs with a higher priority. The items must be numbered to aid in identification; this numbering system may have like items or a family of items within a range of numbers, or items may be numbered corresponding to equipment in a particular area. The item numbers will provide a means of identifying and locating the material. A storeroom catalog should be developed listing each item number, description, location, and vendor information. A central storeroom may be used with other municipal divisions with spare parts for the wastewater plant, filtration plant, and streets divisions.

Inventory System

A card file system should be used to maintain inventory, parts description, cost, date, supplier and the minimum and maximum quantities to be maintained. The inventory cards should be filed by the identification number of the item. For items which may be long lead items, a reorder point should be established to aid in resupply. A storeroom withdrawal ticket should be used to provide information about and a record of material drawn from stock. The storeroom ticket should provide space for item number, description, quantity required, job, and who obtained item. A storeroom ticket or withdrawal slip should be completed when any item is used. The ticket will be a record showing when the items were used and for what purpose. This information will help determine when to reorder. This system will provide an inventory of items currently in stock. Facilities with computers can include this system in their computer and obtain printouts as required. Figures No. 14 and 15 are examples of a storeroom inventory card and a storeroom ticket respectively.

STOREROOM INVENTORY CARD

Item No. _____

Item Description -

Isle No. _____

Bin No. _____

Quantity Maximum _____ Minimum _____

Reorder _____

INVENTORY INFORMATION

Quantity Used or Stocked	Date	Signed	Quantity on Hand	USAGE OR SUPPLY INFORMATION Usage - Work Order No. Supply - Purchase Order No.

FIGURE NO. 14 SAMPLE INVENTORY CARD

STOREROOM TICKET

DATE _____ EMPLOYEE _____ DEPT. _____

FOREMAN _____ DEPT. _____

COST CODE NO. _____

WORK ORDER NO. _____

WORK DESCRIPTION _____

_____

_____

ITEM NO.	DESCRIPTION	QUANTITY	UNIT COST	TOTAL COST

MATERIAL PROVIDED _____ (Signature Storeroom Clerk) _____ (Date)

MATERIAL RECEIVED _____ (Signature) _____ (Date)

FIGURE NO. 15 SAMPLE STOREROOM TICKET

Items considered as consumables do not require withdrawal slips. An inventory card is used to maintain a record of usage of these items. The cards are reviewed periodically to determine when reorder is necessary.

Computer control of the ordering of supplies and replacement parts should be investigated. Time sharing as a computer service may be an economical alternative. In any case, the inventory system is a management task that must be developed using sound judgment.

Purchase Order System

A purchase order system should be established to obtain items required and to replenish the stock of consumable items as the quantity is depleted. Although purchasing for the facility will usually be handled by a central municipal division, the facility should develop a system to provide the necessary purchasing information or to initiate the preliminary order. The system should provide a record for the date items were ordered, when they were received, the quantity, the unit cost, the total cost, the supplier, item destination (maintenance or operation) and space for comments, such as results of receipt inspection or a shipping problem encountered. Standing purchase orders can be used effectively to spread out delivery of large quantities of supplies. The purchase order should contain the following information:

1. Purchase order number
2. Work order number (if applicable)
3. Date initiated
4. Date required
5. Shipping information
6. Information on terms of payment
7. Information on item to be obtained such as quantity, stock number, description, cost per unit, total cost.
8. Specifications or other requirements for the purchase items. (There may be attached information to which the user may be referred.)
9. If a vendor is to supply drawings, information lists, operation and maintenance instructions, these should also be noted.

Upon receipt of material, all specifications, drawings, documents, and purchase order information should be available to the person or persons responsible for receipt inspection to assure the vendor has met all requirements of the purchasing department. All material shipments should be inspected for possible shipping damage, and a check of quantities should be performed for comparison with shipper's forwarding documents. As discrepancies are noted at receipt inspection, they should be noted and action taken to correct any problems.

Purchase orders will include but are not limited to the following items:

1. Fuel
2. Pipe, valves, fittings and other line materials
3. Chemicals and lubricants
4. Expendable items (drill bits, flares, barricade materials, etc.)
5. Small tools and appliances
6. Wearing parts
7. Janitorial supplies and other miscellaneous items

Figure No. 16 is provided as a sample purchase order.

TO _____

_____

_____

SHIP TO _____

_____

_____

PURCHASE ORDER NO. _____

WORK ORDER NO. _____

DATE INITIATED _____

DATE REQUIRED _____

SHIP VIA _____

F.O.B. _____

TERMS _____

_____

_____

IMPORTANT

Our Purchase Order Number must appear on Invoices, Packages and Correspondence.

QUANTITY	STOCK NUMBER/DESCRIPTION	PRICE	PER	TOTAL

APPROVED BY _____ DATE _____

SHEET ____ OF ____

FIGURE NO. 16 SAMPLE PURCHASE ORDER

SECTION VII
MAINTENANCE PERSONNEL AND ORGANIZATION

General

Regardless of the care which goes into the development of a maintenance management system, the system cannot attain its full value without qualified personnel. The Environmental Protection Agency has developed two manuals entitled "Estimating Staffing for Municipal Wastewater Treatment Facilities", Contract Number 68-01-0328, and "Estimating Costs and Manpower Requirements for Conventional Wastewater Treatment Facilities", Contract Number 14-12-462, to provide assistance in estimating the maintenance personnel requirements. To adequately prepare manpower recommendations, a task analysis of each job within the maintenance system should be made.

Maintenance Personnel

The maintenance personnel for a wastewater treatment plant will vary in number and specific job tasks. Job descriptions should be developed as outlined in the EPA report entitled, "Estimating Costs and Manpower Requirements for Conventional Wastewater Treatment Facilities," Contract Number 14-12-462. The job titles given below are taken from the EPA report cited above. The maintenance functions for each job title also are given and are excerpted from the complete job descriptions (operation and maintenance) to assist manual users in developing their maintenance systems.

Superintendent — Responsibile for maintenance of entire plant and review of maintenance functions.

Assistant Superintendent — Assists superintendent in review of maintenance functions and planning special maintenance tasks and alterations.

Clerk Typist — Clerical duties as typing and filing purchase information, maintenance information, and work orders.

Operations Supervisor — Supervises and coordinates activities of plant operators, laborers, custodians, and other plant personnel. Prepares work schedules subject to the superintendent's approval. Inspects plant to determine maintenance requirements.

Shift Foreman — Supervises operation of plant, under general direction of supervisors. Performs duties of operations or maintenance supervisors in their absence. Replaces maintenance worker during emergency.

Operator II — Performs routine maintenance functions and custodial duties. Operates and maintains power generating equipment and incinerators.

Operator I — Assists Operator II in performing the maintenance duties as outlined or shall perform tasks as requested.

Maintenance Supervisor — Supervises all preventive and corrective maintenance on entire plant. Plans, schedules, and directs all maintenance work. Supervises and instructs maintenance workers. Supervises inspections of contract maintenance and submits maintenance budget requests. Responsible for maintenance records.

Mechanical Maintenance Foreman — Supervises mechanical maintenance crew in performance of maintenance and repair tasks on machinery, equipment, buildings, structures and grounds. Supervises and instructs maintenance personnel on routine and emergency tasks. Consults supervisors regarding preventive maintenance program. Establisnes and operates preventive maintenance program. Performs inspections and determines repair methods. Works with contractors and manufacturer's representatives on difficult tasks. Maintains maintenance records.

Maintenance Mechanic II — Performs preventive and corrective maintenance on mechanical and electromechanical machinery and equipment, under direction of superior. Assists in keeping maintenance records and installs and sets up new equipment. Supervises, instructs, and inspects work of Mechanic I, Maintenance Helper, or Laborer to ensure proper performance of maintenance work or repairs.

Maintenance Mechanic I — Under the direction of Mechanic II, Foreman, or Supervisor, performs or assists in performance of preventive and corrective maintenance. These tasks may also include limited laborer and custodial duties. Also, assists in keeping maintenance records.

Automotive Equipment Operator — Operates automotive equipment such as trucks, tractors, or fork lifts. Assists in loading and unloading of equipment. Operates equipment to cut grass and weeds, bulldoze soil, or remove snow. Performs maintenance on the equipment.

Electrician II — Performs corrective and preventive maintenance on electrical or electronic operating and control systems. Performs task using independent judgment in solving problems and under general supervision of maintenance supervisor or assistant superintendent. Maintains maintenance records and supervises Electrician I, Maintenance Helper, and/or Laborer.

Electrician I — Assists Electrician II or performs corrective and preventive maintenance on electrical systems, fixtures, or equipment. Performs tasks based upon oral and written instructions including specifications, codes and wiring diagrams. The work is frequently performed independently and inspected by supervisor. Maintains maintenance records and supervises maintenance helper and/or laborer.

Maintenance Helper — Assists maintenance mechanic in maintaining and repairing equipment, machinery, buildings and grounds. Duties also may include maintaining simple maintenance records and performing laborer tasks as required.

Laborer — Performs general tasks such as cleaning equipment, maintaining buildings and grounds, performing custodian tasks and carries or holds material, supplies, or tools to assist operating and/or maintenance personnel.

Painter — Prepares surfaces for painting such as scraping, washing, burning, sanding, sandblasting, puttying and caulking. Matches, mixes, and blends various interior or exterior paints or wall covers and applies them. Erects and uses ladders, scaffolding, and swinging stage equipment. Able to perform simple sign painting, using stencils. Requisitions material and equipment. Responsible to maintain, clean, and store tools and equipment; and clean or have arrangements made for laborer to clean the work site.

Storekeeper — Requisitions, receives, inspects, verifies, stores, and issues materials, supplies, tools, and equipment. Maintains inventory records; controls material; and reports material used, spoilage or other losses, inventory adjustments, and refusal of shipment. Responsible for determining method of storage, identification and location of stock. Divides stock quantities into portions to fill orders and identifies when reorder is required.

