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Management of preventive maintenance and its implementation in the Southern ports of Iran

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WORLD MARITIME UNIVERSITY

MANAGEMENT OF PREVENTIVE MAINTENANCE AND ITS IMPLEMENTATION IN THE SOUTHERN PORTS OF IRAN

BY

IRAJ SHIRIBABADI

IRAN

A dissertation submitted to the World Maritime University in partial fulfillment of the requirements for the award of the degree of master of science in Maritime Education And Training in Engineering.

1991

I certify that all material in this dissertation which is not my own work has been identified and that no material is included for which a degree has been previously conferred upon me.

The contents of this dissertation reflects my personal views and are not necessarily endorsed by the university.

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IN THE NAME OF GOD

WHO IS MERCIFUL AND GRACIOUS

ACKNOWLEDGEMENTS

I take this opportunity to thank first of all the central management of the Ports and Shipping Organization of Iran which has provided me this chance to gain a little of the broad maritime knowledge through two years of education at the World Maritime University.

I take this chance also to thank the Maritime Education and Training Department's Faculty Members for the provision of the valuable knowledge.

I also thank Mr. Randle Fiebrandt the METE department's lecturer for his assistance and guidelines in completing this work.

I take this opportunity also of thanking Mr. Gota Andersson the maintenance manager of the port of Malmo for co-assessing my work.

ABSTRACT

Preventive maintenance is a planned maintenance task that is performed to prevent machinery from unexpected failures. It provides many benefits and results in saving time, money, material and workmanship for the organization.

This paper mainly deals with the management of this type of maintenance and provides information on different aspects of the subject. It describes the current situation of maintenance in the southern ports of Iran and also discusses the strategies and steps for implementing such a maintenance policy in the southern ports of the country.

INTRODUCTION

Technology is advancing rapidly. Automation is replacing the traditional methods of control in industry to a great extent. The initial costs of machines and equipment rise drastically due to economic reasons every year. The capital requirements constrain the organizations and companies on additional investments in procurement and replacement of machineries. Consequently the organizations and companies have found it more economical to maintain the existing and available assets with acceptable degrees of reliability. But reliability is achieved only if an effective maintenance program is implemented.

Maintenance is a service that has specific value to the production process. It is an organization which provides increase in productivity and profitability.

Maintenance is divided into different types. Each type provides particular policy and specific tasks.

Among all different types of maintenance, preventive maintenance programs have been found as the most successful and effective maintenance programs. They are believed to be successful in the improvement of reliability of equipment and effective in increasing the productivity and profitability of operations.

Regarding the effectiveness and success of preventive maintenance in industry I found it interesting to do a collective research work on the subject. The objective of this work is to increase the knowledge about preventive maintenance and recommend it as a suitable program for the southern ports of my country. For this purpose I conducted this work in six chapters. The chapters introduce and explain different subject matters which are all interrelated and together complete the work for reaching the objective. In the following the chapters of this work

are described in brief:

Chapter one, "Maritime Geography and Trade of Iran", describes the geographical location and climatic condition of the country. It also presents information on the ports, their organizations and their value to the trade of the country.

In chapter two, the main chapter of the work, maintenance and its benefit to the industry are explained. In this chapter preventive maintenance, its prime components, and economics of maintenance are also presented.

In chapter three "Training in Preventive Maintenance" the role of training in preventive maintenance is explained. This chapter introduces the objective of training in maintenance and offers three types of training programs for implementation. Also titles for several courses relevant to those three programs mentioned are presented in the chapter. In the last section of chapter three procedures for course development are described to facilitate training programs in maintenance work when intended.

Chapter four of this work has been devoted to the role of the computer and its application in the preventive maintenance program. In this chapter efforts have been made to provide information on this matter to show its importance and its practical application.

Chapter five describes the current situation of maintenance work, conditions of machineries, and the organization of technical work in the ports of Iran.

Chapter six elaborates on the strategies and recommendations for implementation of preventive maintenance in the southern ports of Iran. For this purpose the procedures and steps involved have been introduced and explained.

CHAPTER ONE

MARITIME GEOGRAPHY AND TRADE OF IRAN

1-1 BOUNDARIES

Iran is situated in southwestern Asia. It is bordered by Pakistan and Afghanistan on the east and Turkey and Iraq on the west. It is also bounded by the USSR and the Caspian Sea in the north and the Persian Gulf and Sea of Oman in the south. About 630 kilometers of the country's northern border and all of its southern border are maritime oriented.

The northern coastline of Iran consists of the southern coast of the Caspian Sea and its southern coastline is made up of 1800 kilometers of the Persian Gulf and the Sea of Oman.

1-2 CLIMATE

Iran has a continental type of climate with cold winters and hot summers. The weather in most of the coastal areas is warm and humid. In the Caspian Sea area temperatures and humidity range from 0 to 36 degrees centigrade and 43% to 100% respectively. The temperature and humidity vary between 6 and 55 degrees centigrade and 15% and 99% respectively in the Persian Gulf region. High temperatures and humidity remain during most seasons. The annual rainfall in the Gulf littoral is less than 13 cm and in the Caspian littoral is about 100 to 150 cm.

1-3 PORTS AND HARBORS

Iran has three types of ports; non-oil commercial ports (seaports), oil ports (oil terminals), and non-oil minor commercial (multipurpose) ports.

The non-oil commercial ports consist of nine major and five minor ports. The minor ports are utilized for different type of trades and are specified as multipurpose ports of the country.

The oil ports comprise of four major oil terminals and all are located in the Persian Gulf.

The prime concern of this paper is the non-oil commercial ports, therefore, the others will not be discussed.

The majority of the commercial ports of Iran are located along the Persian Gulf and the Sea of Oman coastline.

The major ports are :

1- Khoramshahr
2- Abadan
3- Imam (old Bandar Shahpour)
4- Bousher
5- Abbas (Shahid Bahonar)
6- Shahid Radjaei (new port complex)
7- Shahid Beheshti (Chahbahar)
8- Noushahr
9- Anzali

The minor ports are :

1- Jask
2- Lengeh
3- Qeshm
4- Genaveh
5- Deylam.

All of these ports operate under the authority of the Ports and Shipping Organization (PSO) of Iran. This organization is one of the organizational members of the Ministry of Roads and Transportation. It is the legal maritime body in the country responsible for the ports including their construction and operations.

Presently all the ports except for the two ports of Khoramshahr and Abadan are involved in the trade of the country. The two ports of Khoramshahr and Abadan in the Persian Gulf are closed due to the air raids during the imposed war in the early 80s. They suffered some constructional losses and presently are in the reconstruction process.

Figure 1.1 shows the location and tables 1.1 and 1.2 indicate the characteristics of these ports.

1-4 PORTS ORGANIZATIONS

The structural organization of all the ports are essentially similar. They consist of three departments operating under managing directorates of the ports. The departments of Finance and Administration, Maritime Operations and Technical are the prominent departments in the ports. However the organization of some of the ports

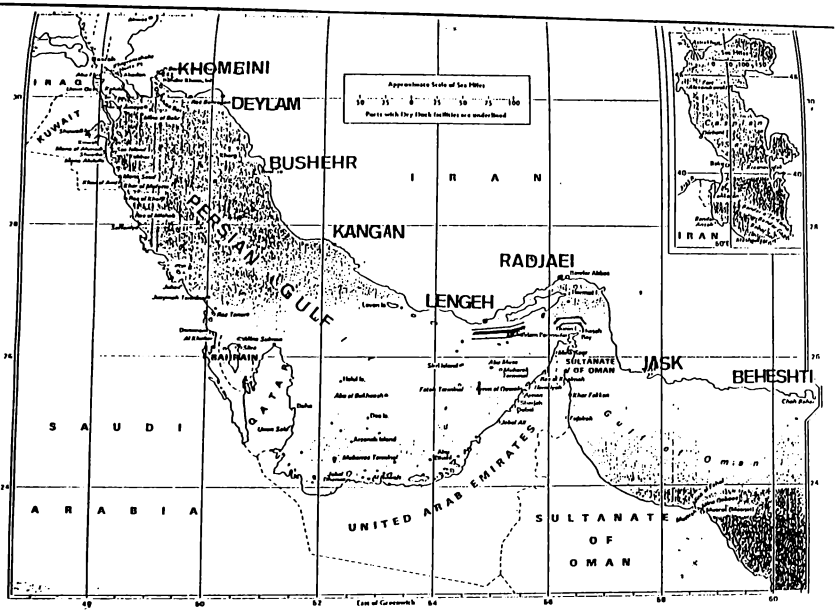


Figure 1.1 LOCATION OF COMMERCIAL PORTS OF IRAN

due to the extent of tasks and trade, port facilities and size may slightly differ. As an example, the structural organization of the port of Shahid Radjaei which is the largest and newest port of the country consists of three additional departments. Those are the departments of Maritime Logistics, Training and Planning, and Executive.

Each department is made up of divisions and sub-divisions. The departments are managed by deputy directorates. The deputies have full authority in their field of duties and are totally responsible for the operations and activities of the own departments.

Figure 1.2 shows a typical organizational chart of the ports and figure 1.3 shows an organizational chart of the port of Shahid Radjaei.

1-5 TRADES AND PORT OUTPUTS

Every year Iran imports and exports millions of tons of cargo through its ports. Most of the trade of the country is conducted through the ports of the Persian Gulf region. These ports play a major role in the economy of the country as well as the world economy. As an example, during the period 1980 to 1990, a total of 12958 ships arrived at all the ports (non-oil commercial ports) of the country and 115.615 million tons of cargo were handled. From these figures 9025 ships berthed at the southern ports and 108.843 million tons of cargo delivered.

Imports and exports are formed from a variety of commodities. Imports mostly consist of general and containerized cargo such as iron, fertilizers, chemicals, food items, spare parts.

Exports are mostly oil and chemical products, stones, molasses, nuts, scrapped metals.

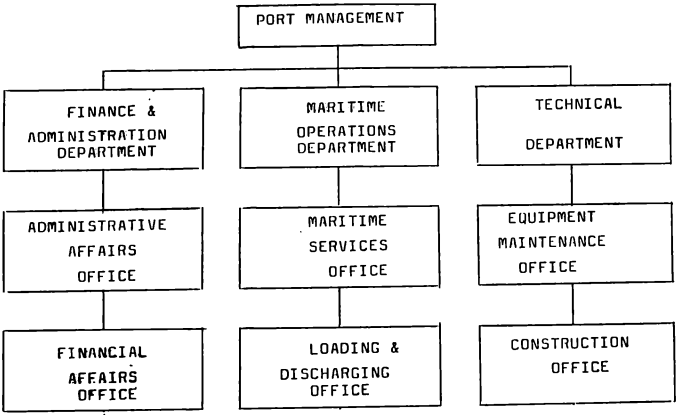


Figure 1.2 Typical organizational chart

NAME OF PORT	NUMBERS AND CAPACITIES OF QUAYS OF THE PORTS										TOTAL CAPACITY IN MILLION TONS
	GENERAL		CONTAINER		STONES		BARGING		OTHERS		
	No. of QUAYS	Cap. in Mil. tons	No. of QUAYS	Cap. in Mil. tons	No. of QUAYS	Cap. in Mil. tons	No. of QUAYS	Cap. in Mil. tons	No. of QUAYS	Cap. in Mil. tons	
IMAM	5	1	-	-	1	2.6	-	1.5	27	6.9	12
BUSHER	1	0.15	-	-	-	- -	-	0.6	2	0.6	1.35
SHAHID RADJAEI	5	1	2	1	-	--	2	0.6	14	6.3	8.9
SHAHID BAHONAR	2	0.4	-	-	1	0.6	1	0.2	4	1.8	3
SHAHID BEHESHTI (CHABAHAR)	1	0.15	-	-	-	---	4	0.6	-	0.9	1.05
ANZALI	4	0.8	-	-	-	--	-	-	-	--	0.8
NOUSHAR	2	0.3	-	-	-	--	-	-	-	--	0.3
TOTAL	20	3.8	2	1	2	3.2	7	3.5	50	16.5	28

Table 1.1 GENERAL CHARACTERISTICS OF MAJOR COMMERCIAL PORTS OF IRAN

Cargo handling activities in the northern and southern ports are done differently. In the northern ports the entire operation from the ship's holds to the port area is done by the personnel of the cargo handling office of the ports. In the southern ports, however, operations from the ship's holds to the quays are performed by stevedoring companies under the supervision of the port authorities. The remaining operations are carried out by the personnel of the ports.

Tables 1.3 and 1.4 illustrate comparisons of shipping and cargo handling activities of the northern and southern ports of the country. Also, tables 1.5 and 1.6 show discharged and loaded cargo at the ports during a period of one year.

