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*for a sustainable future*

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**MAINTENANCE PLANNING, ITS REQUIREMENTS  
AND IMPLICATIONS**

prepared by

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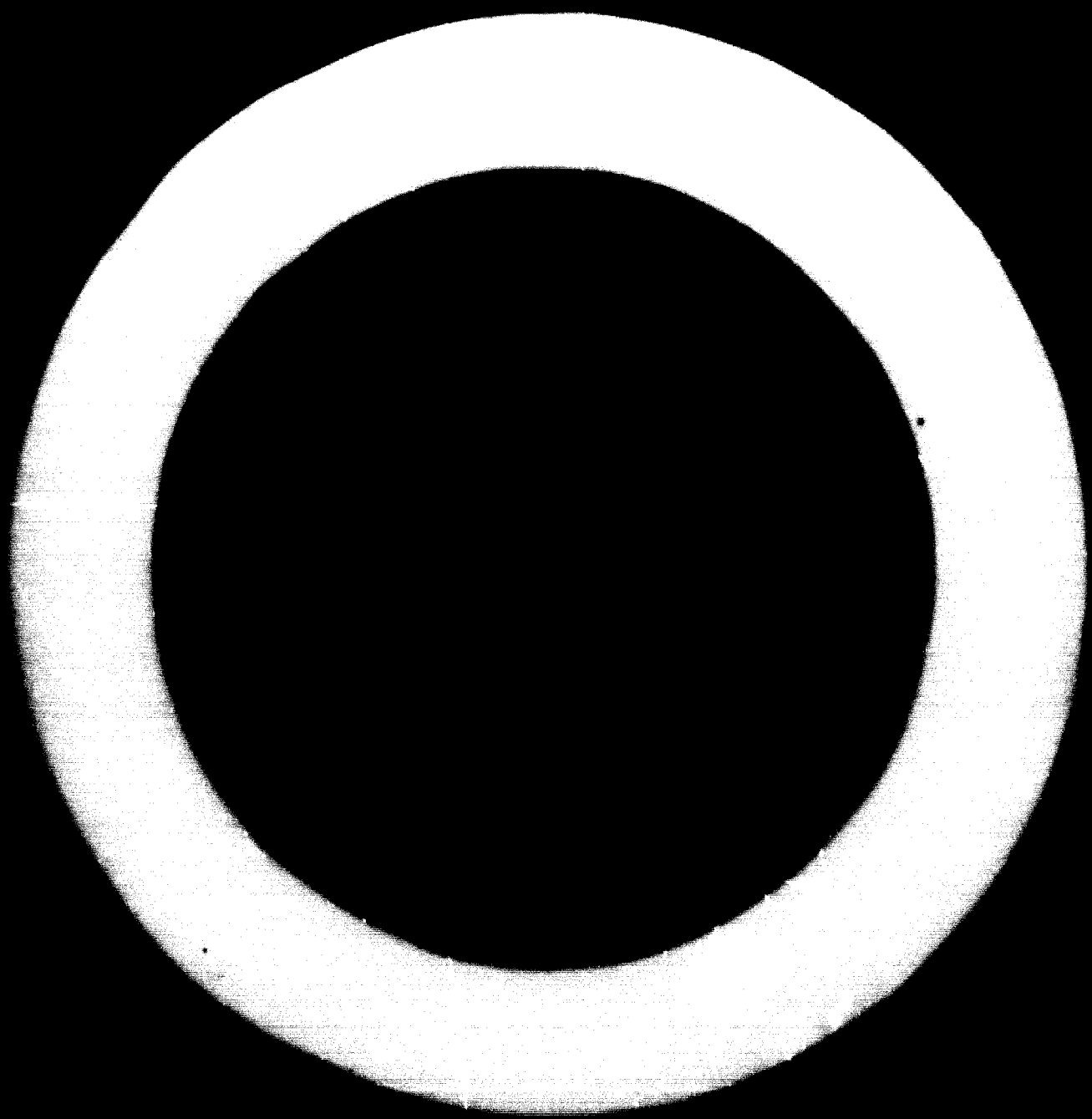
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## Introduction