Custodian — Cleans all or designated portions of wastewater treatment plant and grounds. Performs general custodial duties such as cleaning restrooms, maintaining supplies, emptying waste cans and ashtrays, maintaining grounds, picking up litter, sweeping walks, and shoveling snow or cutting grass. Reports any repairs or adjustments required.

Maintenance Organization

The plant head should review the job descriptions, facility's maintenance force and personnel performing maintenance functions. Based upon this review and guidance provided by the EPA reports on staffing previously mentioned, a maintenance organizational chart should be developed for the plant. Depending upon plant size and type, this

chart may outline each employee by job title or particular groups such as Maintenance Mechanic II or I. Figures No. 17 and 18 are examples of maintenance organizational charts.

The job titles used in these organizational charts are based upon the EPA reports discussed previously. The numbers in parentheses beside each job title identify the possible number of employees of each job title a plant in this size range may have.

Figure No. 17 outlines two organizational charts for plants 10 MGD or less. Maintenance organizational chart number 1 outlines the maintenance staff with a plant superintendent. Chart number 2 has the organizational outline for a smaller plant with the chief operator as the head. Figures No. 18, 19, and 20 outline the organizational charts for plants 10 MGD to 50 MGD, 50 MGD to 100 MGD, and 100 MGD and greater, respectively. The possible number of employees for plants 100 MGD and greater were not included, for this number will depend upon the particular plant. There are relatively few facilities in this size category and each facility's maintenance staff must be tailored to its particular needs. Organizational charts should outline the chain of command for the maintenance work force.

Job descriptions should be developed, and this information, along with the organizational chart for the facility, will help eliminate problems involving responsibilities for maintenance work.

Rating maintenance personnel and evaluating maintenance jobs are important in order to establish salaries and a wage structure for the plant organization. It is beyond the scope of this manual to cover adequately this topic. For additional information refer to Maintenance Engineering Handbook by L. C. Morrow, 2nd Edition, McGraw-Hill, Inc.

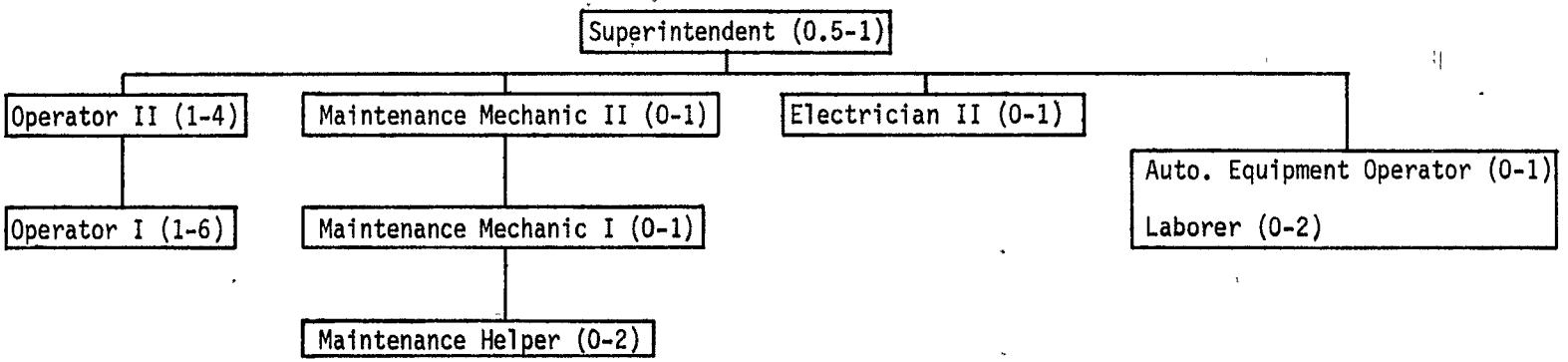
Maintenance Personnel Training

As wastewater treatment plants expand and new equipment is obtained, the maintenance tasks and problems increase. To perform the corrective and preventive maintenance tasks, the maintenance force must be trained and upgraded to handle these problems. An effective maintenance staff is always improving its ability to handle present tasks.

Maintenance training can be considered to perform two basic functions. First, it can be used as a cure for existing deficiencies. Second, it can be used as a preventive measure to help eliminate potential future problems. For any maintenance training program to be successful, it should be aimed at meeting the plant maintenance needs and should become an essential part of the overall plant maintenance effort.

Before initiating a maintenance training program to correct deficiencies in certain maintenance jobs, the specific job should be thoroughly analyzed. The job should be broken down step by step to determine if, in fact, training and not some other factor is the