Port Name	Quay length (m)	Quay capacity (ton)	Water depth (m)	Capacity per year (ton)
Lengeh	225	2000	5.5	250000
Jask	130	2000	5.5	120000
Qeshm	170	2000	5.0	150000
Genaveh	127	1000	4.0	100000
Deylam	146	1000	4.0	130000

Table 1.2 CHARACTERISTICS OF MINOR COMMERCIAL PORTS OF IRAN

YEAR	NO. OF SHIPS		
	NORTHERN PORTS	SOUTHERN PORTS	TOTAL
1980	380	1015	1395
1981	321	873	1194
1982	542	784	1326
1983	600	1052	1652
1984	311	980	1291
1985	479	966	1445
1986	200	832	1032
1987	346	885	1231
1988	388	690	1078
1989	366	948	1314

Table 1.3 Comparison of number of ships arrived at the northern and southern ports

YEAR	CARGO HANDLED IN (1000 tons)		
	NORTHERN PORTS	SOUTHERN PORTS	TOTAL
1980	750	9700	10450
1981	373	10560	11297
1982	976	9176	10152
1983	1174	13819	14966
1984	679	10836	11515
1985	744	10394	11138
1986	379	9589	9968
1987	363	11868	12241
1988	485	8918	9403
1989	512	13973	14485

Table 1.4 **Comparison of amount of cargo handled at the Northern and Southern ports**

TYPE OF COMMODITY	PACKING FORM	CARGO DISCHARGED AT PORTS IN(1000tons)							
		BEHESHTI	BUSHER	ANZALI	NOSHAHR	IMAM	BAHONAR	RADJAEI	TOTAL
IRON	BULK	-	29	44	16	689	16	51	845
FERTILIZER	BAG	138	75	31	66	634	107	309	1360
GRAIN	BULK	44	119	-	-	176	-	261	600
CORN	BULK	59	124	-	-	212	-	393	788
COAL	BULK	-	-	-	-	-	280	-	280
SUGAR	BAGS	78	97	18	9	82	88	130	502
RICE	BAGS	122	110	-	-	253	40	247	772
DAIRY PRODUCT	BOX	-	-	-	-	90	-	-	90
FISH	BOX	-	-	-	-	-	-	31	31
CHEMICALS	BAGS-BR	-	26	-	12	55	-	7	100
PET. PRODUCTS	BULK	192	869	433	318	-	1194	-	3006
WHEAT	BULK	244	42	202	11	1521	-	2199	4219
MEAT	BOX	-	-	-	-	43	-	19	62
SOYA	BAGS	-	39	-	-	2	-	235	276
VEG. OIL	BULK	-	-	-	-	36	-	443	479
OTHERS	-	21	199	73	25	1368	88	1093	2867
TOTAL	-	898	1729	801	457	5161	1813	5418	16277

Table 1.5 Discharged(imported) cargo at ports in the period of one year (March 1989 to March 1990)

TYPE OF COMMODITY	PACKING FORM	CARGO LOADED AT PORTS IN (1000 tons)							
		BEHESHTI	BUSHER	ANZALI	NOSHAHR	IMAM	BAHONAR	RADJAEI	TOTAL
Amonia	Barrels	-	-	-	-	39	-	-	39
Cabotage	-	-	-	-	-	-	-	4	4
Returning Goods	-	-	-	-	-	-	1	1	2
Empty Contain.	-	-	-	-	-	4	-	24	28
Scrapped Metal	Bulk	-	-	-	-	-	82	-	82
Mtal Bars	-	-	-	-	-	84	14	64	162
Cotton	Bundle	-	-	-	3	-	-	-	3
Seeds	Bags	-	5	-	-	-	1	-	6
Fruit	Box	-	8	-	-	-	117	-	125
Salt	Bulk	-	3	-	-	-	6	3	12
Molasses	Bulk	-	-	-	-	34	-	-	34
Liquified Gas	Bulk	-	-	-	-	-	-	113	113
Construction Materials	Bulk	-	-	-	-	-	-	9	9
Sulphur	Bulk	-	-	-	-	276	49	-	325
Nuts	Bags	-	13	-	-	-	14	3	30
Cement	Bags	-	-	-	-	23	31	127	181
Chromite Stone	Bulk	-	-	-	-	-	23	-	23
Buld:Const. Stones	Bulk	-	-	-	-	-	2	13	15
Other Stones	Bulk	-	23	-	-	-	-	28	51
Stone Powder	Bulk	-	-	-	-	9	-	-	9
Others	-	2	18	2	-	1	24	27	74
Total	-	2	70	2	3	470	364	416	1327

Table 1.6 Loaded (exported) cargo at ports in the period of one year (March 1989 to March 1990)

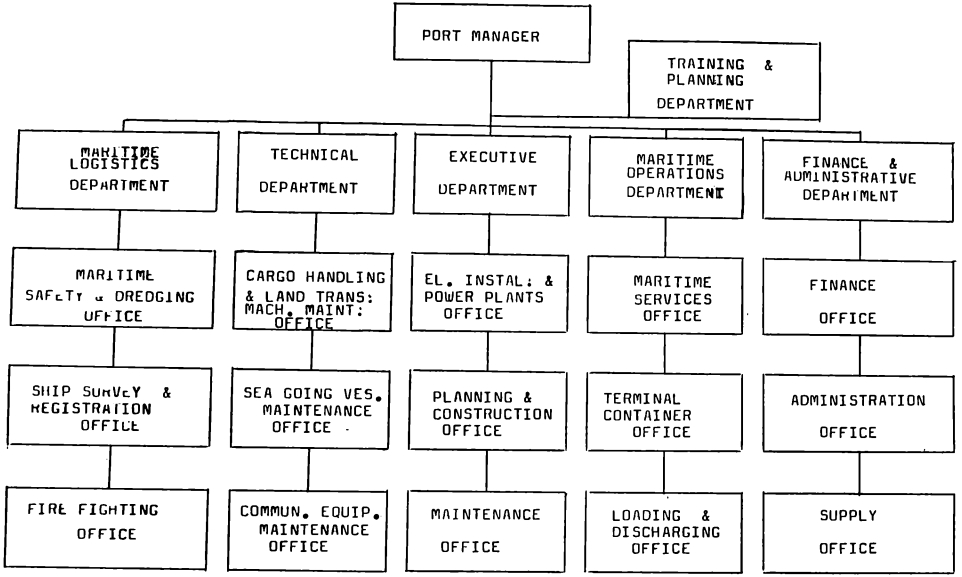


Figure 1.3 Organizational Chart of Shahid Radjaei Port

CHAPTER TWO

MAINTENANCE

The port industry like many other industries is based on profits. The key to survival and endurance of this industry is its profit making activities which must be one of its prime objectives.

For reaching such an objective, all components of the port organization must be functional and produce efficient services. It also must provide a means for attracting customers while saving assets and reducing costs. To satisfy these conditions the port operations which are the products of this industry must be carried out in the most efficient and economical ways. They must be done accurately and repeatedly at an optimum level without interruptions and delays.

The accuracy and continuity of the port operations depend basically on the availability and reliability of the machines and equipment which can be kept in a ready mode and proper running condition if correctly operated and properly maintained. To comply with these conditions and to reduce the cost of investment on equipment and their operations and also to keep the down-time of machines as low as possible, creation of maintenance organizations within the technical organization of the ports becomes a necessity.

2-1 MAINTENANCE DEFINITION

Maintenance can be considered as a series of tasks that keep the machines and equipment in running condition and a ready state for ease of operation and consequently the guarantee of continuation of activities. It is an integral

part of the organization which has a direct effect on the operations. Therefore it is as important as operational activities and it ranges from easy tasks such as cleaning the machine parts to repairs and condition monitoring.

Regarding all the activities concerning maintenance, it has been defined in different words which all conclude in the same meaning. D.A.Taylor (pg.119) defines it as "any action which is carried out to return or restore an item to an acceptable standard". Anthony Kelly in "Maintenance Planning and Control" (pg.17) defines it as "a combination of actions carried out to return an item to, or restore it to, an acceptable condition".

Maintenance work is divided into two main groups, planned maintenance and unplanned maintenance. Planned maintenance is any kind of maintenance policy or any combination of maintenance policies, that is planned, controlled and recorded. It consists of two sub-branches of preventive and corrective maintenance which are made up of breakdown or run-to-failure, shutdown and running maintenance.

Unplanned maintenance consists of emergency maintenance.

Figure 2.1 illustrates maintenance forms and their relationships.

Since the principal objective of this paper is to define and study preventive maintenance, the emphasis will be focused on that type of maintenance. For clarity and simplicity of understanding of preventive maintenance the other forms will be defined briefly in the section of the Definitions of Terms. Also for the purpose of this paper the terms machines and equipment are used for all the facilities applied to cargo handling activities. Those are lift-trucks (fork lift-trucks, top lift-trucks, etc.),

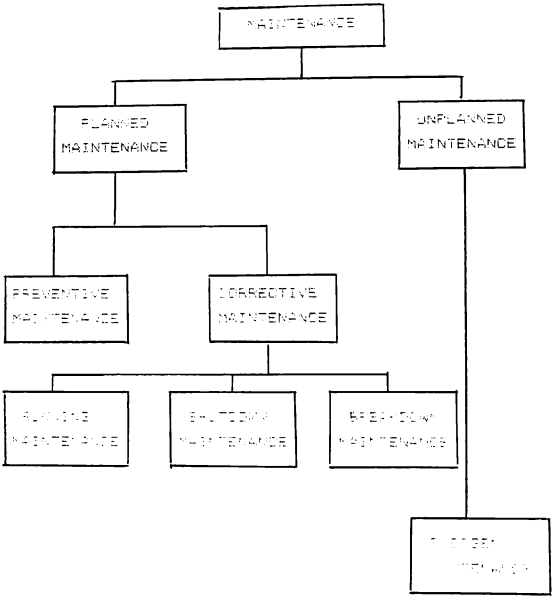


Figure 2.1 MAINTENANCE FORMS

cranes (mobile, gantry and dock cranes), trolleys, push trucks, tractors, transtainers, grain handling vacuum machines, grabs, and so on. Figure 2.2 demonstrates these equipment.

2-2 DEFINITIONS OF TERMS

availability:

The period for which an asset is in a usable state.

assets:

All the resources, rights, and property owned by a person or a company.

condition monitoring:

All the measures intended to determine the condition of equipment and to assess its need for maintenance.

corrective maintenance:

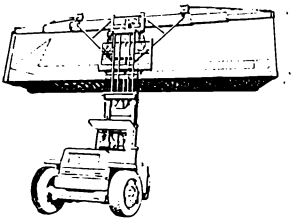
Maintenance carried out to restore an item which has ceased to meet an acceptable condition.

job:

A job is the generic title for a performer's position.

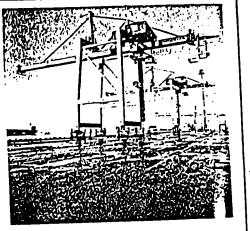
maintenance:

Any action which is carried out to return or restore an item to an acceptable standard.



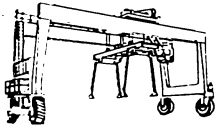
TOP LIFT-TRUCK

FORK LIFT-TRUCK

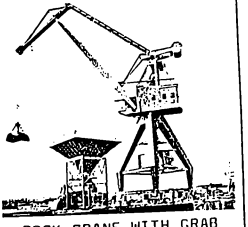


GANTRY CRANE

PULL TRUCK



TRANSTAINER



DOCK CRANE WITH GRAB

Figure 2.2 CARGO HANDLING MACHINERIES

maintenance costs:

The costs incurred in keeping equipment in an operating condition.

mean-time-to-failure (MTTF):

The average time from conclusion of work to rectify a fault until the next fault occurs.

predictive maintenance:

Maintenance scheduled for specific tasks required by equipment.

preventive maintenance:

Maintenance carried out at predetermined intervals, or to other prescribed criteria, and intended to reduce the likelihood of an item not meeting an acceptable condition.

planned maintenance:

Maintenance organized and carried out with forethought, control and the use of records to a predetermined plan.

run-to-failure maintenance:

A reactive maintenance that is carried out when a machine fails.

running time:

The time that the engine has been running.

task:

A task is a single work assignment which is independent of other actions and results in valuable outcomes.

terotechnology:

A combination of management, financial, engineering and other practices applied to physical assets in pursuit of economic life cycle costs.

utilization:

Utilization is a measure of how much use is made of a piece of equipment.

2-3 BENEFITS OF MAINTENANCE

Proper and successful maintenance programs can provide many positive benefits and result in saving time, money, material and workmanship for the organization.

The following is a list of benefits and improvements that can be obtained from implementation of maintenance programs:

1- improvement of overall service quality
2- increase in machine availability
3- improvements of safety and reliability of machines and equipments
4- reduction in the number of down-times of machines and equipments
5- elimination of unpredicted machine failure and unnecessary repairs

6- increase in life time of machines and improvement in their better utilization
7- decrease in maintenance and operational costs
8- increase in total production of organization
9- increase in labor productivity
10- improvement in labor skills and development of new skills
11- improvement in working environment, human safety
12- reduction of stresses due to work congestion
13- reduction of energy consumption and capital costs
14- improvement in design (design changes) to reduce maintenance

2-4 MAINTENANCE AND RELIABILITY

Nowadays machines are more complex and consist of thousands of interrelated parts with different characteristics. Failure in any one part may result in total failure of the system.