The symposium you are attending today is a part of a campaign started by the UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION (UNIDO) in 1968, to help developing countries in improving their maintenance and repair facilities. Because of the crucial importance of maintenance and repair to the industrialization and economic development of developing countries, a special attention is being given by UNIDO to this very important aspect of industrial activity in its programme of technical assistance to these countries. An important part of this programme is the creation, within developing countries of a good understanding of maintenance, its objectives and implications so that this problem is handled and approached in the proper way. In addition to the direct technical assistance given to many developing countries, in the field of maintenance, to solve specific problems or help certain enterprises, a series of meetings are planned to spread the right conception of maintenance. A symposium on maintenance and repair in developing countries was held in 1970 in Duisburg, Federal Republic of Germany, in which the various aspects of the problem were tackled in a general way. This is to be followed by a series of regional symposia in each of which one aspect of the problem is to be tackled in depth. The first of this series is the symposium you are attending today, which tackles the planning and managerial aspect. It was decided to start with this aspect, first because of its importance and second because it is generally the most neglected aspect of maintenance activity. Thanks to the generous help and hospitality of the Government of Japan and the invaluable substantive assistance of the Japan Management Association, it was possible to hold this symposium here in Tokyo today.

Maintenance is becoming one of the most important industrial activities both in developing and developed countries. Developed advanced countries have to cope with the continuous striking progress in technology and science which is revolutionizing manufacturing techniques. Developing countries, in their endeavour to foster their economic development, have started industrialisation programmes which is associated with a transfer of advanced technology from the developed countries. In both cases, more machines with more complications are added each year to the equipment stock. The ratio of maintenance to production



cost is increasing continuously and the ratio of maintenance personnel to production personnel is also increasing. Acquisition of such machines is not an end by itself, but a means to attain certain objectives, the most important of these is a reasonable return on the capital invested and a contribution to the advancement and prosperity of the country. However, if these machines are not cared for and handled properly so that they will give the designed performance and output, the result will be catastrophic. In developed countries, with today's very sharp competition, rising labour costs and increasing capital investment per labourer, if enterprises stick to outdated management techniques, particularly in the maintenance field, they will soon be out of business. The situation would be much more critical in developing countries. Here, this does not mean enterprises going out of business, perhaps to be replaced by more efficient and dynamic enterprises, but it will mean the perpetuation of economic stagnation of these countries. If such invested capital is wasted, either by keeping it idle for an unreasonably long time or by diminishing their useful life-span, such investment will become a hindrance to development instead of being an asset to it. It is much more important for developing countries than for developed countries to look after capital equipment and get the maximum out of every dollar invested. Capital is one of the most scarce resources in developing countries and most of them are already in debt as a result of acquiring capital equipment. They can hardly replace capital equipment, renew their stock and acquire new capital to cope with their development programmes. Yet it is noticed that it is in these countries where maintenance is most neglected. It is ironic to notice that capital is wasted in capital-poor countries, while it is much more cared for in capital-rich countries.

## II. Importance of Maintenance

The volume of this aspect of industrialization and the magnitude of the problem can be judged from the following. In 1970, the maintenance bill for 37 major companies in the chemical and allied industries in the United States of America was \$3.76 billion. Taking into consideration that 37 companies comprise only a small part of this industrial sector, we can form an idea of the magnitude in the whole sector. Again, it was estimated in a certain

study that maintenance mismanagement in U.S. in 1958 cost about \$3.2 billion. In a recent study in the United Kingdom, it is estimated that £ 3 billion are spent on maintenance per year, of which £ 1.1 billion in the manufacturing sector alone. Dr. P. Jost of U.K. has quoted, in a recent conference entitled "Saving Cash by Machine Care" that about £ 500 million could be saved by applying available knowledge to wear. We can visualize the magnitude of the savings if only existing knowledge and experience in other fields, such as management techniques, factors affecting equipment design etc. are applied to maintenance practice. In developing countries, it is not unusual to see figures of downtime exceeding 50 percent. No figures are available for maintenance cost in developing countries. However, to give a rough idea of the magnitude of the problem, the fixed capital formation in machinery and transport equipment in 1967 in 18 Latin American countries, 11 Asian countries and 11 African countries is estimated to be about \$4 billion. Assuming cost of maintenance to be about 15 percent of initial cost (in developing countries this is a low figure) the cost of maintenance in these countries per year for the equipment acquired during the year only will be \$1.6 billion. If, due to lack of adequate maintenance control, the cost is increased by, say, 60 percent of this estimation, then about \$ 950 million are wasted in these countries annually only in as much as newly acquired equipment is concerned. Again, if due to inadequate maintenance, one third of the usual useful life of such equipment is lost, then more than \$1.25 billion are wasted for every new addition per year of capital formation. The actual capital wasted would be many times this figure or would be in the range of tens of billions of dollars. These figures are only for 40 countries or a little more than half the number of developing countries. Although such figures give a very rough indication, they give an idea of the magnitude of losses and waste due to lack of maintenance.