MAINTENANCE ORGANIZATIONAL CHART NO. 1



MAINTENANCE ORGANIZATIONAL CHART NO. 2

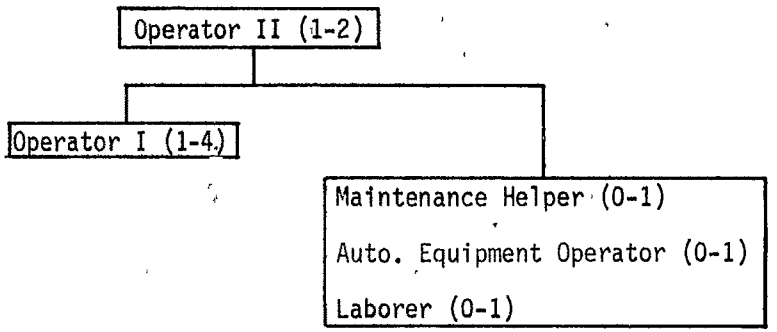


Figure No. 17 Maintenance Organizational Charts - Plant Size: 10 MGD or Less

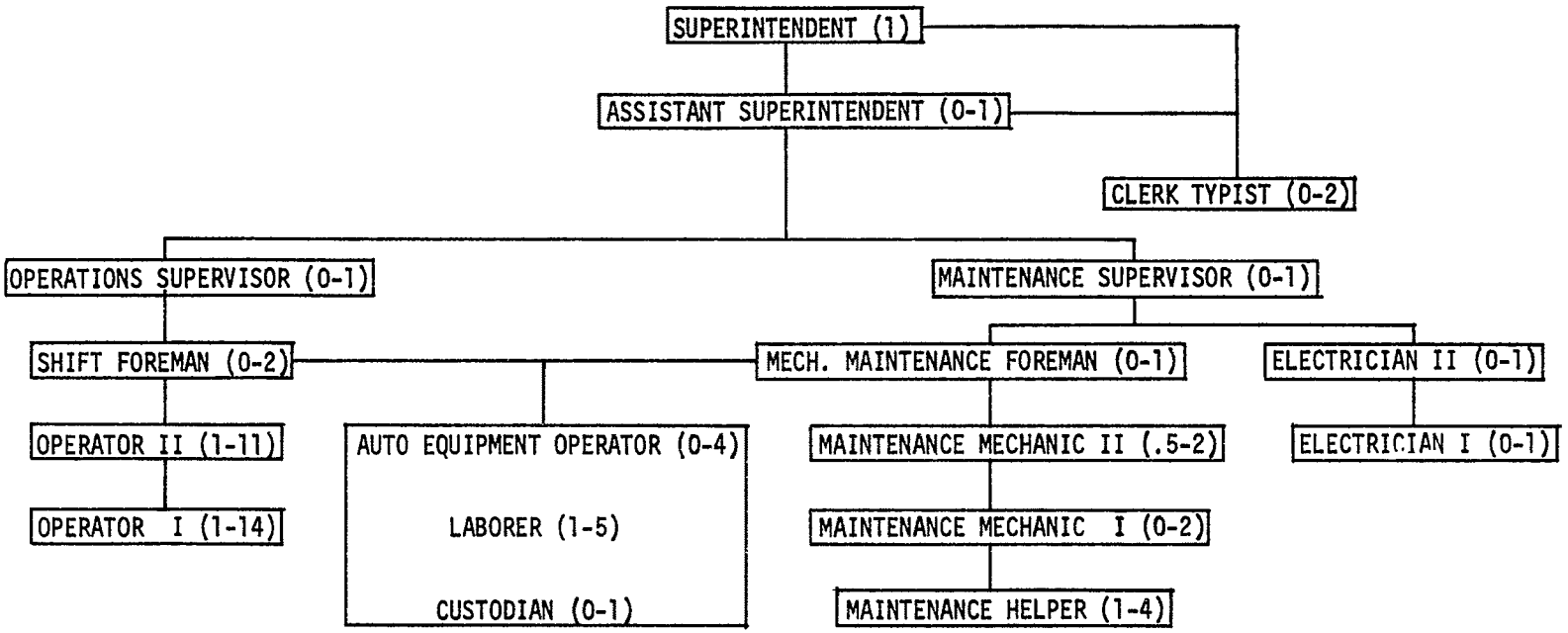


Figure No. 18 Maintenance Organizational Chart - Plant Size: 10 MGD to 50 MGD

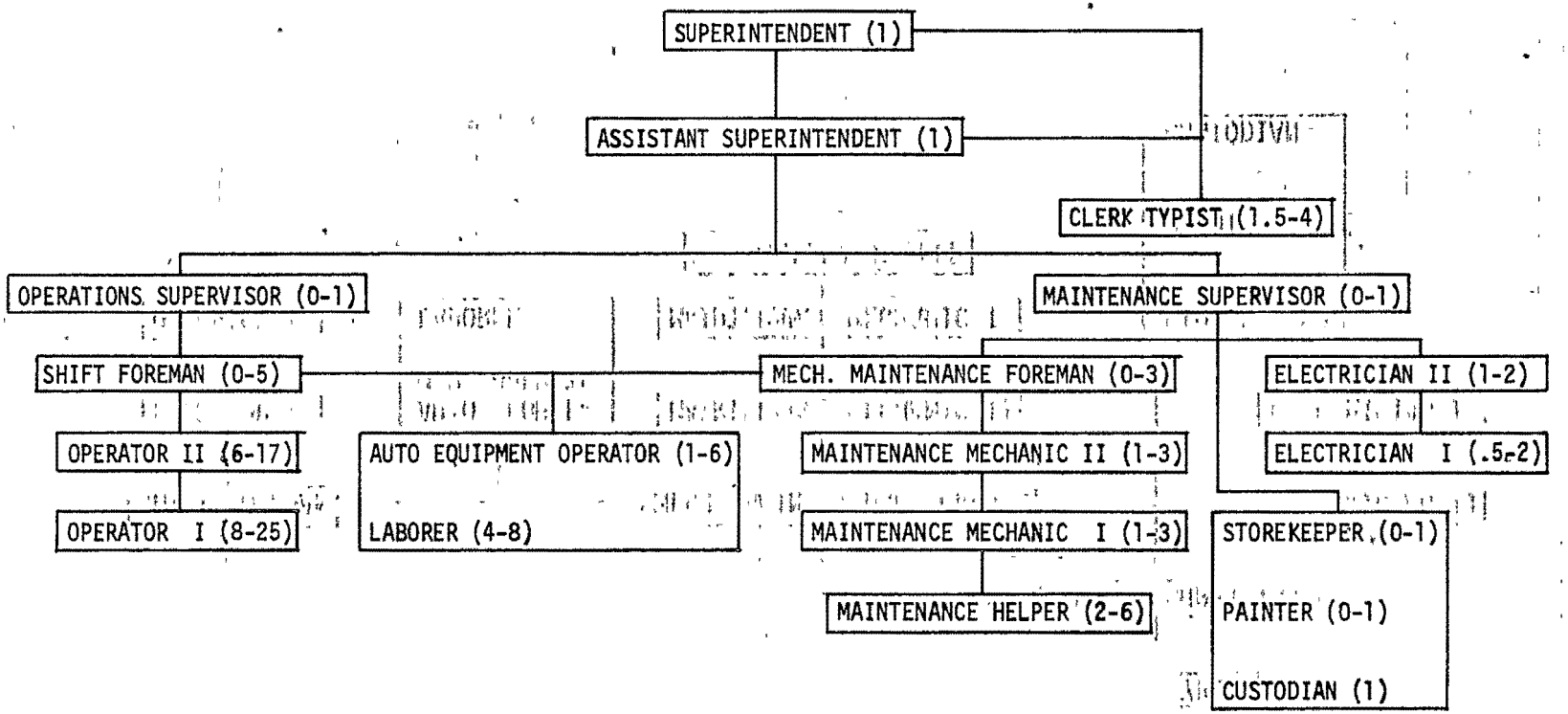


Figure No. 19 Maintenance Organizational Chart Plant Size: 50 MGD to 100 MGD

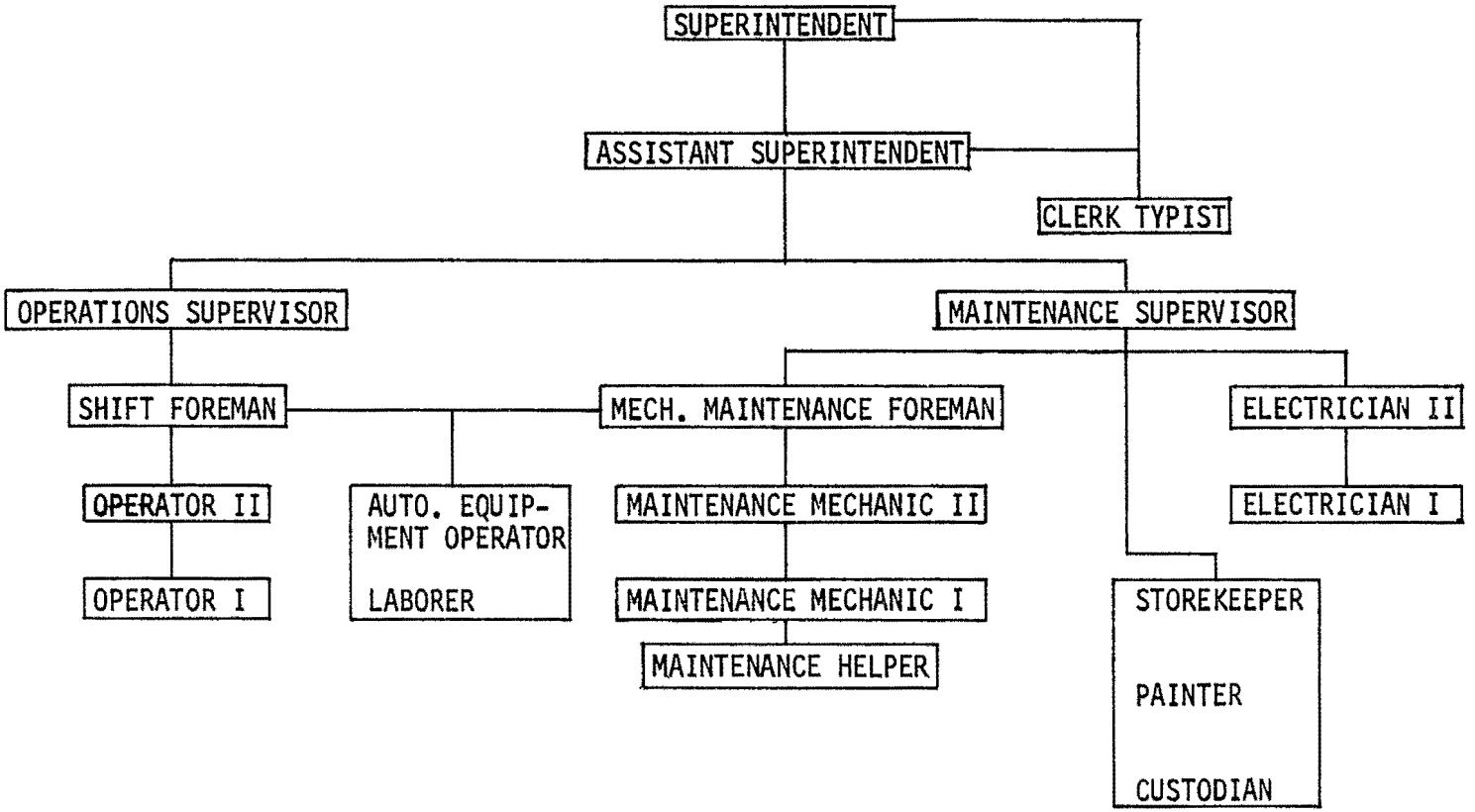


FIGURE NO. 20 MAINTENANCE ORGANIZATIONAL CHART PLANT SIZE: 100 MGD AND GREATER

ingredient that must be improved to achieve the desired efficiency. If the job analysis shows that maintenance training is required, the first step should be to establish realistic objectives.

Realistic criteria for measuring these objectives must also be provided. If adequate labor standards exist for the maintenance tasks personnel are being trained for, these standards can be used to measure training objectives. Inexperience must be considered when evaluating any newly trained maintenance employee's performance. The level at which the maintenance training should be initiated must also be defined. The type of training program that will best accomplish the stated objectives must be selected. The types of maintenance training programs include on-the-job training, classroom instruction, and programmed instruction. Maintenance training programs instituted by other organizations should be studied for both general and specific training techniques employed. Trainees should be given standardized screening tests to provide indication of their technical levels and to give the instructor an indication of any potential student weaknesses. If required, basic and advanced courses could be held on a continuous basis. It is important that class sizes be limited to give students individual attention. Class times of two hours per day, two days per week have been shown to be most effective. Certificates of completion should be awarded to all individuals who successfully complete the maintenance training program.

Training classes are available through Federal and State Water Pollution Control Agencies. Several large industries offer correspondence courses in maintenance subjects, and suppliers of wastewater treatment equipment also provide training classes on maintaining their equipment. All of these potential sources of maintenance training should be investigated and programs selected to help satisfy the facility's maintenance training requirements.

SECTION VIII

COSTS AND BUDGETS FOR MAINTENANCE OPERATIONS

Maintenance Costs

Maintenance costs can be a significant percentage of a wastewater treatment plant's total operation and maintenance budget. Because maintenance costs in general have increased to become such a large part of the total yearly operating cost, plant superintendents have been required to take positive action. It is important that sufficient information be maintained to permit proper monitoring and control of maintenance costs and the maintenance work force.

Before an accurate estimate of maintenance costs can be made or a sound maintenance budget can be prepared, it is necessary to have divided the maintenance operations into service categories. The maintenance service categories are as follows:

Preventive maintenance is the maintenance functions that can generally be performed while the plant is in operation by operating personnel. They include routine inspection of equipment, lubrication, and minor equipment adjustments.

Corrective maintenance is the repairs performed while the plant is in operation or with a minimum of equipment downtime. These maintenance functions include packing pumps, changing belts, and replacing bearings, brushes, etc. They are sometimes performed by operating personnel but most often by plant maintenance men or by being contracted out.

Major repairs or alterations generally occur when a unit is out of service and are performed by maintenance men or are contracted out. They usually involve larger expenditures of money. Budget appropriations for this maintenance service category must never be depended upon to justify long-term maintenance manpower assignments.

With maintenance operations defined by service categories, the maintenance manager's next step should be to establish a record system to compile the cost data maintained in the equipment record system, work order system, storeroom system and contract maintenance. A good maintenance manager should realize that an overall sustained plan based on accurate records is the key to any type of cost reduction. The following items should be considered by the cost conscious maintenance manager:

Work Order System — The work order system should ensure that the specific maintenance task is defined accurately. It should spell out how the maintenance

task is to be done; the forms should provide space for time data and calculated cost information.