The overall reliability of one machine depends on the reliability of every individual part. For example if a machine consists of six parts which are each 98% reliable it is said that that machine is 88% reliable (98% x 98% x 98% x 98% x 98% x 98%). Therefore a slight change in the condition of one component of an equipment will affect the overall reliability of the system. One can imagine how susceptible the reliability of a machine made of thousands of parts is to failure if one part breaks down.

Reliability of a machine is achieved by proper care and time to time inspection of the parts and components. These requirements are the main elements of preventive maintenance which are able to develop means for reliability for components and the systems. With this regard the management of the organizations and companies

must naturally direct their attention toward the operational reliability of machines for improvement of production and economy of operations with the assistance of preventive maintenance programs.

2-5 PREVENTIVE MAINTENANCE

Preventive maintenance is a planned maintenance task that is carried out basically to prevent machinery from unexpected failures. In some cases it is limited to lubrication and minor adjustments and in other cases it consists of scheduled lubrication, adjustments, repairs and overhauls. There are many definitions for this type of maintenance and it has been defined by many authors and experts in the field. Anthony Kelly (pg.17) defines it as "maintenance carried out at predetermined intervals, or to other prescribed criteria, and intended to reduce the likelihood of an item not meeting an acceptable condition".

The main objective of preventive maintenance is to stop functional delays, reduce the maintenance costs, increase the life time and also the operational safety and reliability of the equipment.

There are essentially two techniques which are applied to preventive maintenance; scheduling and monitoring.

Scheduling is the act of carrying out the maintenance at regular intervals. The preventive maintenance task is usually carried out through periodic inspections, adjustments, repairs, parts replacements and condition monitoring. The principal importance of this task is the time selection for the intervals at which the inspections and other jobs must be carried out since the machines are assumed to be degraded within a time that is based on their types and classifications.

The time must be so selected that not only the economical and safety aspects are satisfied but also the availability of the equipment is maintained. However, the maintenance tasks are based on the hours of operation and in preventive maintenance management the time intervals between repairs or rebuilds of machines are based on the mean-time-to-failure (MTTF) statistics. The MTTF indicates the average time it takes for a system to fail. It is the reciprocal of the failure rate. In general the more frequently a machine is inspected, the larger is the MTTF. Therefore if a machine is left without inspection and replacement of defective parts, the MTTF decreases. The relationship between time interval of inspections and MTTF is shown in figure 2.3. From the figure it can be seen that if the machine components are not inspected or the interval between the inspections becomes great the MTTF is reduced and failure occurs.

The monitoring, as an alternative method of deciding on time and place for maintenance, is split into two categories; condition monitoring and performance monitoring. Condition monitoring is keeping a continuous or periodic watch on the equipment's condition. Performance monitoring differs from condition monitoring in that it watches the output or efficiency of the equipment.

The Bath Tub Curve of figure 2.4 shows the probability of machine failure. From the figure it is seen that the probability of machine failure during the first few weeks of operation due to the initial adjustments and installations is high. It then decreases and remains almost constant for a period of time. After the machine life reaches a certain age, again the probability of failure increases. Regarding this probability trend the maintenance programs need to be scheduled so that they can

cover the total operational hours of machines to reduce the possibilities of their failures.

The basic components that a preventive maintenance program as a planned maintenance must possess are planning, control and records. The explanations for these components are given in the later sections.

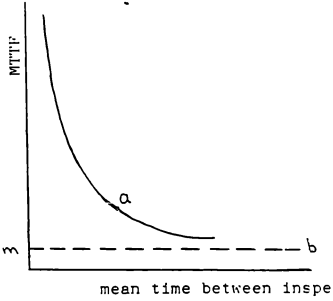


Figure 2.3 VARIATION OF MTTF WITH TIME BETWEEN INSPECTIONS
a) INSPECTED
b) UNINSPECTED
m) AVERAGE TIME TO FAILURE

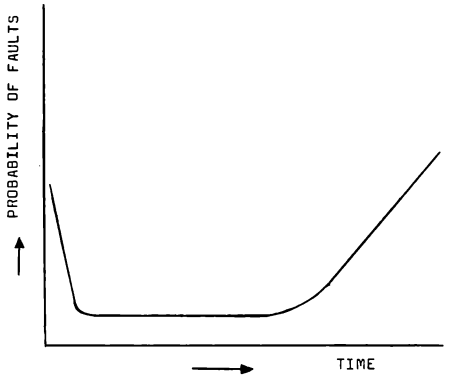


Fig. 2.4 BATHTUB CURVE

2-6 PLANNING FOR PREVENTIVE MAINTENANCE

When planning for a preventive maintenance program there are a number of factors that must be taken into consideration. Variety and number of machines, workshop facilities and test equipment, manpower, extent of tasks, schedules of task performance and manpower, control and analysis of the tasks, personnel assessment for promotions and training are the factors that need to be considered. In this respect the planners must realize all the factors to be able to produce a plan suitable for specific and individual circumstances.

2-6-1 BASIC ITEMS OF PLANNING

a_INVENTORY

Inventory is the first task item initiated in planning. It is carried out to identify the total number of assets that need to be maintained and put into the maintenance program. During the inventory priorities have to be considered and the machines with direct effect on the total production of the organization must be given priority in the schedule.

b_ IDENTIFICATION OF MACHINES

Identification of machines is the next planning item. Each machine must be correctly identified in order to simplify its location and record keeping.

c_ MACHINE REGISTER

Machines listed in the inventory must be properly registered for easy access to the needed information for maintenance tasks. The type of information registered depends mainly on the type of machine and its operational functions. Items such as name, code, description, reference number, location and suppliers are information that must be registered. The best starting point for the collection of such data are the manufacturers manuals and handbooks.

d_ SCHEDULING

For each machine separate schedules for maintenance tasks, inspection, lubrication, repairs, part replacements with regard to the frequencies for carrying them out must be established.

When producing schedules, the priorities with respect to the effect of each individual machine on the total production of the organization and the maintenance cost have to be kept in mind. To keep a balance between the two, records of the past jobs (if available) can help to choose the best solution. If not the manufacturers manuals and documents can become a great assistance.

Having chosen the priorities, frequencies of maintenance work have to be established next. The frequencies can be set up on the basis of either calendar time; i.e, yearly, quarterly, monthly, weekly or operating time, i.e operational hours or kilometers of travel.

Each one of the two mentioned basis for work frequencies have their own advantages and disadvantages. Calendar time gives the opportunity to spread out the work over time thus causing a reduction in workloads within

specific times which results in prevention of under or over maintenance work. The operational hour work, which is solely based on the hours of operation, causes difficulties in long term planning. It may result in work intensity in certain periods that can affect maintenance work quality.

However, with the consideration of different modes of work frequencies it is better to put the maintenance work on both bases so that the tasks can be carried out on maximum time or maximum usage whichever comes first.

e_ WORK CHARACTERISTICS

Work characteristics also known as job specifications, job cards, work orders, work information cards, and maintenance guides are a means for transferring maintenance task information to the maintenance staff.

The work characteristic cards provided for this purpose should contain sufficient information about the maintenance task to be carried out. They need to explain all the details of the tasks and provide necessary instructions.

The time and manpower required for maintenance jobs can also be estimated by the use of efficient work characteristic cards. For this purpose, in addition to the information on the work cards, the technical abilities, degree of knowledge and experience of the personnel in the field have to be evaluated.

f_ SCHEDULE FOR MANPOWER

Manpower is a prime factor in performance of preventive maintenance activities. In order to succeed in the implementation of work schedules, the manpower resources

need to be scheduled carefully according to the grades of activities and labor abilities.

The schedule in some cases is prepared for hours of labor work for one year or more, but in other cases it is developed for a period of five years at the most. This scheduling can become more effective and efficient if supported by correct tools and test facilities, spare parts and provision of technical information resources such as manuals and drawings.

g_ COMMUNICATION WITH USERS

Preventive maintenance tasks can be done according to their planned schedules if they are not disturbed by unexpected failures due to misoperation of machines. Such failures produce extra work and consume extra spare parts. To reduce the possibility of these problems, a means of communication between maintenance and operators departments must be established. Provision of such communication can improve schedule timing and also help the managers to assess the operators knowledge of machines and duties.

h_ CONTROL OF WORK QUALITY

The quality of maintenance tasks must be periodically examined and controlled for their precision, effectiveness and savings. For achieving such control the result of the maintenance tasks have to be compared with the manufacturers specifications and in case of unusual results consultation with the manufacturers can help.

i_ MANPOWER ALLOCATION

Allocation of personnel regarding their skills and abilities for the best performance of the tasks takes a high priority in preventive maintenance planning. As was mentioned earlier, grades of labor, skills and tasks must be identified for referring staff to specific tasks.

The number and skills of personnel required for maintenance work vary greatly depending on the size, type, and shift coverage of the operation. But no matter what size the operation, there should always be specialists available. They must be equipped with proper tools, equipment, parts and true leadership and available either on sites or on call. For ease and simplicity of manpower allocation it is preferable to have more personnel available but for safety and efficiency considerations, there should always be at least two persons on each site.

The manpower allocation job can be dealt with either manually with the use of job cards or through computer software.

j_ DOWNTIME ANALYSIS

If a piece of equipment is broken down, or under repair then it is not available. This is called down or downtime for the duration of this state.

The downtime of equipment may occur as a consequence of break downs, accidental damages, planned maintenance work, modification and waiting for service and/or spare parts.

Records of downtime are information which enable the preventive maintenance manager to assess the condition of machines, operators performance and effectiveness of maintenance tasks and to predict the future need for spare parts. This assessment must be done periodically and

whenever downtime of a particular machine becomes irregular.

In the following example use of downtime records is shown:

A company operates 70 hours per week. There are 10 machines involved in the operation. Their running time has been recorded to be 720 hours in a period of one month. Assuming that the records of downtime (DT) for the machines in that period to be 340 hours, then the availability (Aval) and utilization (Utlz) of the machines in a period of one month operation of the company can be calculated as follows:

The operational time as the base time for calculation equals

70 Hours X 4 Weeks X 10 Machines = 2800 Hours

$$\% \text{ DT} = \frac{\text{Downtime}}{\text{Base Time}} \times 100\ \% = \frac{340}{2800} \times 100\% = 12\%$$

Availability of machines = Base time - Downtime
= 2800 - 340 = 2460 Hours

$$\% \text{ Aval} = \frac{\text{Aval Time}}{\text{Base Time}} \times 100\% = \frac{2460}{2800} \times 100\% = 88\%$$

$$\% \text{ Utlz} = \frac{\text{Utlz Time}}{\text{Base Time}} \times 100\% = \frac{720}{2800} \times 100\% = 25.7\%$$

$$\% \text{ DT per Running Hours} = \frac{\text{Downtime}}{\text{Running Hours}} \times 100\%$$

$$= \frac{340}{720} \times 100\% = 47.2\%$$

2-7 WORK CONTROLS

Preventive maintenance activities need to be controlled. To do work control, systems should be created. The systems should be able to control work orders, work performance, spare parts consumption and storage, technical performance of equipment and personnel.

The control of work can be done either manually through cards or via computer software. To select either one of the methods depends on the number of activities and extent of work.

The work order system is created to have control over the maintenance jobs. This system consists of logging and assigning all the jobs with a specific number. The number is then used to initiate work assignment follow-up and for historical reference.

In developing a system to measure the work performance, preparation of a work plan prior to the commencement of each year is necessary. The plan should include budgeted money, manhours, spare parts and their costs and locations of consumptions. However a physical inspection prior to the development of the plan is needed. This will provide indications for the major jobs that should be planned. After completion of the work, evaluations must be made. To see the performance of the planned job one must calculate

the actual costs and then compare them with the planned ones.

To create control over spares and their use a good and reliable system is required. The system should plan for inventory control, sources and methods of procurement, withdrawals control, provisions and procurement of parts at emergency instances. The system must also plan for identifying the type of equipment to which the part applies.

Work control is achievable by means of an efficient reporting system in the program. Reporting in fact is a feedback development between those who actually do the work and those who manage the system. In this respect reports should include information on:

- completed work
- work not completed and reasons for not completing the work
- list of defects (if any)
- spare parts consumed
- time devoted to the work
- remarks and recommendations

2-8 RECORD KEEPING

The quality of preventive maintenance work is improved via good record keeping. Keeping records of the work helps the program use the history of the machines for better diagnosis and fault finding, machine failure patterns, spare parts consumption, making decisions for machine replacements and many other practical purposes.

Each item of machines and equipment must be provided with a file. When new machines are purchased all the information pertaining to them must be kept in the files.

The filed information should include manufacturing data and part numbers, maintenance manuals, instruction manuals and so on. Also, all the servicing and repairs carried out during the machines and equipment lifetimes must be recorded and kept in the files. The files must be periodically reviewed by the maintenance engineer to monitor the conditions of the machines and suggest changes if necessary.

Records can be kept in card files or on computers. Selection of a method for record keeping depends on the number of assets and extent of maintenance work. No matter what method is employed, any record keeping system should contain:

- useful information
- easily storable information
- easily retrievable information, and should be
- capable of easy comparability and trendability

2-9 PREVENTIVE MAINTENANCE ORGANIZATION

Implementing a planned preventive maintenance program demands organization of manpower resources in the best possible way. The structure of such an organization must be designed to suit specific working environments and also to fulfill the economic requirements of the administration.