It is common belief now that most developing countries would gain more in GDP by spending relatively small sums on the upkeep and care of existing equipment than relatively much larger sums on new investment.

## III. Maintenance Planning and Organization

After indicating the importance of maintenance and the magnitude of its activities, I would like to give a resumé of what is considered as the right approach to maintenance and the role of planning and management in this approach.

After World War II, the spectacular advance in science and technology has revolutionized production techniques; automation, transfer machines, increasing use of electronics are examples of such change. Production management soon discovered that they cannot cope with the complicated production operations and increased volume of production until production operations are adequately planned and controlled. Great advances occurred in this field and production planning and control became a science of very advanced techniques; production planning and control department became one of the most important sections in any industrial enterprise.

However, with the enormous advance in production planning and control, management thought that they are in a position to master all activities; production schedules, costs, etc. Maintenance, even up to a few years ago, was relatively very much neglected. Management attitude was that maintenance is an activity which does not deserve any special attention and it is good enough to assign to it a few technicians and skilled labourers to put machines back into operation if any thing happened to them. The maintenance man was looked at only as a mechanic carrying a couple of spanners and a lubrication can. It is not very long ago when if a technician or labourer did not prove himself in the production line, he was transferred to maintenance.

The idea of management was just to keep machines running. However, with the introduction of quality control which became gradually a highly developed discipline, management realized that it is not enough to just keep equipment running, but they must produce items within close specifications and limits to avoid a high percentage of rejection. It was also realized that repair work must be done quickly to avoid a long downtime and high cost. Management's attitude changed from just keeping the equipment running, to doing the work accurately and quickly. Some serious consideration was then given to maintenance. Repair technicians and labourers were specially trained to handle production machinery properly and special repair tools and equipment were introduced. This was a big improvement in maintenance work at the time. At that stage, all attention was directed to repair operations after failure and management was happy and satisfied when equipment was repaired accurately and quickly when something happened to them. Some sort of planning repair work was introduced, but this was very primitive in nature and was delegated to the fourth or fifth line of management.



With the introduction of more complicated equipment and the increasing market competition, management began to realize that coping with maintenance by just waiting for failure to happen and then handle it quickly and accurately was a suicidal procedure, which resulted in enormous downtime and cost. It was difficult to implement production plans and schedules and to meet market demand and sales termines were impossible simply because no one knew when a machine was going to stop and emergency repairs were in the range of 80 to 90 percent of maintenance work. Again, the sudden stoppage of one machine may stop a complete line of production and perhaps the whole factory and in addition it may cause damage to other equipment and products.

Management conception of maintenance changed from the attitude of coping with failures after they happen to the control of stoppage and failures, the preventive maintenance conception was introduced. The term "Preventive Maintenance" is conceived, up to now, differently by different maintenance experts. However, it entails usually the planning of stopping equipment a little before they are liable to fail, the ultimate aim being that all stoppage should become planned stoppage and not emergency stops. In this way maintenance management will be controlling the machines instead of the machines controlling them. Preventive maintenance techniques and other planned maintenance systems proved to be very successful in reducing downtime and maintenance cost. However, it is still not introduced in many enterprises even in developed countries and is still lacking many supporting activities. It is very important for preventive maintenance programmes and planners to be well acquainted with possible equipment performance under local conditions. They should be aware of any physical changes taking place and the possible timing of equipment stoppage and breakdown. This will enable them to determine when a machine should be stopped long beforehand and can thus plan for it, and in this respect they need supporting activities. The first of these activities is the building up of adequate records of past performance and the establishment of an efficient feedback system, I believe there is room for improvement in this field. The second is what is called "Predictive Maintenance". Many techniques have been developed which help in predicting failures noise and vibration analysis, ultra sonic measurement technique, crack detectors are some of the most important of such techniques. These two supporting activities and others would help planners in working out factual schedules in avoiding failures before they occur and to stop equipment just short of the failure point instead of

loosing too much useful life of the equipment. Predictive techniques also help in avoiding surprises. Although such supporting techniques proved very successful, are not expensive and easy to use, they are still slow in being introduced into industry. It is well known now that visual inspection only is far from being enough and the adoption of monitoring techniques to indicate physical changes and predict failures would lead to better planning and thus to better maintenance performance and more economy.