Organization — The maintenance organization must provide a method to communicate work requests quickly, accurately, and simply. The responsibilities, accountability, and function of all personnel in the organization must be clearly defined.

Leadership — A good maintenance manager must let his workers know what is expected of them. He must give them the necessary training and equipment to perform the tasks they are assigned. He must provide them with some means to measure their performance and he must help the workers improve themselves.

Control — The key to maintaining control of the wastewater treatment system maintenance functions is based on records which keep the management so well informed that budgets and purchases may be forecast accurately. The minimum records necessary to maintain control are the work order, storeroom requisition, schedules, equipment history, and time sheets. Periodic reviews should be made to ensure the maintenance expenses are not exceeding the budget, and, if they are, the cause should be determined.

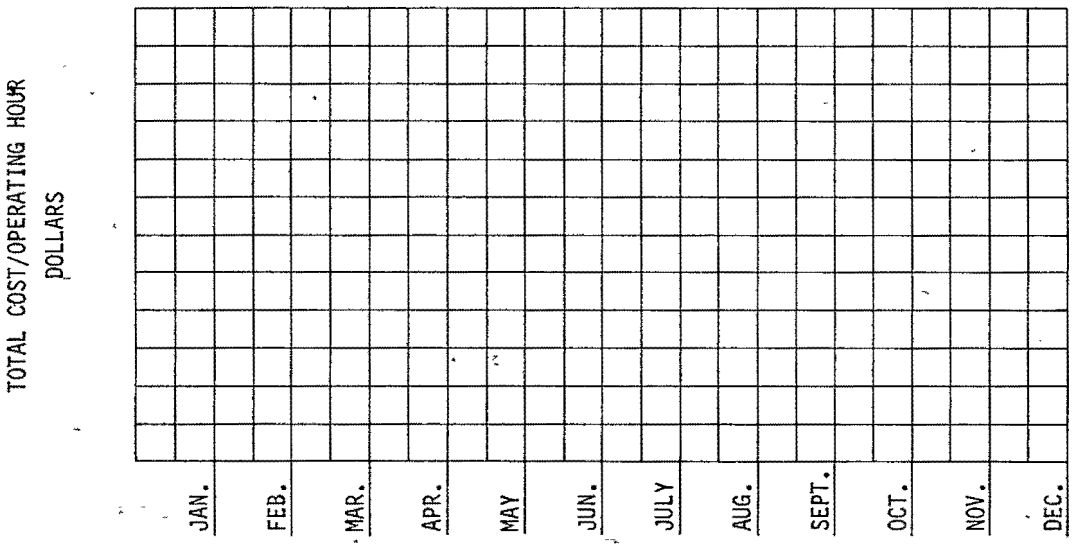
The equipment history record should contain a detailed description of the item and register total maintenance hours and cost. An additional form can also be used to establish maintenance cost trends. This form should provide for recording preventive maintenance and repair labor hours, equipment operating hours, labor costs per operating hour, total labor and material cost per operating hour, and a graph for plotting the total cost index. The cost index plotted over a period of months is helpful in determining when maintenance costs on an item are becoming excessive. This form is a good tool for management to use to determine the normal operating expense for an item of equipment. An abrupt change from the normal will indicate a problem which should be investigated. This same plot is helpful in estimating the length of time any item should be allowed to operate before it is shut down for rebuilding or replacement. Figure No. 21 is an example of a maintenance cost trend form. This form could be used to prepare budgets for maintenance operations and to illustrate cost trends to management personnel responsible for purchasing maintenance supplies and equipment items.

In budgeting maintenance and operating costs certain needs inevitably occur that cannot be readily anticipated. Examples of this type of expenditure would be major emergency repairs such as those caused by floods or other catastrophies or unscheduled minor capital improvements required on short notices. Needs of this type can be handled effectively by establishing a renewal fund or replacement and heavy maintenance fund over

MAINTENANCE COST TREND FORM

EQUIPMENT NAME _____ LOCATION _____

I.D. NO. _____



MAINT. COST/HOUR $ / DATE	OPN. HOURS	REPAIR LABOR HOURS	PM LABOR HOURS	TOTAL LABOR HOURS	MAT'L COST	LABOR COST PER OPN. HOUR	MAT'L COST PER OPN. HOUR	TOTAL COST PER OPN. HOUR
JAN.								
FEB.								
MAR.								
APR.								
MAY								
JUN.								
JULY								
AUG.								
SEP.								
OCT.								
NOV.								
DEC.								

REMARKS _____

FIGURE NO. 21

and above the normal maintenance budget. Money is generally allocated to such funds on an annual basis and if not used carried over to the next year.

Maintenance Budget

The plant superintendent or head of the facility should be responsible for the development of the maintenance budget. If a system of records is established using guidelines previously outlined, the data from past cost reports will be used to develop the proposed maintenance budget. The following is a checklist of items which should be included in the proposed budget:

- Preventive Maintenance — including PM man-hours, supplies, lubricants, and related cost.
- Corrective Maintenance — including information from work orders on CM man-hours, supplies, and parts.
- Major Repairs or Alterations — Estimated cost of proposed major tasks and capital improvements.
- Contract Maintenance or Repair Services — All cost related to maintenance services provided by outside maintenance personnel.
- Special Project Cost — Maintenance cost related to experimental projects such as proposed treatment alterations; these might be such alterations as chemical addition or a trial change of a trickling filter to high rate.

The preventive maintenance and corrective maintenance budgets are computed in a similar manner. The man-hours and supplies used should be broken down by craft. The previous year's maintenance man-hours can be determined based upon a review of time sheets and jobs performed with information on filed work orders. Man-hours can be converted to dollars using next year's projected standard man-hour rate with an extension to cover fringe benefits cost. The man-hour figure should be adjusted for an anticipated increase or decrease in equipment. An additional 0.5 to 1.0 percent should be included with last year's man-hour totals to cover wear and tear on equipment. The average percent increase or decrease in the cost of supplies and lubricants should be obtained from the purchasing department. The percent increase or decrease in storeroom operating overhead should be noted as well as any anticipated change in freight rates. This information should be consolidated into one percentage figure and the lubricant and supply dollars computed by craft. The preventive maintenance budget will be the total of the labor and supply dollars. The corrective maintenance budget is also determined by totaling the labor and supply dollars assigned to it.

To obtain the major repair and alterations budget, remove the costs of jobs performed last year that will not be repeated this year. The cost of projects in active backlog which will span the new year should be added. The major repair and alterations which have received approval should also be listed. To these items must be added the forecast of next year's needs. This includes equipment overhauls, modifications, any alterations, and building repairs. A total of the items listed under major repair and alterations will yield the budget request for that maintenance service category.

The importance of adequate maintenance budgets cannot be overstated. A lack of funds is detrimental to any maintenance system. The information in the equipment record system on work performed, work contracted out, items used from storeroom stock and purchased, and a breakdown of man-hours provide information on maintenance costs. Using these costs and making allowances for equipment replacement, expansion, and information on maintenance history for the plant, the maintenance budget can be developed. A sample maintenance budget calculation follows:

MAINTENANCE BUDGET — SAMPLE CALCULATION

Last Year's PM Man-Hours*

Mechanic II	6,000 hours
Mechanic I	6,000 hours
Mechanic Helper	12,000 hours

*NOTE: No adjustment required for increase or decrease in equipment.

Next Year's Projected Man-Hour Rates

Mechanic II	$8.00/hr	x 6,000 hr =	$ 48,000
Mechanic I	$6.00/hr	x 6,000 hr =	36,000
Mechanic Helper	$3.00/hr	x 12,000 hr =	36,000
		TOTAL	$120,000

Add 5% To PM Labor Costs to Cover Wear and Tear on Equipment

$120,000 + 5% ($120,000) = $126,000

PM Supply Costs Last Year

Lubricants	$ 2,500
Supplies	+ 12,500
	$15,000

Add 5% to Cover Increases In Costs of Supplies & Lubricants

$15,000 + 5% ($15,000) = $15,750

$ 126,000 — Labor
+ 15,750 — Supplies
$ 141,750 — Preventive Maintenance Budget

CORRECTIVE MAINTENANCE BUDGET

NOTE: Calculation similar to PM budget calculation. Assume costs shown below were determined using procedure given for PM budget.

$ 70,000 — Labor
25,000 — Supplies
$ 95,000 — Routine Repair Budget

MAJOR REPAIR BUDGET

$ 50,000 — Last Year's Projects
−35,000 — Projects that will not be repeated this year
$ 15,000
20,000 — Projects in active backlog which will span the new year
25,000 — Projects approved for next year
+ 5,000 — Forecast of next year's needs
$ 65,000 — Major Repair Budget

TOTAL MAINTENANCE BUDGET

$ 141,750 — PM Budget
95,000 — Corrective Maintenance Budget
65,000 — Major Repair Budget
$ 201,750 — TOTAL MAINTENANCE BUDGET

NOTE: The example above has been simplified to illustrate only the basic steps in preparing a maintenance budget. However, using costs determined in the manner illustrated and making allowances for equipment replacement, contract maintenance work, and the maintenance history for the plant, a sound maintenance budget can be developed.

It is preferable that maintenance cost and budget data be recorded and transferred to a central utility accounting system from which it can be recalled; however, if this cannot be accomplished the data must be maintained informally in logs in a "cuff system" by plant personnel. Additional information on accounting systems can be found in the Water Pollution Control Federation Manual of Practice No. 10 Uniform System of Accounts for Wastewater Utilities.