Many maintenance managers prefer to have a variety of skills available in their schedules to speed up the operation. This is an ideal preference but from the point of view of economy, labor and work control it may raise problems.

To reduce maintenance costs and to improve control qualities, when planning an organizational structure,

grades of tasks and skills must be taken into consideration and based on those, job descriptions have to be developed. One way to improve these conditions is to make use of multi-skilled maintenance staff for all preventive maintenance tasks.

The maintenance organization can be very complex or very simple. It primarily depends on the amount and type of equipment to be maintained.

Figure 2.5 shows a basic organization of manpower resources for preventive maintenance tasks. As it is seen from the figure, this organization is made up of managerial and practical staff. In these respects there are certain qualifications and responsibilities that each group of staff must bear.

As a practical example, figure 2.6 shows an organizational chart of the maintenance department of the port of Seattle.

2-9-1 QUALIFICATIONS AND RESPONSIBILITIES

a- MANAGERS

The Preventive Maintenance Manager is the leader of the organization and is totally responsible for the completion of all the maintenance tasks and related matters, maintenance planning, organizing, controlling and implementing. He must understand the nature and functions of preventive maintenance and its relations with production. He also must have a good background in management and engineering.

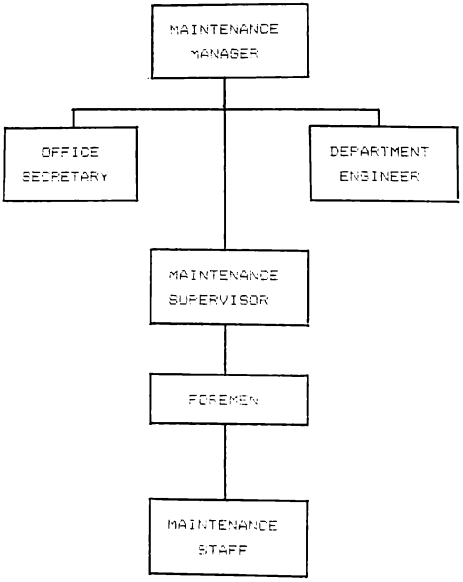


Figure 2.5 BASIC ORGANIZATION OF MANPOWER

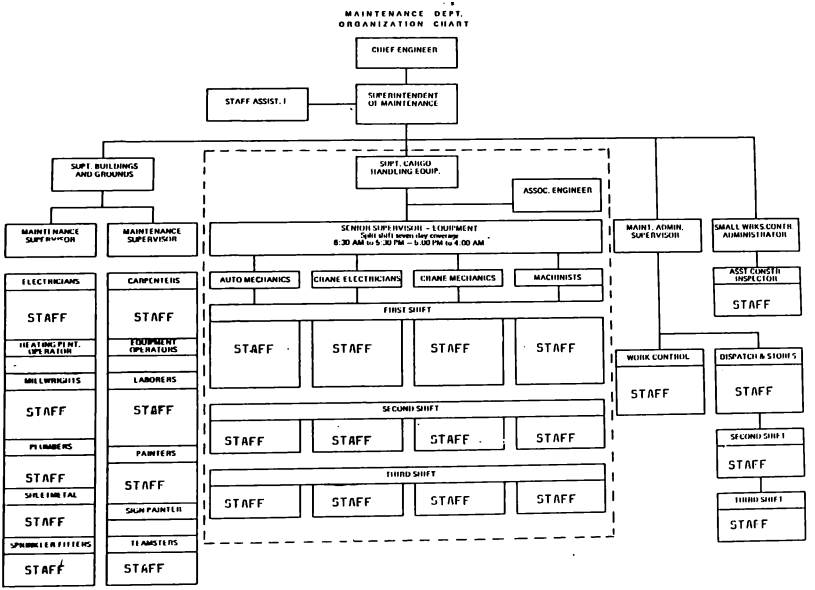


Figure 2.6 ORGANIZATION CHART OF PORT OF SEATTLE (US)

b- ENGINEERS

The Department Engineer is the individual in the management section who is responsible for solving technical problems in his department. He is expected to help the maintenance supervisor in estimating and ordering spare parts, inspecting machines and writing reports. For his qualifications, he must have an academic background with practical experience in the field.

C- SUPERVISORS

The Maintenance Supervisor is the person in charge of the progress of maintenance operations. He must ensure the implementation of the schedules and running conditions of machineries, understand the standards to be met, and have an interest in maximizing the efficiency and qualifications of the persons selected to do particular jobs.

There are different methods to have personnel responsible as supervisors. One method is to have individual supervisors for specific skills in the program. For example, one for electrical work, one for mechanical work and so on. The advantage of such method is that the supervisors can become specialists in their fields of work.

Another method is to have individual supervisors for particular areas or types of work, i.e. lift-trucks, cranes, etc. This method also has advantages and disadvantages. The advantage is that the responsibility of specific areas is transferred to one person. The disadvantage of this method, which is also applicable to the previous method, is that if operations are performed on different shifts or on a continuous basis then the

actual control and coordination of work becomes poor when a particular supervisor is absent.

One other method is to appoint a supervisor responsible for all the skills and areas of work. The main advantage of this method is that the supervisor has full authority and conflicts in priorities and responsibilities do not exist. However, there are two disadvantages to this system. One is that the supervisor must know about all the maintenance tasks; therefore he may lose control over the details. The other is that in times of failures or other problems he is the only person that will be blamed.

A person for a supervisory position must hold certain qualifications. He must have a general education and practical experience in the performance of at least one preventive maintenance task. He must have served as a foreman for some period of time. He ought to have technical knowledge and be able to read and understand diagrams, drawings and manuals. He is required to some extent to have management knowledge for directing and leading the foremen and other related personnel.

d- FOREMEN

The Foremen are the personnel in the lower management level who are in charge of practical works, coordinating and directing the preventive maintenance staff. In this position personnel must have a general education with practical experience in diagnosing technical problems, and repairing and operating machines. He must be able to read and understand technical drawings, diagrams and manufacturers manuals and maintenance recommendations.

e- STAFF

The Preventive Maintenance Staff are personnel who are responsible for the actual performance of preventive maintenance tasks. They take orders from their foremen and work according to the work orders (work cards) or work schedules. They must be fully aware of the operational functions of machines to be able to pinpoint malfunctions and unusual behavior of machines and related equipment. They also have to be properly trained for doing minor repairs and adjustments.

2-10 MAINTENANCE ECONOMY

Plants and business organizations always look for economic solutions to improve the profitability of their operations. An area of major expenditure is the cost of operational maintenance. Unfortunately some organizations do not deal with this problem meticulously. The budgets for repair and maintenance jobs are considered according to their own past experience. This is obviously a good approach but they should also look for the future expected usage, inflation, major expenditures and goals when setting budgets.

The budget may have to be revised from time to time during the year as situations change. It should be broken into categories by equipment type, locations, and where possible, by type of work performed, i.e. modifications, failure and repair.

The managers must spend sufficient time to sense the real value of maintenance tasks since it directly affects the productivity and profitability of the total operations.

Managers can realize the maintenance values if they are

provided with the values in numerical figures. If these figures are put into cost benefit calculations a genuine sense for cost effectiveness and interpretation for economy of maintenance is established.

The maintenance costs are divided into two groups of direct and indirect costs. The following costs are usually regarded as direct maintenance costs:

a- Personnel (labor) costs for those carrying out the maintenance work. These include wages and salaries.
b- Material and spares costs. These are the costs for spare parts, lubricants and other materials which are consumed in connection with maintenance.
c- Administration costs.
d- Purchased Services costs. These are the costs of work carried out by third parties, contractors or companies.
e- Premises and equipment costs.

The indirect costs include lost production, loss of profit due to delay or stoppage and non-availability of operational services.

For better economic results of maintenance activities, direct and indirect costs must be equated. There are many methods for equating the two costs. Figure 2.7 indicates the principle of the overall maintenance cost determination. This figure is an optimized one and with the help of such figures the managers are able to forecast the maintenance costs and set up optimum maintenance policies.

To evaluate maintenance performance in numerical values, the Corder's Maintenance Efficiency Index can be used (Clifton pg.149). This formula only produces a

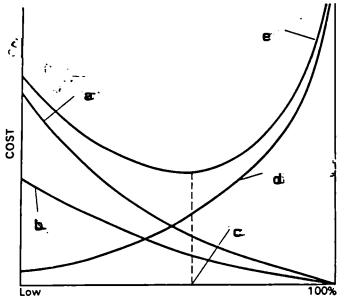


Fig. 2. 7 Mode of determining overall maintenance cost

a = Direct (corrective) maintenance cost + indirect (loss of production) maintenance cost

b = Direct (corrective) maintenance cost

c = Optimum availability

d = Direct (preventive) maintenance cost

e = Total maintenance cost

comparative measure for efficiency. For absolute values other methods must be used.

Corder's Maintenance Efficiency Index :

$$E = \frac{K}{xC + yL + zW}$$

E = Index of Maintenance Efficiency. In the base year it will take a value of 100. Values over 100 indicate improvement of efficiency and values less than 100 refer to undesirable results of maintenance jobs.

K = a constant which has a value of 100 for the base year.

C = total cost of maintenance, expressed in percentage of the replacement value of the plant and equipment.

L = downtime due to maintenance, expressed in percentage of the scheduled production hours.

W = waste of materials caused by maintenance, expressed in percentage of total output at certain stage of process.

x = total cost of maintenance in the base year.

y = total cost of lost time due to maintenance in the base year.

z = total cost of production at a given stage of process in the base year.

The following example illustrates the use of the "Corder's Maintenance Efficiency Index".

Example:

The Maintenance Department of port X provides maintenance services for cargo handling machineries. The manager of the maintenance department was asked to measure his department's maintenance efficiency for budgetary and cost effectiveness purposes.

Solution:

The following steps were taken by the manager:

Step I:

Data Collection:

The operational and maintenance costs were collected from year 1989 (base year) and year 1990:

Total value of maintenance equipment = $ 1000000.00
Total maintenance cost in year 1990 = $ 100000.00
Total maintenance cost in year 1989 = $ 90000.00

Total port operational hours in year 1990 = 3200
Total downtime due to maintenance causes in year 1990 = 70

Total cost of lost time (demurrage, opportunity costs,...etc.) due to maintenance causes in year 1989 = $200000.00

There is no waste of materials caused as a result of maintenance responsibility due to the nature of the service.

Step II:

Calculations:

The Corder's Maintenance Efficiency Index is:

E=100/((90000)*(100000/1000000)+(200000)*(70/3200)+0)

E=1.06%

Step III:

Analysis:

The above index suggested that little improvement was made (the E value is greater than 1) as compared to the base year.

Step IV:

Recommendations:

The following request and recommendations were made by the manager:

a. BUDGET:
Last year's budget plus inflation

b.CONTINUOUS IMPROVEMENT PLAN:
To develop and implement a comprehensive improvement plan to reduce downtime and the opportunity costs by focusing on training and installing a computerized inventory control system.

2-10-1 PREVENTIVE MAINTENANCE AND ECONOMY

Increases in preventive maintenance causes reduction of repair costs and increases in production.

Increased preventive maintenance requires extra personnel, equipment and facilities and other services which are cost demanding. But on the other hand too great an increase may result in interference with production. It may cause the production to be delayed or stopped. In such a case the loss of production is added to the total costs and will affect the balance of overall economy of the operation.

To prevent the imbalance of economy, performance of certain amounts of corrective maintenance and optimization of the program is essential.

In figure 2.8 increases in preventive maintenance and its effect on overall economy are shown.

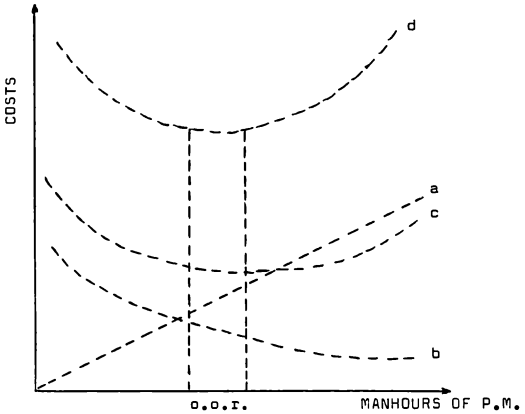


Figure 2.8 PREVENTIVE MAINTENANCE AND ITS EFFECT ON OVERALL ECONOMY

a= Cost of carried out P.M.
b= Repair cost
c= Revenue loss due to operational shutdowns
d= Total result (a+b+c)
o.o.r. = Optimum Overall Result

CHAPTER THREE

TRAINING IN PREVENTIVE MAINTENANCE

3-1 INTRODUCTION

With the advancement of technology and the introduction of new machinery and equipment, the need for training of new skills and updating and upgrading the knowledge of the work force becomes essential. The maintenance work force as well as other sectors of the port must satisfy the requirements of technical knowledge to be able to keep up with the changes in technology.