Although preventive and planned maintenance coupled with efficient repair proved to be useful and helped tremendously in reducing both downtime and cost and minimizing the risk of equipment unplanned stoppage, they satisfy only partially the true objectives of maintenance. Engineers and managers have been paying too much attention to the improvement of plans and preventive maintenance schedules to control the required maintenance work and to improve the efficiency of repair operations, and very little to eliminate maintenance work. In many cases, good planning and adequate repair became ends by themselves. The real aims of maintenance should not be overlooked, these are:

- a) maximum possible availability and readiness of equipment for production;
- b) the longest possible life of equipment;
- c) these should be attained with a minimum of cost.

From the third objective point of view, there is no point in spending money and resources on an action which could be eliminated altogether. Also, I would like to stress that the objective of maintenance is to keep the equipment running with a minimum cost and not in building up proficiency in coping with maintenance work.

The new attitude towards maintenance is to eliminate technically maintenance work as much as it is economically possible, then apply an efficient repair and planned and preventive maintenance systems to maintenance work which could not be eliminated. This is generally called "maintenance prevention". According to this conception, maintenance starts with equipment ordering and design and plant layout. Paying enough attention to these at this stage from the maintenance point of view, will result in elimination of a lot of future headaches and an appreciable savings. In this connection, management would be interested in two aspects:

- a) that the equipment runs for the longest possible time before failure occurs. This is called machine reliability;
- b) when failure occurs, equipment is brought back to normal running condition in the shortest possible time and with minimum of resources, this is called maintainability of equipment.

Equipment reliability and maintainability, both together determine the availability of equipment for production, which is the ultimate aim of maintenance. These aspects of maintenance will be covered in the third and fourth days of this symposium. In the plant layout, enough attention should be given to equipment accessibility so that they can be reached and maintained easily. Pipe network layout is an example of how future maintenance work can be made easy and how much time could be saved if maintenance management takes a part in planning of such layouts.

Maintenance prevention continues after equipment is installed and actually producing. When a failure occurs, it is not enough to repair the equipment and return it to its original working condition. It is much more important to study carefully the reason of the failure in order either to eliminate it completely in the future or prolong the time between failures. Unfortunately, many would still hesitate to establish a technical unit to study failures, they think it is too expensive. These usually forget or are not aware that future savings which could be achieved by the avoidance of failures are perhaps ten times bigger than the cost of the technical unit.

#### IV. Maintenance Planning Requirements

Unfortunately, we are far off from the time when all maintenance work could be avoided or all stoppage could be planned well, this is the dream of the future. Even if this could be achieved technically, it would be too expensive economically. Maintenance operations in the field are that a combination of maintenance prevention, preventive and other planned maintenance and repair work. Maintenance planning and management should cover the whole range from the ordering of equipment and start of design to the actual repair when equipment is in production, it should thus entail the following:

- 1) Ordering stage: At this stage, management responsibility is to see that past records of equipment in the field and the experience of the maintenance personnel is made use of in order to have the optimum design and specifications and plant layout from the maintenance point of view. Decisions made at this stage would influence the profitability of the enterprise during the whole lifetime of equipment. The cost of maintenance during the lifetime of equipment varies from 80 to 300 percent of the initial cost; eliminating part of this at this stage would result in an appreciable saving.

Equipment reliability should be scrutinized carefully and the optimum level balancing the cost of increasing equipment reliability and gains due to increased availability and cost of maintenance should be decided upon. Increasing equipment reliability means, in most cases, increasing initial cost. A point is reached where the further increase in equipment cost due to increasing equipment reliability is not matched by an equivalent decrease in maintenance cost and increased profitability. This would be the optimum level of reliability. This level of reliability is very much affected by local conditions. In many developing countries where skilled labour is scarce and spare parts are expensive and difficult to get, it may be a wise policy to look for a higher level of reliability with higher initial cost. Saving on initial cost does not mean only increased maintenance which could not be done by available means, but also a great loss in production. The more expensive equipment may prove to be the cheapest for the country in the long run.

Maintainability of machinery is another aspect which should be studied very carefully. Unfortunately, many designers up to now direct almost all of their attention to design from the production point of view and very little attention is paid to the accessibility of parts if repair is needed. In some cases, half the engine has to be dismantled in order to change a small bearing.