A cost coding system should be developed to permit labor hours to be assigned to normal operations, preventive maintenance, corrective maintenance, and major repairs or alterations. The coding system also permits time charged to sick leave, vacation and holidays to be recorded. Typical cost coding systems include the following:

Code	Description
00	Unassigned
01	Vacation
02	Sickness
03	Holidays
04	Normal Operations
05	Preventive Maintenance
06	Corrective Maintenance
07	Major Repairs or Alterations
08	Training

NOTE: For example, changing oil, a PM task, could be assigned the Code No. 05-7. This would permit similar PM tasks to be grouped within the general PM task heading.

For plants in which most personnel are performing certain maintenance duties, the man-hours for each employee should be broken into each half hour of the work shift with charge numbers established to cover operations and maintenance work.

There are several factors which maintenance managers should be aware of in developing their budgets. The method of sludge processing generally produces the greatest single impact on total plant costs for a given type plant. As more sophisticated means are used to upgrade the treatment of wastewater, O & M costs can be expected to rise sharply. O & M costs are also greatly affected by cost of labor and supervision; any changes that affect manpower (wage increases and training) will markedly affect O & M costs. To determine the yearly change in total maintenance cost, costs of maintenance based upon flow volume can be used as indicator.

SECTION IX
CORRELATION OF THE BASIC SYSTEM FEATURES INTO A WORKING MAINTENANCE MANAGEMENT SYSTEM

General

This section provides examples of maintenance management systems for various size plants. The following three examples are for a small facility, a middle size facility, and a large facility. The examples assume all facilities are properly staffed and are operating continuously. The example maintenance systems for the three size facilities are all workable systems. However, they are not intended to be rigid formats for all facilities within a given size range. In developing a system for a particular plant, a person may use any combination of the feature techniques from larger or smaller plants and may adapt them to his particular plant. Because various procedures can be used in a variety of plants, no size range has been assigned to these examples. A person preparing a new system or updating an existing system can use these examples to help develop the maintenance management system which best fits his particular plant.

Each example is broken down into the five basic features of a maintenance management system. This breakdown corresponds to this manual's format which has a separate section on each of these five basic features. This permits persons reviewing these examples of maintenance management systems to quickly refer to the appropriate section in this manual for a discussion of any item described in the examples.

EXAMPLE MAINTENANCE MANAGEMENT SYSTEM

SMALL FACILITY

General

This example is based upon a facility with a superintendent and several operators having to perform the operations and maintenance work and keep the maintenance records.

Equipment Record System

To develop the equipment record system, each item of equipment is numbered. For a small plant, the first equipment item in the pretreatment area is given the number one. All other equipment is numbered consecutively following the wastewater flow through the facility Multicomponent items are broken down and numbers are assigned to each component requiring any type maintenance tasks. After numbering equipment following the wastewater flow, the numbering is continued to cover all sludge handling equipment The consecutive numbering was chosen because the number of items in a small plant is usually less than one hundred and the system is simple to apply The following is a sample of this equipment numbering system

Number	Equipment Description
1	Mechanically Cleaned Bar Screen
2	Comminutor
3	Raw Wastewater Pump No 1
4	•
•	•
•	•

MIDDLE SIZE FACILITY

General

This example is for a middle size plant with a maintenance staff performing the major maintenance tasks and a clerk typist to assist in record keeping. The operators will be required to perform minor preventive maintenance on some equipment.

Equipment Record System

To develop the equipment record system, each item of equipment is numbered. All items of equipment are numbered with the equipment in a specified area or building being within a range of numbers Multicomponent items are broken down and numbers are assigned to each component requiring any type maintenance tasks The numbering sequence follows the flow through the plant and is continued to cover all sludge handling equipment The following is a sample of this equipment numbering system·

Number	Equipment Description
1-25	Pretreatment Structure
1	Mechanically Cleaned Bar Screen
2	Comminutor
3	•
•	•
•	•
26-100	Primary Treatment Structure
26	Primary Sedimentation Tank No 1
27	Manifold Valve No 1
28	•
•	•

LARGE FACILITY

General

Because of the size and the number of personnel required to efficiently operate a large plant, its maintenance management system must be tailored for that particular plant The following is an example using a closed system computer approach

Equipment Record System

To develop the equipment record system, each item of equipment is numbered. The equipment numbering system assigns 1000 numbers to each major stage of the treatment plant Multicomponent items are broken down and numbers are assigned to each component requiring any type maintenance tasks The following is a sample of this numbering system

Number	Equipment Description
1000	Pretreatment Structures
1100	Raw Sewage Pump Station
1110	Bar Screen Room
1111	Influent Bypass Valve
1112	Influent Diversion Gate
1113	Comminutor No 1
1114	•
1200	Control Room
1210	Pump Motor Control Panel
1211	•
1300	Pump Room
1310	Raw Sewage Pump No 1
1311	•

EXAMPLE MAINTENANCE MANAGEMENT SYSTEM
(Continued)

SMALL FACILITY		MIDDLE SIZE FACILITY		LARGE FACILITY	
Number	Equipment Description	Number	Equipment Description	Number	Equipment Description
10	Primary Sedimentation Tank	101-150	Aeration Tanks	2000	Primary Treatment Structure
11	Sludge Collection Mechanism	101	Aeration Tank No. 1	2100	Primary Sedimentation
		102	Mechanical Mixer No. 1	2110	Influent Manifold
•	•	103	•	2120	Primary Sedimentation Tank No. 1
•	•	•	•		
•	•	151-175	Final Clarifiers	2121	Valve No. 1
35	Aeration Tank	151	Final Clarifier No. 1	2122	•
36	Aerator No. 1	152	Sludge Collection Mechanism	2130	Primary Sedimentation Tank No. 2
•	•				
•	•	153	•	2131	•
•	•	•	•	2132	•
42	Final Clarifier	176-250	Operations Building	2200	Boiler Room
43	Sludge Collection Mechanism	•	•	2210	Raw Sludge and Scum, Pumping System
		•	•		
•	•	251-275	Chlorine Contact Tank	2211	Raw Sludge Pump No 1
•	•	251	•	2212	•
49	Chlorine Contact Tank	•	•	2213	•
•	•	276-300	Sludge Thickener	2220	Digested Sludge Recirculation System
•	•	276	•		
58	Raw Sludge Pump No. 1	•	•	2221	Sludge Recirculation Pump No. 1
•	•	301-325	Digester and Sludge Gas System		
•	•			2222	•
63	Primary Digester	301	•	2300	Control Room
64	Primary Digester Stirring Mechanism	•	•	2310	Motor Control Center No 1
		326-350	Centrifuges		
72	Sludge Drying Beds	326	•	2320	High Pressure Air System
•	•	•	•	2321	Compressor

EXAMPLE MAINTENANCE MANAGEMENT SYSTEM
(Continued)

SMALL FACILITY

NOTE: The consecutive numbering system is not flexible with respect to equipment additions and omissions. Therefore, consideration might be given to alternating equipment numbers (1, 3, 5, 7, 9, etc.) or using an alphabetical suffix (12A, 12B, 12C, etc.) to handle this problem.

The list of equipment numbers along with their corresponding equipment descriptions are kept in a folder. This folder is filed and used as an equipment catalog This catalog provides a convenient list of equipment numbers and their corresponding equipment descriptions.

In a small plant with the superintendent and/or chief operator having to plan, schedule, perform and record maintenance tasks, the equipment record system selected is a single card file system Figure No. 23 is a sample single card containing nameplate data and preventive maintenance tasks on the front and a record of repairs on the reverse side. These equipment record cards are set upright in a file holder with the top edge exposed A metal tab is placed on the week of the month in which the next preventive maintenance task is to be accomplished

MIDDLE SIZE FACILITY

A list of the equipment numbers and their corresponding item descriptions are kept in a notebook. This notebook serves as an equipment catalog. This catalog provides a convenient list of equipment numbers and their corresponding equipment descriptions.

A three card system is used as the plant's equipment record system. Figure No. 22 shows samples of the cards used in this three card system. The first card contains the equipment description, nameplate data, and spare parts list The second card is a combination work order form and preventive maintenance list PM frequencies also appear on this card.

The card is removed and copied when preventive work is scheduled The copy is assigned a work order number and the preventive maintenance tasks to be performed are circled The third card contains a history record of repairs. When a history record card is filled with information, the completed card is removed and placed in permanent history record and a new card is placed in the file These cards are maintained in a horizontal tray with the bottom edge of the third card exposed The third card has a sliding progressive signal positioned on the month for the next scheduled PM inspection, when the inspection is completed, the signal is moved to the month designated for the next inspection The card also contains a four window multicard

LARGE FACILITY

Number	Equipment Description
2322	Holding Tank
2400	Chlorinator Room
2410	Scales
2420	•
3000	Aeration Tanks
3100	Aeration Tank No 1
3110	Mechanical Mixer No. 1
3120	•
3130	•
•	•

Equipment numbers, item descriptions and nameplate data are input to the computer. An up-to-date printout of this information is bound and used as an equipment catalog Additions or deletions of equipment items are made with a computer data card. The computer can be keyed to reproduce any desired portion or all of the equipment catalog information.