A reliable and well organized maintenance program demands the support of a viable training scheme so that not only technical awareness is gained, but also the productivity and profitability of the port is maintained as well.

There are many methods and disciplines through which the productivity and profitability are achievable. Prevention of wasted tools and spare parts, improvement in technical communication, efficient utilization of resources, increases in general safety measures and efficient management programs can be counted as some means for improvement of efficiency and consequently the productivity and profitability that are only attainable with a reliable training program.

3-2 OBJECTIVES OF TRAINING

Training is a never-ending process and it should be continuous in one way or another during a worker's career. It is one intervention that can be used to close the gap between actual performance and desired performance. The

objectives of training can vary according to the goals of the organization. Thus to meet the goals the objectives must be explained to personnel at all levels.

The objectives and aims of training can be listed as follows:

a- increase understanding, technical knowledge and skills for introduction of new ideas and techniques
b- improvement in efficiency
c- increase morale and job satisfaction
d- increase personnel potentials which ease their promotion within the organization
e- establishment of commitments and motivations

3-3 TYPES OF TRAINING

The training program must be so designed that it covers all levels of the maintenance staff. Managers, engineers, technicians, inspectors, electricians, mechanics and helpers all must be trained and kept up to date. The type and level of training for each group may differ from one another but they primarily depend on the goals and policies of organizations (companies).

When considering a training program, a needs analysis plays a major role. This task is considered as the basic step for training development activity. It provides the actual facts and reasoning as to whether a need exists for training.

There are different levels of training for personnel: formal and informal. The formal training at practical level consists of manufacturers' courses, government and college courses. The informal training includes on-the-job training and practical experience, and training through manuals and audio-visual media.

Considering the above as the basis for selecting a suitable program, the following three training programs are suggested to be implemented regularly and according to the circumstances:

1- training for new skills
2- training of manpower for multidisciplinary job purposes
3- training for fault finding and repairs

Of course the implementation of these programs requires the cooperation of the training department and the support of the management of the ports.

In the next section the procedure for developing courses for training programs is introduced. However, there are courses which suit the programs. E.N. White (pgs.93-100) offers a large number of courses for improvement of maintenance programs. The following is a list of some of the relevant courses suggested for the three training programs discussed:

- technical communications: terminology, catalogs, manuals, drawings
- combustion and propulsion
- hydraulics and pneumatics
- fault diagnosis
- repair techniques
- electricity and electronics
- general safety
- introduction to computers and computer applications

- introduction to terotechnology: management, finance, engineering
- staff development and management
- maintenance management
- skills development

3-3-1 TRAINING FOR NEW SKILLS

Ports use equipment and machinery with new technology on a regular basis. Consequently the need to have maintenance staff equipped with proper knowledge and new skills becomes essential. Realizing this fact, it is important to foresee the needs and take appropriate actions long ahead of time. The types of skills, number of skilled personnel in the fields and areas of need should be specified and then a proper solution as regards to staff is sought.

One way to satisfy the needs is to employ skilled personnel in the fields. But it is obvious that due to various factors this is not always possible.

Another solution for the maintenance management would be to train the currently engaged personnel in the fields of necessity.

In this respect training can be done in two ways, on-the-job training with the assistance of professionals from manufacturers and suppliers side, and training in advance through designed courses for the needed skills.

It is important to bear in mind that once the necessary skills are developed, those skills must continuously be updated and examined. This is to assure that the efficiency of the maintenance program is maintained and the objectives are met.

3-3-2 TRAINING OF MANPOWER FOR MULTIDISCIPLINARY JOB PURPOSES

Developing an ideal standard for staffing a maintenance program that satisfies both economy and practice is not an easy task. Over-staffing and under-staffing can create difficulties, whereas properly manning a maintenance program is almost impossible. Consequently, depending on circumstances, job allocations become a hard task to perform. This is a result of an inadequate number of personnel on the program chart due to economical and administrative reasons.

One way to solve this paradox is through the development of multidisciplinary manpower with a well-thought and well-organized training program.

In order to start this program, job descriptions must be formulated so that the skills within the maintenance program will fit in effectively. A training curriculum with the consideration of internal and external sources for theory and practice, variety of skills, levels of education and talent must also be developed. Finally, the program must be scheduled so that the current functions of the maintenance program do not suffer any losses due to unavailability of skilled personnel on the jobs.

The internal sources can be considered as any of the following items within the company or organization:

a) staff with higher educational capacity
b) staff with sufficient job experience and background
c) staff with the abilities in (a) and (b)
d) tools, equipment, machines and other facilities

The external sources can be the expertise, equipment and facilities of other companies, organizations and

technical institutions which can be available through agreements or contracts. Other major external sources can be manufacturers and suppliers of machines and equipment that mostly are responsible for training of the operators and maintenance staff.

Skills have to be verified and studied carefully to pinpoint the deficiencies and weaknesses to be improved during the program.

3-3-3 TRAINING FOR FAULT FINDING AND REPAIRS

Fault finding, diagnosis and correctly performed repair jobs are the major areas of attention in well-organized maintenance programs. Repair work must be led by fault finding and thorough fault diagnosis procedures in order to save manpower and spare parts. The reliability of a repair job depends solely on understanding of the problem(s). To achieve an efficient result from any repair job, the maintenance staff must be provided with training programs that present the techniques for fault finding, diagnosis and repair operations on an interval basis.

Decisions on the areas of emphasis, periods of training and contents of the programs depend on the need of the maintenance department in the present and the future and must be made by the maintenance management.

In the following, a number of courses suggested by E.N. White (pgs.96-98), which are suitable for such programs, are illustrated:

- basic principles of machines
- parts recognition
- drawings and manual reading
- use of charts and tables
- use of hand tools and workshop facilities

- recognition of faults and defects
- fault diagnosis
- methods of repair and maintainability
- application of computers in maintenance program

3-4 COURSE DEVELOPMENT

When developing courses for a maintenance program the average level of knowledge, educational background and capability of understanding for each individual must be considered. Also the contents of each course have to be selected in accordance with the needs of the specific maintenance program.

To meet these requirements and ensure the effectiveness and efficiency of training for satisfaction of the related maintenance job certain steps (phases) need to be considered. Analysis, design, development, implementation and evaluation are the major steps of the process.

ANALYSIS PHASE

Analysis involves the examination of an objective, event and item for making particular decisions. The conduction of analysis procedures establishes a manageable foundation for a training development project, ensures that the training will be effective and efficient, and is relevant to the job. In the analysis phase the following items are considered:

a- job analysis
b- selection of tasks for training
c- job-aid analysis
d- target population analysis
e- conduction of task analysis

f- conduction of course content analysis

DESIGN PHASE

The design phase includes identification of skills and strategies for developing teaching items. The following items have to be considered in this phase:

a- development of objectives of the course
b- development of test items to observe whether the course has met the objectives
c- development of instructional strategy to identify the methods of approach
d- development of instructional plan
e- development of course curriculum

DEVELOPMENT PHASE

The development phase consists of items which are useful for identifying the course materials. It involves items such as:

a- reviewing the existing materials relevant to the course curriculum item
b- development of courseware materials (materials that facilitate teaching)
c- validating the designed course materials

IMPLEMENTATION PHASE

This phase of the process is actually the conduction of instructions. It provides information as to how the

lectures have to be performed and how the instructors should act.

EVALUATION PHASE

The final part of the process is the evaluation phase. This phase is to measure how well the training is developed and implemented, and how effective it is for the job. It provides feedback required for revising, improving, or verifying the training.

There are two types of evaluation: internal evaluation and external evaluation.

CHAPTER FOUR

COMPUTERS IN PREVENTIVE MAINTENANCE

The rapid progress in micro-electronics in the last decade has had a lot of effects on improvements of computer technology. Nowadays computers have remarkable applications in all branches of science and technology. It is a tool that provides useful information by solving complex problems.

In the industrialized countries, computer applications have already passed the infancy stage and have reached further developments. Many of the newly industrialized countries have found it very beneficial to employ computer-aided technologies to increase their production.

In industry, computers have developed many positive prospects. Precision and accuracy, efficiency improvement, faster and better quality production, upgrading production techniques, significant cost reductions and elimination of human factors are the results of the developments.

The maintenance organization as an integral part of the port industry can not be exempted from any of the above mentioned developments. If preventive maintenance is to function efficiently it must be simply updated, flexible and require minimum administration. These requirements can be satisfied by engagement of a computerized system. Of course if a computer system is to be used a thorough study of availability and cost determination of the programs, installation, training and operation have to be done ahead of time.

4-1 FUNCTIONS OF COMPUTER IN MAINTENANCE

Computerized systems can be used for various purposes in maintenance programs. The main objectives can be listed as follows:

1- For maintenance control jobs
   a_ correct activities
   b_ proper frequencies of jobs
   c_ control of quality of maintenance tasks
   d_ allocation of man power for specific tasks

2- For record keeping purposes to
   a_ assess work progress in certain periods
   b_ calculate planned to unplanned work ratios
   c_ calculate downtime periods
   d_ calculate preventive to corrective work ratios
   e_ investigate breakdown and failure causes
   f_ evaluate reliability of particular types of machines
   g_ forecast spare parts consumptions
   h_ detect machine failure patterns
   i_ record defect history and wear trends of particular parts
   j_ evaluate maintenance program costs

3- provision of maintenance job descriptions and instructions

4- inspection purposes
   a_ intended activities
   b_ priorities
   c_ frequencies of inspections

5- personnel performance and evaluations

6- work load assessments

4-2 COMPUTER SYSTEMS FOR MAINTENANCE

In the early days of computer applications in maintenance programs, powerful and expensive main frame machines were used. The use of such systems made machine applications for the programs expensive and limited. The machines were shared with other departments. Hence the unavailability of the computer machines for performance of on line maintenance operations was a major factor in making their applications less efficient and unreasonable. But today with the introduction of new generations of handy and less expensive computers the problems of cost and unavailability have been resolved to some extent. Now it is possible to dedicate a complete machine for maintenance purposes.

Presently there are four types of computer systems available for maintenance functions (Kelly pgs.187-230):

4-2-1 Systems using main frames

This system is used when large quantities of information must be handled. It is mostly restricted to large organizations which have greater needs for larger systems. Due to its capacity it is usually shared between departments.

In this system the computer is engaged as an electronic filing cabinet. It can analyse large information files if applied properly. The maintenance system is capable of multi-user application through several terminals.

Considering hardware costs and losses due to

limitations when shared with other departments, it becomes an expensive system to operate.

4-2-2 Systems with mini-computers backed up with main frame

This system is a combination of main frame and mini-computer which is economically a cheaper setup to operate. It is a multi-user system and the maintenance functions are on the mini-computer.

Figure 4.1 shows the hardware for the system. As it is seen in the figure, the system consists of a main frame, mini computer and terminals.

The main frame is basically used for main database storage. The mini-computer is used to easily display, update, interrogate and extract information. The amount of information kept on it is limited to the diskdrive capacity. It operates the system in response to on line received instructions and uses data from either its own storage or the main frame database. The execution of on line inputs and outputs are via keyboard and display units (or printer) respectively. The terminals are also used to enter and extract information. The personnel involved in planning find the possibility to utilize the terminals at the central planning and site offices.

In practice this system has been used by one of the largest steel plants in Europe for maintenance jobs. The results of this experience proved that the system has been very strong in work planning, weak on plant control and very weak on cost and availability control (Kelly pg.198).

In the following, the specifications of the hardware used by the European steel plant is given as an example for the system:

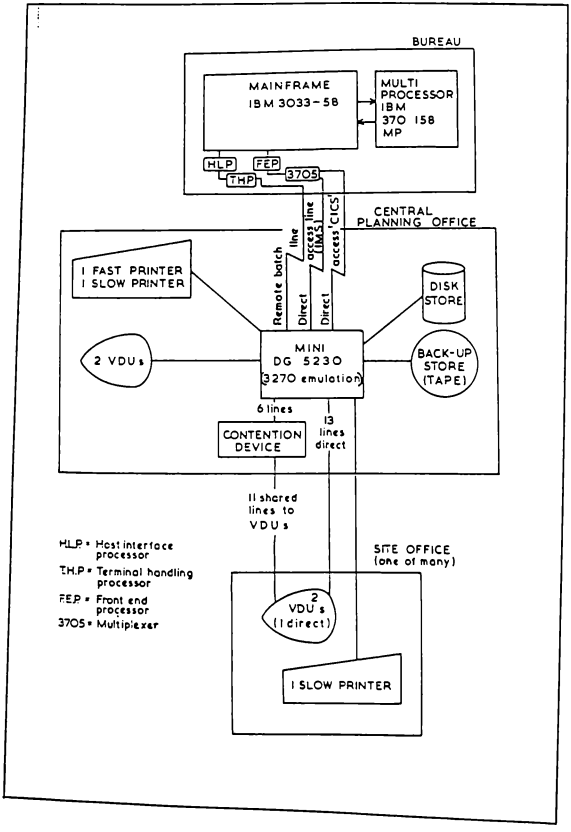


Fig. 4.1 HARDWARE SYSTEM OF MINI—COMPUTER BACKED UP WITH MAIN FRAME

MAIN FRAME

IBM 3033-S8 backed up by a 370/158 multiprocessor

IBM specifications:

RAM	8 Mbyte core store
disk storage capacity	10200 Mbyte (34 diskette drive units at 300 Mbyte each)
handling capacity	2.5 million instructions per second (mips)

370/158 specifications:

core store	8 Mbyte
handling capacity	1.7 mips

MINI COMPUTER

Data General 5230 with 3270 emulation

core store	384 Kbyte
disk storage	192 Mbyte and a single diskdrive unit (with magnetic tape back up)
printer	fast printer (600 lines per minute)
display units	2 visual display units (VDU)
3270 emulator	for translating messages to IBM terminal

TERMINALS

24 Data General VDUs
12 slow printers (180 characters per second)

SOFTWARE

WEPAC (Works Engineering Planning and Control)

CAPLAR (Computer Assisted Plant Registration)

4-2-3 Micro-computer based system

This is a cheap and easy to operate system designed specially to use a range of Commodore micro computers (system hardware is shown in figure 4.2). It is a single terminal system with limited storage capacity and suitable for planning and control of functions of small maintenance programs. It is also applicable for independent planning and control of sections of large maintenance organizations.

The system uses a Computer Maintenance Control (COMAC) software package. This package consists of five modules- Asset Register, Maintenance Planning, Work Order System, Plant History and Manpower Analysis. It lacks connection to spare parts, drawings and manuals access systems.

The system and the module operating programs are on master floppy diskettes. Additional information can be stored on separate diskettes. The system starts when the master disk is loaded and the user can access the modules through the main menu (figure 4.3). The instructions are given via a keyboard.

4-2-4 Systems using mini-computers

This system has been developed based on the Idhammar Konsult AB manual system and is named TEREMA (Terotechnology, Reliability, Maintenance). The system is primarily preventive maintenance oriented and consists of four main modules_ Information Base, Preventive Maintenance, Work Planning and Technical Analysis. It reduces paper work and motivates maintenance personnel for

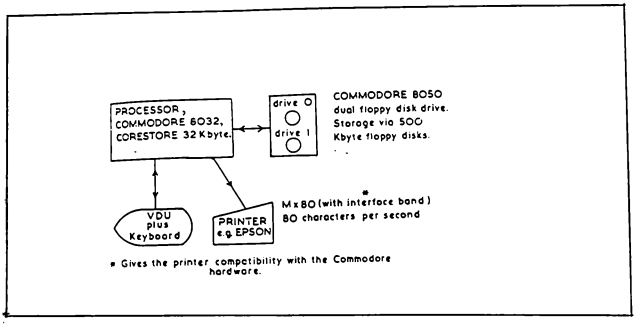


Fig. 4.2 HARDWARE SYTEM FOR COMMODORE MICRO-COMPUTER

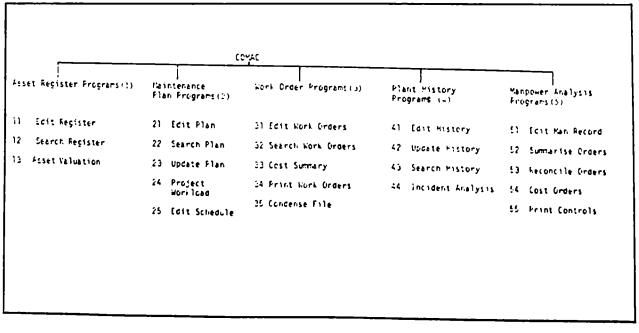


Fig. 4.3 MAIN MENU OF COMAC PROGRAM

feedback by entering data into the computers.

The hardware used by TEREMA consists of a 64 terminal system with Nord mini computers (fig 4.4). The computer terminals are installed in repair shops or production areas for shift maintenance work.

In this system the plant inventory is done in detail. Every item and area is given an identification number (ID). These ID numbers are used for retrieving and entering information purposes. The data is entered via VDUs situated at specified stations. The stored information comprises of Plant Code, Job Priority (from 1 to 5), Comments, Time, Types of Work (electrical, mechanical, etc.). Before start of a job, staff initials and starting time and after completion, reasons of work and actions taken (from menu), comments (up to 2 lines), finishing time and the staff's name are entered by the maintenance staff. This information is then automatically entered to the history of the machine or equipment for future reference.

The computer provides work order lists according to the job priorities and registered times of failures. The lists are then used by the management personnel for job execution and personnel allocations based on the priorities and time. Figure 4.5 shows the operation of the system and figures 4.6 and 4.7 show a main list and a routine inspection list.

4-3 AVAILABLE COMPUTER SOFTWARE PACKAGES

There are many computer packages developed by different suppliers for maintenance job purposes. Table 4.1 introduces some of these packages. Table 4.2 illustrates evaluation of these packages. It is important to note that

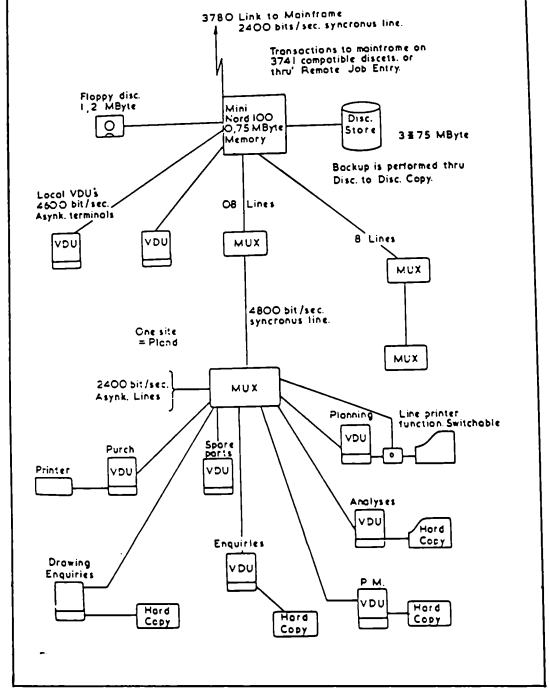


Fig 4.4 HARDWARE OF MINI-COMPUTER SYSTEM

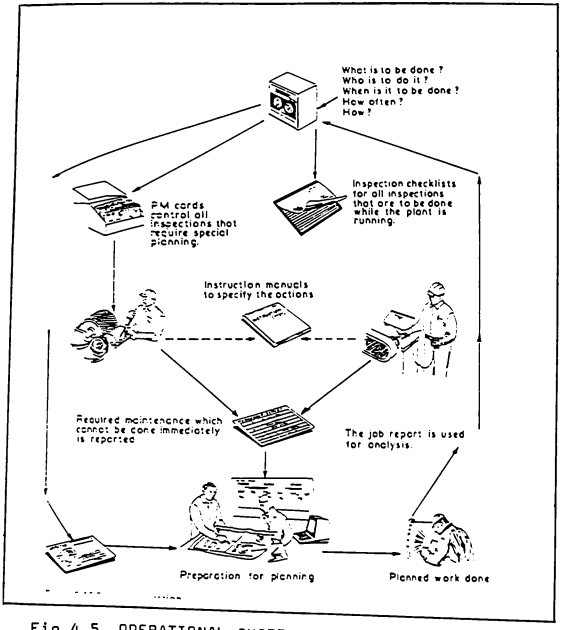


Fig 4.5 OPERATIONAL SYSTEM OF MINI-COMPUTER

PM CO. (05)	MAIN SCHEDULE FOREST INDUSTRY LTD.	PRINTOUT: 1981-01-09 FACTORY: (02) PULP MILL 1		CLASSIFICATION: POSITION NUMBER AREA: (02) DRIER, LINE 4	PAGE.
POS. NO. OWN I.D.NO. INSP. NO.	MACHINE NAME 1 MACHINE NAME 2 MACHINE PART NAME	INTERVAL STOP/OPER.F	CATEGORY DATE	NOTES NO. VOLUME COST ACCOUNT	JOB SPEC.
				INSTRUCTIONS, WORK, ETC.	S-CODE
74-31-7701	White water pump	4	Mech	Bearing temperatures max 75 C, abnormal noise, vibrations, leakage, seal cooling water, shaft glands, mountings	70
74-31-7701 549	White water pump 1st press Electric motor	4	Mech 8123	Motor temperature, abnormal noise, vibration,mountings,moisture, cleaning requirements	001D 44
74-31-7701 M3062 550	White water pump 1st press Electric Motor	26	Elect 8125	Clean and check motor, damaged cables Seals and cable clamps. Check disconnector and starter. Bearing noise	500D 500
74-31-7701 551	White water pump 1st press Coupling	4	Mech 8123	Look for run-out and vibrations. Rubber marks on inside of guard indicate misaligned coupling	22
74-31-7701 552	White water pump 1st press Coupling	52	SP 81101	Inspect coupling rubber element. Measure distance between scribe marks, Max. 8 mm	032S 21
74-31-7701 74-72-0060 553	White water pump 1st press Water Separator	12	M 8123	External inspection of insulation, support devices, pipe connections. Check for leaks or damage	102
74-32-5200	Condensate pump	4	M 8112	Bearing temperatures Max 75 C, abnormal noise, vibrations, leakage, seal cooling water, shaft glands, mountings	110D 70
74-32-5200 12	Condensate pump	520	SM 8101	Pump and motor bearings, spm measurement every three months, see spm system	
74-32-5200 M9412 532	Condensate pump Electric Motor	4	M 8112	Motor temperature, abnormal noise, vibration, mountings, moisture, cleaning requirements	001D 44

Fig 4.6 MAIN LIST

NAME	WIMS	CUBMAS	CUBAC	SAMSON	SAMSON	I.B.M.	PMS	PMIS	Sicon	Vesper	Sicomp	ECL	Microtech
SUPPLIER	ABS	Ronner & Moore	Comac	Davy	Davy	I.B.M.	PMS	P.A.Consultants	Sicon	Vesper Thornecroft	Sicomp	ECL	Microtech
MICRO/MINI	Mini	Mini	Micro	Micro	Mini	Mini	Micro	Micro	Mini	Mini	Mini	Mini	Micro
COMPUTER	ABS MK	Data General	Commodore Pet	Any	HP1000	8100	Any CP/M	Any CP/M	HP3000	9007/Vax	PDP11	2903,MC29	Any
HARDWARE COST	£18,000+	£700,000	£ 2,000	£10,000	£20,000+	£20,000	£5,000+	£7,000	£80,000	£15,000	£20,000+	£30,000	£3,000
SOFTWARE COST	£ 5,000	£100,000	£ 3,000	£15,000	£50,000+	£30,000	£6,000+	£15,000	£70,000	£25,000	£12,000	£11,000	£500
PACKAGE COST	£23,000+	£800,000	£ 5,000	£25,000	£70,000	£100,000	£11,000+	£22,000	£150,000	£40,000	£32,000+	£41,000	£3,500
INVENTORY	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
TECHNICAL INFORMATION	N	Y	N	Y	Y	Y	Y	N	Y	Y	Y	Y	Y
DRAWINGS AND MANUALS REF	N	Y	N	Y	Y	Y	Y	N	Y	Y	N	N	Y
ON-LINE LINK TO SPARES	Y	Y	N	Y	Y	Y	Y	N	Y	Y	Y	Y	Y
INFORMATION ON REPLACEABLE ITEMS	Y	Y	N	Y	Y	Y	Y	N	Y	N	N	Y	N
PRINTED CATALOGUE OR VISIT SCHEDULES	J.C	J.C.	U.S.	J.C.	J.C.	No PR	U.S.	J.C	J.C.	J.C.	J.C	J.C.	U.S
WORK SPECIFYING FACILITY	N	Y	N	N	N	N	N	N	N	Y	N	N	N
MINIMUM WORKING PERIOD	Week	Day	Week	Day	Day	Day	Day	Week	Day	Day	Day	Day	Day
FACILITY FOR JOBS OTHER PARTING	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
FACILITY FOR PRINTING	N	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	N
EMPLOYEE WORK CARDS													
SAVING REPROGRAMMING FACILITY	N	N	N	Y	Y	N	Y	N	N	Y	Y	Y	N
ANALYSIS OF WEEKLY JOBS WEEKS	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	Y
HISTORY RECORD	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y
ONLINE SEARCH AND ANALYSIS	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y
HELP-LIN	N	Y	N	Y	Y	N	Y	N	N	N	Y	Y	N
COST CONTROL	Y	Y	N	Y	Y	N	Y	N	N	Y	Y	Y	Y