A multifile, multipurpose computer system is used for the equipment record system. The preventive maintenance tasks and frequencies are input into the computer files Additional information on planning and scheduling and cost data are also filed. The system provides a closed-loop maintenance control system that permits one reporting plan The system provides a total documented control readout of scheduling, cost, equipment history, and manpower requirements

EQUIPMENT RECORD

ACME VISIBLE #60P03

TAG NO	OLD PL NO
TAG LOCATION	EQUIP LOCATION
MFG Robbins & Myers, Inc.	VENDOR Motor - U. S. Motors
MFG SERIAL NO 5000	P. O. NO - DATE - COST -
JOB NO	PA SERIAL NO FLOW DIA BOOK NO CAT NO

DESCRIPTION OF EQUIPMENT	SPARE PARTS IN STOCK	
	PART NO	PART NAME
Centrifuge Feed Pump No. 2		

DRAWING NO	TITLE

FIGURE NO. 22 SAMPLE THREE CARD SYSTEM

RMS COURTESY OF
Acme Visible Records, Inc.
Crozet, Virginia

SHEET 1 of 3

ITEM No. - Centrifuge Feed Pump No. 2 LOCATION

ACME VISIBLE Crozet Virginia #60P06 WORK ORDER NO DATE

WORK ORDER

NO	OPERATION (DO ONLY THOSE ENCIRCLED)	EST TIME	FREQUENCY MECH	FLE	LUB	MISC
1	Operate all valves	W 10 min.				
2	Check oil level in motor gear case	W 10 min.				
3	Operate variable speed unit through entire range	W 10 min.				
4	Operate gland seal water shut-off valves, clean strainer and check operation of solenoid valve	W 30 min.				
5	Check drive belt tension and condition	M 30 min.				
6	Remove belt guard and check separation of back stop	Q 30 min.				
7	Check varidrive belt condition, lubricate splined shaft Q or Ev. of 250 hrs.	30 min.				
8	Change oil in motor gear case	S 1 hr.				
9	Repack motor bearing and flush and relubricate pump bearing	A 4 hrs.				
10	Clean entire unit and retouch paint	A 4 hrs.				

PERFORMED BY | DATE COMPLETED | COMMENTS

A - ANNUAL
S - SEMIANNUAL
Q - QUARTERLY
M - MONTHLY
W - WEEKLY

MAINTENANCE SCHEDULE

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52

FIGURE NO. 22 SAMPLE THREE CARD SYSTEM

FORMS COURTESY OF
Aceme Visible Records, Inc.
Crozet, Virginia

HISTORY OF REPAIRS

DATE	W O. NO	DESCRIPTION OF REPAIRS	DOWN TIME	MAN HOURS	MATERIAL COST
2/7/73	981	Change oil in motor gear case	1 hr.	1¼ hr.	3 00
2/14/73	1031	Repack motor, flush and relubricate pump bearing	4 hrs.	4 hrs.	10 00
3/15/73	1190	Check drive tension and condition	½ hr.	½ hr.	

TAG NO	DESCRIPTION	MONTHLY INSPECTION CONTROL
	Centrifuge Feed Pump No. 2	JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

FIGURE NO. 22 SAMPLE THREE CARD SYSTEM

FORMS COURTESY OF
Acme Visible Records, Inc.
Crozet, Virginia

SHEET 3 of 3

JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4

Preventive Maintenance Program — Equipment Record Number 2

EQUIPMENT DESCRIPTION	ELECTRICAL OR MECHANICAL DATA
Name Comminutor	Size 1½ HP
Serial No. 1-432-607	Model K1824PK71
Vendor Worthington Corp.	Type K
Vendor Address -- --	
Vendor Rep. John Doe Phone --- ---	
Initial Cost --- --- Date --- ---	

WORK TO BE DONE	FREQUENCY	TIME
Cutting surfaces should be inspected and adjusted	Quarterly	
Cutting surfaces should be checked for sharpness	Semiannually	
Lubricate communitor with Grease #1	Biweekly	
Change gear motor oil - SAE 10 (Winter) - SAE 40 (Summer) - SAE 30 (Fall & Spring)	Quarterly	
Inspect for unusual noise or heat	Daily	
Inspect combs, cutter teeth, shear bars, and base seal	Biweekly	

DATE	WORK DONE	SIGNED	DATE	WORK DONE	SIGNED	DATE	WORK DONE	SIGNED

FIGURE NO. 23 SAMPLE EQUIPMENT RECORD CARD

SMALL FACILITY

Maintenance Planning and Scheduling

The required preventive maintenance tasks are listed on the equipment record cards with their frequencies

Each week the superintendent reviews all the equipment record cards with tabs denoting work to be performed in the coming week He uses these cards to prepare the PM work orders for the coming week A work order priority list is then developed This priority list includes work orders which will not be completed during the present week and must be carried over to next week. Figure No 25 is a sample work order form and Figure No 26 is a sample work order priority list Current work orders are maintained in a log book with the priority list as the first page Each Friday, all completed work orders are taken out of the log by the superintendent, applicable information is recorded on equipment record cards and the work orders are placed in a file. This file becomes a history of work accomplished at the facility

Before an operator or maintenance helper starts to work on a work order, he reviews the notebook containing the preventive maintenance procedures and checklists Preventive maintenance procedures and checklists are typed on 8½"x11" pages with file

MIDDLE SIZE FACILITY

signal to designate the four weeks in each month A signal is lowered to denote the specific week in which the task is to be accomplished.

Maintenance Planning and Scheduling

The preventive maintenance tasks and frequencies are listed on the second card of the equipment record system.

The clerk typist reviews the card system weekly and removes the work order cards (second card) for all equipment requiring PM work in the coming week. Copies of this card are made, a work order number assigned, and required PM items circled

The work orders are forwarded to the maintenance supervisor for his review and to have work priorities established. The work orders and priority list are forwarded to the mechanical maintenance foreman who assigns the work. When the work is accomplished, the work order form is completed and returned to the clerk typist. He records pertinent information and files the work order in a history file of work orders.

The mechanical maintenance foreman reviews all the work orders prior to assigning them to the maintenance staff. He then provides each crew with the PM procedures and checklist for the particular task assigned The PM procedure and checklist are typed on 8½"x11" pages and have file numbers

LARGE FACILITY

Maintenance Planning and Scheduling

All corrective and preventive maintenance tasks are initiated by work orders Figure No 24 is an example of the type work order used

A weekly computer printout provides a listing of preventive maintenance tasks to be performed in the coming week. The maintenance clerk uses this listing to prepare preventive maintenance work orders The preventive maintenance work orders are then forwarded to the maintenance foreman who assigns the work The records clerk also prepares the corrective maintenance work orders The maintenance supervisor reviews all corrective maintenance work orders and approves them before forwarding them to the maintenance foreman.

The maintenance foreman prepares a corrective maintenance work estimate before issuing the work order to the maintenance staff Upon completion of the work orders the clerk forwards the forms to the computer center Here the cost information on the work orders is input to the computer The computer program lists equipment number, description, total cost of maintenance, preventive maintenance cost, corrective maintenance cost, total man-hours and cost of

Date 8/7/73

Work Order No. 738

Location	Requested By:	Priority:
Pretreatment Structures	J. D. ---- (Phone)	7

Equipment Name	No.
Communitor No. 1	1114

[X] Inspect [ ] Replace [ ] Service

[ ] Repair [ ] Overhaul [ ] Paint

Work Description

Inspect and adjust cutting surfaces.

Work Performed/Comments

Cutting surfaces were inspected and adjusted. It was required to sharpen some surfaces.

Job Estimate

Labor $ 260.00

Material $ 0

John Jones
Maintenance Superintendent

Work Record

Personnel Assigned	Manhours	Date	Work Done	Parts & Materials
C. G. Doe	20	8/16/73	Adjusted and shar-	
D. Smith	20		pened cutters	None
Total	40			

Work Completed By D. Smith Date 8/16/73

Work Accepted By John Jones Date 8/17/73

FIGURE NO. 24

SAMPLE: WORK ORDER

WORK ORDER

WORK ORDER NO. 452 DATE: 8/9/73

WORK TO BE PERFORMED:

Aerator No. 1 Equipment No. 36
Lubricate motor bearings.

MATERIALS REQUIRED:

Grease #2

WORK PERFORMED BY:

1. Jack Smith 2 HOURS
2. _____ HOURS
3. _____ HOURS
4. _____ HOURS

WORK COMPLETED:

SIGNED: Jack Smith

DATE: 8/13/73

COMMENTS:

FIGURE NO. 25 SAMPLE WORK ORDER

Form 1

MAINTENANCE SECTION GENERAL PRIORITY SCHEDULE

ORDER DATE	PRIORITY	JOB DESCRIPTION	COMPLETION DATE
8/14/73	1	Work Order No. 572 - Replace flexible connections to the chlorine cylinders	8/17/73
8/10/73	2	Work Order No. 569 - Inspect and adjust cutting surfaces of communitor	8/24/73
8/10/73	3	Work order No. 571 - Lubricate worm gear and speed reducer on Clarifier No. 1	8/24/73
8/10/73	4	Work Order No. 570 - Lubricate aerator motor bearings	8/24/73
8/3/73	5	Work Order No. 550 - Paint rear entrance signs, gates, and post.	8/31/73

Courtesy of Mr. L. W. Ketcham
Plant Superintendent
Central Treatment Plant
Tacoma, Washington

NOTE: The Maintenance Section will generally pursue the highest priority assignment unless specifically instructed otherwise by a supervisor. When conditions are not favorable to work on a higher assignment they may drop back to the next lower one.

SUPERVISOR, TREATMENT PLANTS

FIGURE NO. 26

EXAMPLE MAINTENANCE MANAGEMENT SYSTEM
(Continued)

SMALL FACILITY

numbers corresponding to the equipment number of the item the procedure was developed for. The notebook is located with the work order log book. The preventive maintenance procedures are removed and placed on a clipboard for use in the work area When preventive maintenance procedures are removed, a card is placed in the notebook identifying who is using the procedure. Upon completion of work, the procedure is replaced and the card is removed.

Storeroom and Inventory System

A storeroom is provided to maintain parts and supplies. Each shift operator maintains a key to the storeroom. All storeroom items are numbered and listed in a storeroom catalog A reference to the item's location in the storeroom is also included in the catalog The storeroom has consecutively numbered shelves and bins for storing supplies.

To maintain an inventory of each item, a card file is used. The card file has an index card for each item and the cards are filed by item number. The card contains the information as shown on the sample form, Figure No. 27 As items are removed from stock, a storeroom withdrawal slip, (see Figure No. 28) is completed. The withdrawal slip is used

MIDDLE SIZE FACILITY

corresponding to equipment numbers. A sign-out sheet is provided and initialed when a procedure has been removed from the PM procedures file. Upon completion of the work, the procedure is returned and the sign-out sheet updated.

Storeroom and Inventory System

A storeroom is provided for maintaining parts and supplies The clerk typist maintains the storeroom and controls access to it.

All storeroom items are numbered and listed in a storeroom catalog. The materials are stored on shelves and in bins. Their location is noted in the storeroom catalog.

To maintain an inventory of each item, a card file is used. This card file has an index card for each item and the cards are filed by item number. A sample index card is shown in Figure No. 27 As items are withdrawn from stock, a storeroom withdrawal slip is completed The clerk typist revises the index

LARGE FACILITY

supplies The work orders are then filed and become a history of work accomplished.

Comprehensive preventive maintenance procedures and checklists have been developed for each item of equipment. These procedures are based upon the manufacturers' recommendations. These procedures are bound into a maintenance manual and each operating section has a copy of the manual. The procedures are indexed and referenced to the equipment number. As a procedure is needed, a copy of the procedure is made and given to the mechanics who are to perform the PM tasks

Storeroom and Inventory System

The storeroom catalog is maintained on the computer. The computer printout lists item number, description, vendor information, cost data, location in the storeroom, maximum and minimum quantities and reorder point The storeroom catalog printout is placed in a binder for easy use in the storeroom

The storeroom clerk issues supplies using a storeroom ticket such as the sample shown in Figure No 28. The clerk will record the information from the storeroom ticket on the inventory form for the equipment item Items considered as consumables do not require withdrawal slips. The record card is used to maintain information on quantities consumed. The clerk will inventory these items periodically to determine when reorder is required. The inventory system is

STOREROOM INVENTORY CARD

Item No. 87

Item Description - Set of Gaskets

Part No. U-21247
For Wallace & Tiernam Chlorinator
Series A-741

Aisle No. 4

Bin No. 18

Quantity Maximum 2 Minimum 1

Reorder 1

INVENTORY INFORMATION

Quantity Used or Stocked	Date	Signed	Quantity on Hand	USAGE OR SUPPLY INFORMATION Usage - Work Order No. Supply - Purchase Order No.
2	1/15/73	J. D.	2	P. O. No. 55
1	2/21/73	B. G.	1	W. O. No. 212
1	3/18/73	J. D.	2	P. O. No. 197

FIGURE NO. 27 SAMPLE INVENTORY CARD

STOREROOM TICKET

8/7/73 DATE	Joe Smith EMPLOYEE	Maintenance DEPT.
	John Jones FOREMAN	Maintenance DEPT.

COST CODE NO. P25

WORK ORDER NO. 792

WORK DESCRIPTION Change oil in gear box

ITEM NO.	DESCRIPTION	QUANTITY	UNIT COST	TOTAL COST
47	SAE 40 Motor Oil nondetergent	8 qt.	0.79/qt.	$6.32

MATERIAL PROVIDED E. White (Signature Storeroom Clerk) 8/7/73 (Date)

MATERIAL RECEIVED J. Smith (Signature) 8/7/73 (Date)

FIGURE NO. 28 SAMPLE STOREROOM TICKET

SMALL FACILITY

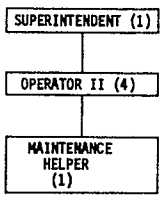
by the superintendent to keep the index card file up to date. The withdrawal slips are maintained in a file as a record of items withdrawn from stock.

Items considered as consumables do not require withdrawal slips. The superintendent inventories these items periodically and updates the inventory cards to determine when reorder is necessary.

When the quantity in stock drops to the reorder point, the superintendent provides a list of items, descriptions, and quantities to the municipal purchasing department to initiate reorder of supplies.

Maintenance Personnel and Organization

The following is a sample organizational chart for a small plant. The number in parentheses identifies the number of employees for each job title:



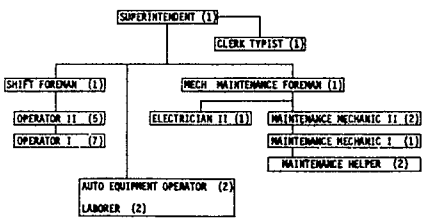
MIDDLE SIZE FACILITY

cards with information obtained from the withdrawal slips. The withdrawal slips are placed in a permanent file for a record of supplies consumed. Figure No. 28 shows a sample withdrawal slip. Items considered as consumables do not require withdrawal slips. The inventory card is used to maintain a record of usage of these items. The clerk typist inventories these items periodically and updates the inventory cards to determine when reorder is necessary.

The clerk reviews the index cards as they are updated to determine if the reorder of supplies is necessary. The items required are listed and given to the maintenance supervisor for his review and to be forwarded to the municipal purchasing department.

Maintenance Personnel and Organization

The following is a sample organizational chart for a middle size facility The number in parentheses identifies the number of employees for each job title:



LARGE FACILITY

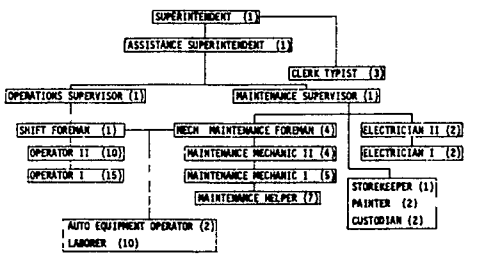
kept up to date by the storeroom clerk. A sample of the inventory card used is shown in Figure No. 27. When the storeroom clerk determines a reorder is required, he prepares the purchase order and forwards it to the city purchasing department. Figure No. 29 is a sample of the type of purchase order used.

Items in the storeroom are located using an aisle and bin designation. This location information is on the storeroom catalog printout.

The storeroom clerk also checks out special tools and keeps information on the cost of general supplies not chargeable to corrective or preventive maintenance work.

Maintenance Personnel and Organization

The following is a sample organizational chart for a large facility. The number in parentheses identifies the number of employees for each job title:



TO Progress Pump Corp.
88 Worthington Drive
St. Louis, Missouri 63043

SHIP TO Lynchburg STP
1005 River Road
Lynchburg, Virginia 24502

PURCHASE ORDER NO. 972
WORK ORDER NO. 585
DATE INITIATED 8/9/73
DATE REQUIRED 8/27/73
SHIP VIA
F.O.B.
TERMS

IMPORTANT
Our Purchase Order Number must appear on Invoices, Packages and Correspondence.

QUANTITY	STOCK NUMBER/DESCRIPTION	PRICE	PER	TOTAL
1	Drive shaft Cat. No. 26501			
1	Connecting rod Cat. No. 26502			
	NOTE Parts for pump 8" - 5444C Frame type 2A5 Serial Number 70 42 89			

APPROVED BY J. A. Jones DATE 8/10/73

SHEET 1 OF 1

FIGURE NO. 29 SAMPLE PURCHASE ORDER

EXAMPLE MAINTENANCE MANAGEMENT SYSTEM
(Continued)

SMALL FACILITY

The superintendent does not have an assistant. The second and third shift have only an Operator II on duty.

On the day shift, the superintendent will review operations and maintenance work. The Operator II, in addition to normal operations and maintenance tasks, assigns maintenance tasks to the maintenance helper.

The small plant, because of its limited maintenance capability, must contract out electrical repairs and major mechanical repairs

The small plant depends on outside sources for training courses to upgrade their staff. The state sponsored operator training schools and short courses sponsored by the Environmental Protection Agency are used to meet the plant's training needs.

The operators must perform maintenance tasks, clerical duties, and record keeping in addition to their normal operating tasks. The superintendent follows operations and maintenance closely to help in planning and scheduling work

MIDDLE SIZE FACILITY

The superintendent has responsibility for overall plant operations and maintenance. The maintenance foreman is responsible for maintenance planning and scheduling and reviewing maintenance tasks to be accomplished. The clerk typist is responsible for recording maintenance information in the equipment record system and maintaining the storeroom and inventory system. The maintenance mechanics perform the preventive and corrective maintenance tasks. The operations section only performs the minor maintenance required during the normal operation of the equipment.

The maintenance foreman continuously reviews his maintenance staff and provides training to upgrade their qualifications. Maintenance men are sent to short courses or take correspondence courses offered by the State and Federal Water Pollution Control Agencies.

The superintendent and mechanical maintenance foreman review all preventive and corrective maintenance tasks with respect to staff size and capabilities. They then decide what tasks must be contracted to outside repair services Arrangements are made with private contractors or service agencies to perform all tasks beyond the capability of facility personnel.

LARGE FACILITY

The superintendent has responsibility for overall plant operations and maintenance. The maintenance supervisor is responsible for maintenance operations and keeps the superintendent informed of the status of the maintenance program. The maintenance supervisor is responsible for reviewing maintenance tasks and planning and scheduling the work. The records clerk maintains equipment records and prepares the work orders.

The storeroom clerk maintains the storeroom and inventory system, keeps all related records and initiates purchase orders. The Electrician II aids in planning and scheduling electrical tasks. The operation section correlates operations with required maintenance tasks and only performs the minor maintenance required during the normal operation of the equipment.