Table 4.1 COMPUTERIZED MAINTENANCE PACKAGES

No.	Supplier	Program	(1) Devl Stage	(2) Type of Suppl.	(3) Work Plan	Func. Spares Contr.	Character Maint. Contr.	Info. Base
1	ABS COMPUTERS	WIMS	E	C+S	3	2	3	2
2	AKZO SYSTEMS	BISTRO	E	S+O	3	2	2	0
3	COMAC SYSTEMS	COMAC	L	M	?	0	?	0
4	DAVY	SAMSON	E	C+S	1	0	0	3
5	IBM	DPM	E	C+O	3	2	2	2
		OPMS	F	C+O	0	2	0	3
6	ICL	PMS	E	C	1	4	1	3
7	IDHAMMAR	TEREMA	L	M+S	1	4	3	4
8	IMO	CMMS	L	M	4	3	1	2
9	MAYNARD	MANCOM	L	M	?	0	0	?
10	MOM OFFSHORE	MYRIAD	E	M	?	?	0	?
11	QUARTO		L	M+S	3	3	2	4
12	RIVA	ROMEO	E	S	2	4	2	3
13	SCICON	TEROMAN	L	S+O	4	0	0	3
14	SCOMAGG		E	C	?	0	?	?
15	TRANSCON	COMPASS	F	S	3	4	3	4

Key: 1) F = Fully Developed
L = Largely Developed
E = Limited

2) M = Maintenance Consultant
S = Software House
C = Computer Manufacturer
O = Operating Company

3) 4 = [illegible]
3 = 50% - 75%
2 = 25% - 50%
1 = 25%
0 = nothing
? = data unknown

Table 4.2 EVALUATION OF COMPUTERIZED PACKAGES

PM ROUTINE XI (05)	INSPECTION LIST FOREST INDUSTRY LTD.	PRINTOUT: WEEK 11, 1981 FACTORY: (02) PULP MILL 1	CLASSIFICATION: POSITION NUMBER AREA: (02) DRIER, LINE 4	PAGE 18
POS. NO. OWN I.D.NO. INSP. NO.	MACHINE NAME 1 MACHINE NAME2 MACHINE PART NAME	MAINT. INSTR. STD CODE INTERVAL	INSTRUCTIONS, WORK, ETC.	NOTES NO. VOLUME COST ACCOUNT
74-35-0010- 476	Reject Pump	110D	Bearing temperature max 75 C, abnormal noise, vibration, seal Cooling water, shaft glands, mounting	
74-35-0010 477	Reject Pump Electric Motor	1D 44 4	Motor temperature, abnormal noise, vibration, mountings, moisture, cleaning	
74-83-4430 480	Bird Strainer	255 4	General inspection for damage, cracks, loose bolts, leakage etc.	
74-83-4430 481	Bird Strainer Electric Motor	1D 44 4	Motor temperature, abnormal noise, vibration, mountings, moisture, cleaning	
74-83-4430 483	Bird Strainer Vee-belt drive	13D 116 4	Noise, whipping, oil, belt guard, belt tension, bolts	
74-31-7701 548	White water pump 1st press	70 4	Bearing temperature Max 75C, Abormal noise, vibration, seal cooling water, shaft glands, mounting	
74-31-7701 549	White water pump 1st press Electric motor	001D 44 4	Motor temperature, abnormal noise, vibration, mountings, moisture, cleaning	

Figure 4.7 ROUTINE INSPECTION LIST

selecting the most suitable system and package is not an easy task. Kelly (pgs.226-229) offers some measures to be taken before any decisions are made:

1- Based on the present operating maintenance program (Preventive Maintenance in the case of this paper), the desired condition of the program has to be considered. In this respect factors such as the number of units to be maintained, the extent of information, the number of jobs, the number of work orders per week, the extent of required feedback, the burdens in feedback response, the complexity of the required data analysis, and the amount and extent of required records and history need to be analyzed, studied and considered in the process.

2- With regard to the capabilities of the computerized systems and the costs involved decisions must be made whether the desired conditions are achievable with computerized or manual systems.

3- If the decision is to computerize the maintenance program, the next task is to assess the characteristics, functions and capabilities of the available hardware within the organization (company). Also the possibilities of access to the spares and software packages suitable for the program to achieve the desired conditions must be taken into considerations.

4- If new hardware is to be hired then a survey of the available software packages must be made. During the survey the best available package to match the hardware and satisfy the needs of the program has to be selected. It is not always possible to find the most suitable software package for a maintenance program. In this case

it is necessary either to do modifications on a software package or develop a new package to match the specific program. However these are costly operations and are often not very feasible solutions. The most economical solution would be to introduce minor changes to the maintenance program to match the software package.

5- Since much of the available software is designed for specific types of hardware there sometimes is a necessity to select hardware that suits the software.

Once the system is selected parallel systems have to be maintained for a certain period of time. This should be carried on until the efficiency and effectiveness of the system is proven.

CHAPTER FIVE

MAINTENANCE PROGRAMS IN THE SOUTHERN PORTS OF IRAN

5-1 CURRENT SITUATION

Presently the condition monitoring procedure and maintenance of cargo handling machines and equipment in the southern ports of Iran consist of a combination of repair and maintenance tasks. The tasks are based on break-down, run-to-failure and corrective maintenance schedules. Machines are repaired and inspected whenever they stop functioning due to minor or major mechanical or electrical failures. However, they are put on routine lubrication programs. These programs are believed to be important factors in preventing machines from major breakdowns and prolonging their life times as well.

As a consequence of unscheduled maintenance programs, the number of breakdowns in many cases are remarkably high and sometimes result in sudden disruption of cargo handling operations.

The maintenance tasks are very costly. The tasks demand engagement of large numbers of repair personnel with continuous daily and overtime work. The spare parts in many cases are consumed extravagantly and their costs are extremely high.

The control over the spare parts is dictated by the supply office of the department of finance and administration. That office purchases and stocks the parts and then makes them available to the relevant consumers in the port.

The withdrawal of the parts from the stockrooms is done through the request of the consumer (technical workshops)

and the final approval of the finance and administration department.

The parts inventory and control in the stockrooms in some ports are carried out by computers (PCs). The data is provided to the repair and maintenance office if necessary but the repair shops of that office do not have direct access to the files. However the purchase of the spare parts is done with the request and consultation of the technical department.

Normally the request for purchase of the spares is based on the manufacturers guidance and advice and the consumption rate. Due to various factors in some occasions the availability of spare parts is delayed. The delays cause an increase in down-time periods which naturally increase the indirect costs of current methods of repairs and maintenance work.

All the records and history of the repair and maintenance work are done manually. Individual files have been set up for each machine and the information is added as work is done on the machine. This causes a lot of paperwork and consequently requires extra manpower.

There have been many efforts made to amend the current situation. In some ports contractors have been hired to execute the repair and maintenance jobs under certain conditions. The conditions mainly concern the availability of machines and equipment. In other ports regrouping of skilled and experienced staff have been established but in spite of either method the concept of combination of repair and maintenance still remains unchanged.

In the following some informative data is provided to give a better insight of the situation concerning repairs and maintenance work.

5-2 CONDITIONS OF MACHINES AND EQUIPMENT

Different types of cargo handling machines and equipment exist in the ports. The number for each type varies in different ports depending on the kinds of cargo handled and capacity of each port. In general lift-trucks and mobile cranes with different capacities, gantry cranes, farming tractors, pull-trucks, push-trucks, trolleys, and transtainers are used for cargo handling activities. The equipment mentioned comprise different brands and, to some extent, different manufacturers.

Despite the fact that different categories of cargo handling machines are at the disposal of the ports, inadequacy and inefficiency of machines and equipment in some areas exist. Almost none of the machines are equipped with comfort facilities for the operators as the weather condition is concerned. Some of the machines operating in the ports have been over-worked and their lifespan has exceeded the limits. Operators with few options continue to use the machines and the repairmen continue to repair, sometimes with high costs.

Due to the age of those machines the number of breakdowns and need for repair increases each year. According to the records of the Land Transport and Cargo Handling Repair and Maintenance Office of the Port of Shahid Radjaei during the period of March 1988 to November of 1990 a total of 27813 repair job requests were submitted to the repair shops of that office. Most of the repairs were unexpected incidents which were caused by lack of prior inspections. In table 5.1, each year's job requests are shown separately. It should be noted in the those figures contain the land transport request figures as well.

The presence of such deficiencies are explained in

terms of foreign exchange constraints and government policies on purchase. In this context the authorities have been restricted in procurement, replacement and scrapping of the machineries.

Table 5.2 shows the category and number of cargo handling machines in some of the ports of the country.

YEAR	NUMBER OF JOB REQUEST
MARCH 1988 TO MARCH 1989	10264
MARCH 1989 TO MARCH 1990	10882
MARCH 1990 TO NOVEMBER 1990	6667

Table 5.1 ANNUAL REPAIR JOB REQUESTS

CATEGORY OF MACHINE	NUMBER OF MACHINES IN EACH PORT						
	ABBAS PORTS RADJAEI & BAHONAR	IMAM	BUSHER	CHABAHAR	ANZALI	NOUSHAR	TOTAL
MOBILE CRANE	28	42	13	10	17	15	125
FORK LIFT_TRUCK	74	39	22	20	22	15	192
TRACTOR	54	66	17	22	29	14	250
TOP LIFT_TRUCK	2	2	--	--	--	--	4
TRANSTAINER	3	2	--	--	--	--	5
GANTRY CRANE	--	2	--	--	--	--	2
PULL TRUCK	7	--	--	--	--	--	7
PUSH TRUCK	--	4	--	--	--	--	4
LOADING TROLLEY	155	142	80	54	65	50	546

Table 5.2 CATEGORY AND NUMBER OF CARGO HANDLING MACHINES IN THE PORTS OF IRAN

5-3 TECHNICAL DEPARTMENT ORGANIZATION

The technical department of the ports has the responsibility of repair and maintenance of cargo handling, land transport machines and sea going vessels and other technical jobs. The department is comprised of different divisions. The number of divisions varies from port to port. As shown in figure 5.1 it usually consists of three prominent divisions.

The department is managed by a technical director. He works directly under the supervision of the port manager. He is also responsible for coordination of technical matters with the technical department of the central office of PSO.

Under his supervision, the technical director has department engineers, office personnel and the divisions of the department. Since the prime concern of this paper is the maintenance of cargo handling machines and equipment, only the organization of that division will be introduced.

5-3-1 CARGO HANDLING AND LAND TRANSPORT MACHINERY REPAIR AND MAINTENANCE OFFICE

This office is directly responsible for performance of the repair and maintenance jobs of machines and equipment. It also supervises the operation of the related maintenance contractors.

This office is comprised of one or more (depending on the size of the port and number of machines) repair shops called the divisions of the office.

Each division carries out specific types of work. The repair shop of cargo handling machineries is one division

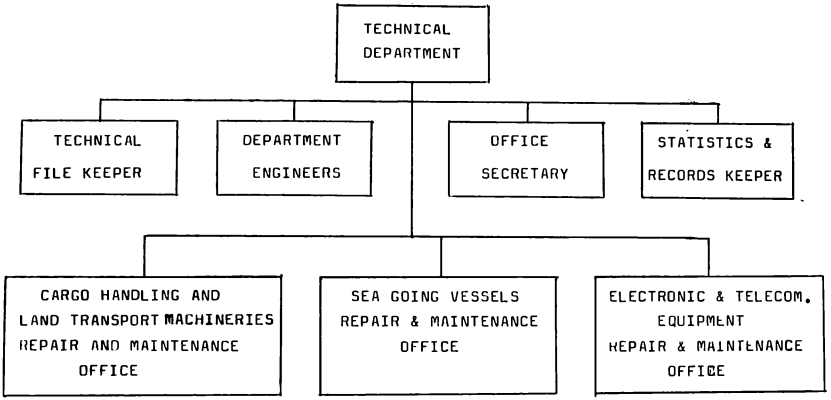


Fig 5.1 ORGANIZATION CHART OF TECHNICAL DEPARTMENT

of this office which shares its workshop with and transport division in some ports. Figure 5.2 shows the layout of the land transport and cargo handling machineries repair and maintenance office.

As was mentioned earlier this office mainly deals with repair jobs and, except for the routine lubrication schedules, the machines are maintained based on corrective and run-to-failure maintenance programs.

The staff to a great extent are technically experienced but as far as their educational background is concerned they are divided in several groups. The younger generation of the staff have good educational background whereas the older generation lack this background.

Due to the age of machineries, unavailability of spare parts at times of need and misoperations, repair work congestions exist. This work load along with the climatic conditions usually result in creation of physical and mental stresses for the staff. This situation causes low efficiency and sometimes misbehavior towards their responsibilities.

5-4 TRAINING

During the past few years great emphasis has been put on training activities within the PSO. The conduct of training activities is the responsibility of the central office for training.

To provide opportunities for the ports to train their staff in the areas of needs and deficiencies training centers have been set up in many of the ports.

According to the training policy of PSO different levels of training are carried out in the centers i.e. on-the-job training, training for newly recruited personnel

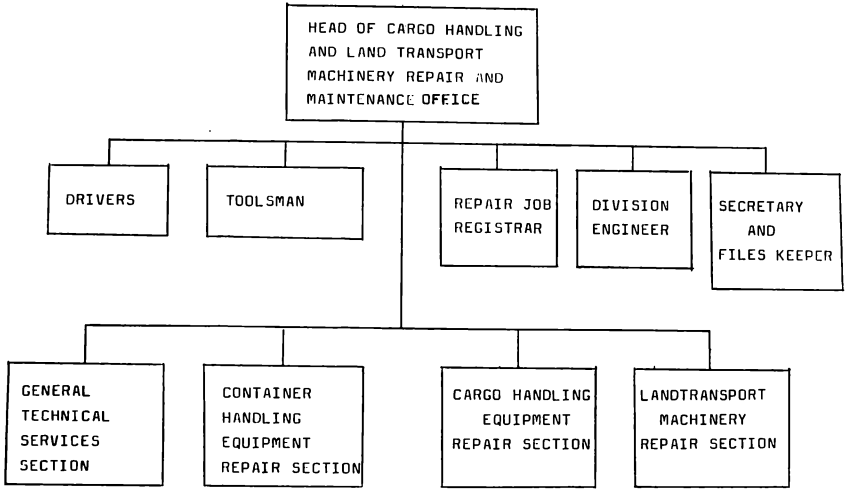


Figure 5.2 Cargo handling and land transport division layout

and training for promotion purposes. Also there are training programs arranged outside the organization for all levels of staff. Such arrangements provide opportunities for personnel at all levels to participate in courses at colleges, institutions and higher technical schools.

There are short term and long term courses offered by the training centers in the ports. The courses are usually in nautical, technical, cargo handling methods, fire fighting and safety.

In the technical field courses in general machineries are offered. Such courses normally cover theory and repair procedure aspects of the subjects. These courses basically are pre-designed courses and are conducted repeatedly.

Although there are training facilities in the ports, the degree of utilization is not so great for technical staff. As a consequence of work loads and other factors the technical staff do not find sufficient time to utilize training facilities. On the other hand, in many occasions due to almost the same reasons, on-the-job training becomes a difficult task to do. As a result, in some of the ports to some extent, insufficiency of training and lack of up-to-date technical knowledge is noticeable.

CHAPTER SIX

STRATEGIES AND RECOMMENDATIONS FOR IMPLEMENTATION OF PREVENTIVE MAINTENANCE IN THE SOUTHERN PORTS OF IRAN

6-1 INTRODUCTION

The southern ports of Iran definitely have a great value to the trade of the country. They provide the means for importation of the needs of the population and exportation of the national products. For this purpose thousands of ships enter those ports and depart from them every year. Therefore the state of readiness of those ports to eliminate delays in handling cargoes is very important. The delays can bring about social and economic consequences. The shortage of food and public needs, the lack of raw materials for industrial activities, and the demurrage charges from the ships can be regarded as the outcomes of the problem.

To increase the country's trade capacity through its seaports, port development and construction programs are underway. Some ports are planned to be extended and some are going to be operating as free ports. Plans to purchase machines and equipment facilities to handle the cargoes and speed up operations are being studied.

All the planning and studies are affected by one unalterable circumstance. That is the weather condition in the southern areas of the country.

The weather in the portal regions is not pleasant. It hampers human activities in certain seasons of the year. It also influences very much the operational potential and conditions of the machines and equipment. It shortens their utilization periods and the mean-time-to-failure

intervals. It also increases the number of breakdowns and repair calls, and shortens machines overall life spans. The machine operators also show less tendency to work with the machines and try to announce them unfunctional whenever they get a chance.

To overcome the difficulties emerging from the weather conditions and increase the availability of the machineries, one might contract out the work. The contract could cover either the cargo handling operations or the maintenance of the machines and equipment or both.

This is done by many ports of the world but the amount of contracted work depends on the objectives and policies of the ports. However for several reasons many ports have chosen not to contract out the maintenance of their machines and equipment. One reason has been for the extra costs charged by the contractors. The other has been the loss of control over work and its actual quality, especially in emergency situations. One other reason has been the requirement for establishing a particular administration for controlling the contractors.

Due to the above reasonings on not contracting out the maintenance of machineries it is suggested that the control over the maintenance activities of the machines and equipment be left directly to the ports. This certainly demands a well planned maintenance program and support of the authorities.

If this decision is made, according to the benefits and advantages of preventive maintenance programs, it is also suggested that such a policy be implemented in the southern ports of Iran. Moreover, it is suggested that an office with the title of Inspection and Preventive Maintenance be created in those ports to do preventive repair jobs. With this plan the current office of Repair and Maintenance would be confined to the repair jobs

introduced by the office of Inspection and Preventive Maintenance and other general repair work.

6-2 IMPLEMENTATION PROCEDURE AND STEPS

The complete implementation of preventive maintenance requires a certain procedure which consists of a series of steps. The steps should be followed and applied based on their priorities and arrangements. The arrangement is important from the point of view of speed of the process and prevention of doubts and unexpected difficulties.

To apply the implementation procedure a good organization of interested and devoted manpower, effective team work, sufficient budget and above all the support of the central management is required.

In the following the steps involved in the process are explained:

6-2-1 INVENTORY AND INSPECTION

As the first step towards the implementation of a preventive maintenance program it is necessary to conduct inventory and inspection jobs to obtain the latest data and information about the existing machines and equipment.

The information collected from the inventory job must provide data such as category of machines, the quantity in each category, brand, location and the technical specifications of the assets that have to be maintained.

Along with performance of the inventory a general inspection has to be carried out. The inspection is essential for determining the latest condition of the machineries. This action must produce information like the amount of repair work, and the types and quantity of spare parts that are required to bring the machines to an

acceptable condition from where the preventive maintenance can follow up. This exercise should also generate data for the other future demands of the program. Those are personnel and the time intervals in the areas which do not agree with the manufacturers recommendations on maintenance.

When the needs are determined a supplementary budget needs to be allocated. The budget must cover the purchasing costs of the necessary parts and materials that are not available in stock and are needed for the initial maintenance repair work.

Having the necessities available, plans should be made for repair work. This work can be done with the assistance of the work force of the present repair and maintenance office. It needs to be carried out prior to the actual start of the preventive maintenance activities and ensures that the machines reach acceptable conditions.

6-2-2 ADMINISTRATIVE WORK

Based on the information gathered from the first step, the next act would be the administrative work. This work should consist of development of an organization chart, writing job descriptions for the positions specified in the chart, setting the policies and goals, writing the preventive maintenance job descriptions, developing a reporting system, and absorbing the qualified personnel for the program.

The organization chart must be developed so that it can fit into the current organization of the technical department. It should consist of all the elements necessary to run the program. Also it should have the potential for the future enlargement of the fleets and further activities if ever intended.

For the purpose of chart development the organization charts shown in chapter two can be used as examples.

The responsibility of every individual for the positions in the organization chart has to be identified by a clear job description. The descriptions must be as complete as possible for prevention of future conflicts and disagreements.

When writing job descriptions, the past practical experience and the assistance from manufacturers and suppliers can be used. The job descriptions must be written on cards and be submitted to the position holder as a reference. They also have to be kept as parts of the policy of the program.

The policy and goals of the program have to be clearly identified and put into writing. The policy must cover all the aspects of preventive maintenance and must be developed with the assistance of the experts in the field.

It should be remembered that the drawn policy has to respect and meet the objectives of the port at which it is implemented and the goals of the PSO.

Once the policy is developed it is the job of the technical department to supervise its implementation and performance.

After the completion of the above mentioned tasks the next move would be to allocate qualified personnel to the key positions.

The personnel with appropriate qualifications can be called from other technical sections within the organization if possible or could be recruited from outside. The recruitment of personnel of course requires certain permissions but one should not forget that the key element to success is to have competent personnel whose qualifications satisfy the standards. In section 2-9-1 the qualifications and responsibilities are explained.

6-2-3 WORKSHOP LOCATION AND DESIGN

The location for a workshop to execute the preventive maintenance work is of a great importance. The preferred location would be of course an area close to the terminals and warehouses, and the areas where cargo handling activities take place. But since those locations are very valuable from the point of revenue for the ports it may not be feasible to locate the maintenance workshop on those premises. However, very remote areas in the port may be very costly from the point of travel time, wear and tear of machines, and the fuel costs. Therefore the best location would be somewhere in the vicinity of the terminals and not too far off the main routes. Moreover since the preventive maintenance workshop will be working closely with other repair shops its location should also be near those workshops as well.

One other main factor in selecting a correct location for maintenance workshop is the distance from the spare parts warehouses. It is preferable to have the spares available in the shop. Since this is not always a practicable exercise the location for the workshop needs to be within a short walking distance from spare parts warehouses.

The design of the workshop itself is very important as well. The design must provide sufficient and separated space for each division in the shop. The office space for managers and supervisors must be accommodated on the second floor from where they will be able to monitor all the activities. The design must also have the capability for incorporating all the necessary tools and equipment for the maintenance tasks.

6-2-4 PROVISION OF TESTING EQUIPMENT

Successful preventive maintenance work needs equipment and tools necessary for the jobs. Most of the tasks of the maintenance work deal with testing and measuring the wear and tear of the parts. Hence one major activity in the implementation of the program would be to provide those testing equipment and tools.

In this respect an ample budget must be allocated to purchase the necessary equipment. To do so a thorough study for the vital tools is essential prior to any action. The equipment can be purchased locally or from other markets. What is important at this stage is the precision and accuracy of the equipment and testing facilities.

Another possibility would be to search for the equipment in other ports or other sectors which deal with such facilities within the same port.

In the case of sophisticated equipment training of the personnel for the proper use of the equipment must not be forgotten. In this case the best would be to train the personnel on the job and while the equipment is in use. However, basic knowledge about the equipment must be introduced to them in advance and prior to the time of hands on training.

6-2-5 COMPUTERIZING MAINTENANCE WORK

The preventive maintenance program needs to be computerized. It can introduce many benefits to the program and definitely to the ports objectives.

Computerization maximizes the efficiency of the program tasks and capability of the personnel and availability of the machines. It reduces the amount of paperwork and

promotes record keeping activities. For more information concerning the computerization benefits several other benefits have been listed in section 4-1.

When decided on computerization, it is necessary to have a parallel manual system until the system is proved and the users feel confident in using it. Also in the beginning of the process care must be taken for the hardware and software selection. It is advisable that the hardware be selected from the same type and brand as the existing ones within the organization if possible. This can generate some advantages. One would be the existence of the familiarity with the system and hence the presence of relatively trained personnel. Other would be the spares and unity of the supplier.

For software selection reference can be made to the list of suppliers at the end of chapter four.

The second step towards computerization would be the explanation of the needs for using computers and developing of motivation in the personnel to utilize the system. At this point training for all levels of personnel who will utilize the system is needed and must be offered. For training of such a group of personnel courses in computer system have to be designed and presented to them according to their need and level of position in the program.

To satisfy the training goals and create motivation the following courses can be suggested (E.N. White pg.98):

- Brief history of computers
- Introduction to computer terminology
- Why computers are used
- The computers as an aid to maintenance
- The computer in feedback analysis

Once the personnel are trained to use and apply the system the next task would be to apply the system. For each individual machine and equipment to be maintained, and any other maintenance related job a file has to be developed.

The entering information into the files must be correct and accurate to eliminate extra future work and confusions. This information could actually be what is collected during the inventory period. For the sake of updating the system as far as the current conditions of the machines are concerned, general surveys are needed to be carried out periodically. Other data could be entered to the system based on the capability and functions of the computer program.

One major concept that has to be considered and applied in the computerized maintenance program is the connection between the spare part warehouse and the preventive maintenance workshop. This is to make information and data relevant to every single item in stock available to the workshop office for better planning.

6-2-6 TRAINING OF THE WORK FORCE

When the work of the preventive maintenance program has begun a monitoring system to watch over the activities of the personnel needs to be established. This of course would be a temporary system and it is produced only to identify the areas of deficiencies of the personnel as well as the maintenance program itself. The results of this work are used to identify the needs and types of training in each field of work and every level of personnel.

The monitoring method should be decided upon by the higher level managers in the technical department with

cooperation of the training department experts.

The members involved in the monitoring system must also be from the managerial sectors. They need to be fully competent in the fields of responsibilities and aware of the objectives and policy of the preventive maintenance program. The monitoring method should be decided by the managers in the higher levels.

When the needs and areas of training are identified then preparations for training program have to begin. The preparation should consist of planning for the time, venue, number of trainees in each group, and contents of training courses.

The planned courses have to be suitable to fill the gap between the actual and desired performance. They have to be designed on the basis of the level and background of the trainees.

For further training related materials the information provided in chapter three is introduced.

6-2-7 UNIFORMITY OF MACHINES

One exercise that can improve and facilitate the maintenance work is to have specialized personnel. This can be achieved in two ways. One way is to hire specialized personnel. Another way is to produce specialized personnel by having them repeat the same profession and the same tasks over their period of service.

In the case of preventive maintenance if the staff perform their duties (maintenance tasks) repeatedly on the same brand and type of machine and equipment they can become specialists in their fields of professions. However job rotation is necessary as a means of training the personnel for emergency situations, promotions, and

production of multipurpose personnel.

To create such a circumstance it is essential to engage and utilize machines and equipment of the same brand for the usual applications in the ports. This may not be a common practice and not always possible but if applicable it may not only produce specialists but can also resolve many other problems like spares and so on.

Considering the above to ease and improve the preventive maintenance tasks it is recommended that when purchasing machines at first machines of the same brand of accepted quality and to be purchased and employed in the ports, and second, action for gradually uniforming the existing machines in each port take place.

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