The maintenance foremen continuously review the maintenance operations and report to the maintenance supervisor. They also review the maintenance staff and recommend training to upgrade their qualifications. The facility management provides training courses for the maintenance personnel at the facility in addition to courses provided by high schools, colleges, and State Water Pollution Control Agency The maintenance supervisor reviews all preventive and corrective maintenance tasks with respect to staff size and capabilities. A list of tasks which must be contracted to outside repair service has been prepared. Arrangements have been made with private contractors

SMALL FACILITY

Costs and Budgets for Maintenance Operations

The cost information from the equipment record system, work orders, storeroom inventory cards and the maintenance man-hours are used to develop the maintenance budget To aid in determining maintenance man-hours, a cost coding system breaks an employee's eight hour shift down into time spent performing various types of work The coding system uses 01 as the charge code for normal operations, 02 for preventive maintenance and 03 for corrective maintenance The municipal accounting department maintains these man-hours and provides cost summaries to the superintendent He uses these totals to determine if maintenance man-hours are excessive and to compare corrective maintenance man-hours to preventive maintenance man-hours This helps the superintendent to determine if his preventive maintenance program is being performed satisfactorily (NOTE· See Section VIII, Costs and Budgets for Maintenance Operations, for additional information on maintenance budget preparation.)

The user of this manual should review his particular plant's requirements and develop his own system using this example as a guide

MIDDLE SIZE FACILITY

Costs and Budgets for Maintenance Operations

The superintendent and maintenance supervisor review the cost information in the equipment record system, work orders, storeroom inventory cards, and the maintenance man-hours to help them develop a maintenance budget To aid in determining maintenance man-hours, a cost coding system breaks an employee's eight hour shift down into time spent performing various types of work The coding system uses 002 for sick leave, 001 for vacation, 003 for holidays, 004 series numbers for normal operation tasks, 005 series for PM work and 006 series for corrective maintenance work. Only breaking the man-hours between operations and maintenance is sufficient for budget purposes, but the breakdown on maintenance man-hours helps the supervisor in establishing time requirements for performing repetitive maintenance tasks In addition, he uses these man-hours and cost summaries to determine if maintenance man-hours are excessive and to compare corrective maintenance man-hours to preventive maintenance man-hours This helps the superintendent determine if his preventive maintenance program is being performed satisfactorily (NOTE. See Section VIII, Costs and Budgets for

LARGE FACILITY

and service agencies to perform all tasks beyond the capability of the facility staff

Costs and Budgets for Maintenance Operations

The sources of information on maintenance costs include computer files, storeroom cards, work orders and maintenance contracts The maintenance supervisor assists the superintendent in developing a maintenance budget. The computer has the cost data on preventive and corrective maintenance on file, and this information is used in evaluating maintenance work

In addition, maintenance costs for an individual item of equipment can be obtained from the computer to determine if maintenance costs are excessive in relation to original cost.

To aid in determing maintenance man-hours, a cost coding system breaks an employee's eight hour shift down into time spent performing various types of work. A sample coding system provides codes as V01 for vacation, S02 for sickness, H03 for holidays, N04 series for normal operations tasks, N05 series for preventive maintenance and N06 series for corrective maintenance work Breaking the man-hours between operations and maintenance is sufficient for budget purposes, but the breakdown on maintenance man-hours helps the superintendent and

SMALL FACILITY

MIDDLE SIZE FACILITY

Maintenance Operations, for additional information on maintenance budget preparation.)

A person developing a system for a middle size plant should review his particular plant's requirements and develop his own system using this example as a guide.

LARGE FACILITY

maintenance supervisor establish time requirements for performing repetitive maintenance tasks. (NOTE: See Section VIII, Costs and Budgets for Maintenance Operations, for additional information on maintenance budget preparation.)

A person developing a system for a large plant should review his particular plant's requirements and develop a system compatible using this example as a guide.

SECTION X
MAINTENANCE MANAGEMENT SYSTEM EVALUATION GUIDELINES

This section is to aid persons developing maintenance management systems by providing a checklist for evaluating a proposed system and to aid treatment plant management in evaluating an existing maintenance management system. The evaluation guidelines are broken down into the five basic maintenance features considered essential to a maintenance management system. A maximum of two hundred (200) points have been allotted to each feature, thus a maximum score of one thousand (1000) points is possible. In reviewing a system, the evaluator must remember these guidelines apply to all types and sizes of treatment plants. Due to the range of plant sizes and their complexities, no minimum passing score has been given. The purpose of these guidelines is to aid in locating problem areas so they may be corrected or improved. An individual using these evaluation guidelines will generally find the maintenance system he is analyzing does possess most of the features outlined in the Guidelines. However, there will probably be many qualifications accompanying each positive response to the questions in the Guidelines. This is true because the features of many maintenance systems are either incomplete or are incapable of performing their intended function. Each question in the Evaluation Guidelines should be carefully weighed and given a rating commensurate with the feature's ability to perform its role in the total maintenance management system.

EQUIPMENT RECORD SYSTEM

EVALUATION GUIDELINES	MAX. RATING	YOUR RATING
1. Do you have an equipment numbering or other identification system to aid in locating and identifying all major items of equipment?	20	
2. Do you have a system for maintaining nameplate data and other essential information on all major equipment items within the treatment system?	50	
3. Does your maintenance record system provide for listing preventive maintenance (PM) tasks, giving their frequency and recording the PM work performed?	30	

EQUIPMENT RECORD SYSTEM
(CONTINUED)

EVALUATION GUIDELINES	MAX. RATING	YOUR RATING
4. Does your maintenance record system provide for recording corrective maintenance work performed?	20	
5. Does your maintenance record system provide for recording such information as maintenance man-hours, spare parts or components used in repair and name of individual performing each job?	30	
6. Does your maintenance record system provide for recording all maintenance related costs and can these costs be readily compiled for use in maintenance budget preparation?	30	
7. Are miscellaneous maintenance related documents such as as-built drawings, construction specifications and photos, shop drawings and manufacturers' literature properly filed and indexed and readily available to maintenance staff?	20	
TOTAL	200	

PLANNING AND SCHEDULING

EVALUATION GUIDELINES	MAX. RATING	YOUR RATING
1. Is some form of schedule chart or priority list provided to assist maintenance supervisors in controlling maintenance tasks?	20	
2. Do you plan and schedule preventive maintenance (PM) tasks for all major equipment items within the treatment system?	30	

PLANNING & SCHEDULING
(CONTINUED)

EVALUATION GUIDELINES	MAX. RATING	YOUR RATING
a. Are PM frequencies based upon manufacturers' recommendations and by inspection?	10	
b. Does the existing maintenance organization permit the proper scheduling of required PM and take into account the corrective maintenance demands on the maintenance force?	10	
3. Are potential corrective maintenance tasks adequately considered in maintenance planning?	20	
4. Do you have a work order system that satisfies the treatment system's maintenance requirements?	30	
5. Are manpower management techniques used effectively to obtain maximum utilization?	30	
6. Do you have some form of labor standards to assist in preparing accurate work estimates for repetitive maintenance jobs?	30	
7. Have you contracted for maintenance tasks beyond the capability of your staff and determined the availability of this support?	20	
TOTAL	200	

STOREROOM AND INVENTORY SYSTEM

EVALUATION GUIDELINES	MAX. RATING	YOUR RATING
1. Have you provided a storeroom or storage area to assist in controlling the flow of spare parts, components and maintenance supplies?	40	
2. Have you reviewed manufacturers' recommendations and studied each major equipment item's maintenance requirements to determine what maintenance items should be maintained?	40	
a. Have you developed a system to monitor quantities of all maintenance items kept in stock?	20	
b. Have you established minimum and maximum quantities for all maintenance items kept in stock?	20	
c. Do you have a purchase order system that adequately controls the procuring of maintenance items?	20	
3. Do you have system for locating a given item in the storeroom?	20	
4. Do you have a catalog or index system to assist in identifying and locating a given item in the storeroom?	20	
5. Do you have a storeroom ticket or withdrawal slip to use when maintenance items are taken from stock?	20	
TOTAL	200	

MAINTENANCE ORGANIZATION & PERSONNEL

EVALUATION GUIDELINES	MAX. RATING	YOUR RATING
1. Do you have a maintenance organization chart that satisfies treatment system requirements?	30	
2. Is your maintenance organization chart reviewed and updated as required?	20	
3. Do you have job descriptions for each job title within your maintenance organization?	30	
4. Are job descriptions kept up to date and made available to maintenance personnel as required?	20	
5. Prior to initiating any program to correct deficiencies in a maintenance job, is a thorough analysis of this job performed?	50	
6. Do you have a maintenance training program that satisfies the maintenance objectives of the treatment system?	50	
TOTAL	200	

COST AND BUDGETS FOR MAINTENANCE OPERATIONS

EVALUATION GUIDELINES	MAX. RATING	YOUR RATING
1. Are maintenance costs broken down by maintenance categories such as preventive maintenance, corrective maintenance and major repairs or alterations?	50	
2. Do you have a system of cost codes or charge numbers for allocating labor and materials to specific maintenance jobs?	40	

COST AND BUDGETS FOR MAINTENANCE OPERATIONS (CONTINUED)

EVALUATION GUIDELINES	MAX. RATING	YOUR RATING
3. Do you have a system for recording the maintenance cost history of all major equipment items?	30	
4. Do you have a system for compiling cost information for use in budget preparation and maintenance cost studies?	50	
5. Do you have a system for recording contract maintenance costs so they can be used in preparing maintenance budgets?	30	
TOTAL	200	

Persons using these Evaluation Guidelines should follow up the evaluation with a review of the areas receiving the lowest ratings. It should be remembered that an apparent weak area may be due to another system feature performing poorly and pulling the weak area down.

The questions in the Evaluation Guidelines are grouped into the five basic maintenance features. Individuals can review the section of the manual which discusses each basic feature when they find deficiencies in the maintenance system they are analyzing. The information contained in the manual should assist persons in correcting the weaknesses in their maintenance management system.

It should be recognized that several of the questions in the Evaluation Guidelines deal with items that are absolutely essential to the success of any maintenance management system. These critical items include an equipment identification system, planning and scheduling preventive maintenance tasks, control of spare parts and supplies, and a system for preparing maintenance budgets. Maintenance management systems that receive low ratings in any of these critical areas should be considered deficient and appropriate corrective actions taken.

SECTION XI
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