- 2) Maintenance work: This includes the work to be carried out during the lifetime of the equipment and which could not be avoided at the previous stage. It consists of the following:



- a) Planning and scheduling of all necessary routine operations, lubrication, adjustment, etc. This entails the operation to be carried out, who is to do them and when.
- b) A programme of preventive maintenance schedule indicating which machine is to be stopped and at what time, in order to avoid emergency stops. The probable time of equipment failure should be estimated and equipment is stopped a little before failure is supposed to occur. The time the equipment is stopped before the estimated time of failure depends on many factors. The first is the seriousness and probable damage and loss if equipment failed suddenly. In other words the ratio of the equipment life sacrificed for safety varies according to working conditions. In the case of an aeroplane, where the sudden failure of a part means the loss of the whole plane with passengers and crew, or in the case of an equipment whose failure would result in damage to more expensive machinery, stoppage of the whole factory and spoilage of production material, in such cases a high safety should be looked for. The second is the knowledge of technical maintenance personnel of the working conditions and their effect on equipment behaviour. The more it is known about equipment behaviour under working conditions, the more the stoppage of equipment is brought nearer to failure point and this would result in making more use of the equipment and more economy. On the other hand, it is conceived by many that the most economic handling of equipment is to wait until the part actually fails; in this case parts are utilised to the maximum possible. This would be the right conception where the sudden failure or stoppage of one equipment does not affect other parts of the factory, have no harmful consequences and would not make the repair of the machine itself more complicated and difficult. A very important part of maintenance planning and management is to determine

which machine should be allowed to work until they actually fail and which equipment should be stopped, according to a plan, some time before failure is anticipated. This is very important from an economic point of view since preventive maintenance can be overdone.

- c) The establishment of a technical unit. Maintenance prevention should continue after equipment is installed and actually producing. In this case all failures should be analysed carefully in order to avoid their occurrence as much as possible in the future or prolong the periods between failures. From the preventive maintenance point of view and to help planners in establishing factual and more economical plans and schedules, it is important to have as much knowledge as possible about equipment behaviour and to follow up any physical changes taking place. With such knowledge at hand, planners would be able to know more about the timing of equipment stoppage and can bring the equipment stoppage nearer to failure point with the same degree of safety. Visual inspection is not enough and monitoring equipment such as noise and vibrations analyses etc. should be used. The saving and increase in production which would result from establishing such a unit will be much more than the cost of the technical unit itself with its competent staff and equipment.
- d) The establishment of an efficient costing system. Management means the collection of facts and the choice between alternatives based on these facts in order to attain ultimate objectives. Maintenance management would be working completely in the dark without an adequate costing system which would inform them where money is going and an adequate technical office which would inform them what is happening to the equipment. The subject of maintenance costing will be discussed during the fourth day. In the past, costing reports and data were prepared for management from the production point of view. It is high



time that they also be prepared from the maintenance point of view so that maintenance management could make use of them. Management should look at maintenance costing not from the narrow angle of scrutinizing direct maintenance costs, but from the wide angle of the total cost of the enterprise. An increasing direct maintenance cost which would result in an increase in the enterprise profitability is a good sign and not a bad one as many managers would consider it to be.

- e) Maintenance control. Contrary to the belief of many managers, maintenance could be adequately controlled and a control system is very necessary as a part of maintenance organization. Many systems have been developed such as standard maintenance timing and sampling techniques. In this respect, maintenance management has a lot to learn from techniques already developed and applied successfully in production activities. This subject of applying production management techniques to maintenance will be discussed in the second day.

Part of maintenance control is the follow-up and measurement of maintenance efficiency. This will also be discussed in the third day. In this respect maintenance management should always keep in mind that the ultimate aim is to maximize the enterprise's profitability. Maintenance costs would increase with increasing equipment availability, but this is more than compensated by the decrease in the cost of downtime. However, a point is usually reached when a further increase in equipment availability is not compensated by an equal further decrease in maintenance cost. This would be the right level of maintenance activity and equipment availability. Putting in more resources to improve equipment availability beyond this level would result in a decrease in profitability. Over-maintenance is as harmful as under-maintenance and management should guard itself in making maintenance an end by itself and it is one of the major responsibilities and decisions of maintenance management to determine the optimum level of maintenance activities. Such decision is actually a compromise

between direct maintenance cost and downtime cost, the sum of the two should be minimized. While direct maintenance cost is a function of the activity within the enterprise, downtime cost depends on market conditions. There would be no downtime cost if the enterprise would not be able to see the goods which would have been produced during this downtime. This implies that maintenance management's policy is very much influenced by market conditions. Maintenance managers should not detach themselves from the commercial field and look at themselves as purely technicians. It is also the duty of the top management to see that maintenance management is continuously acquainted with the varying market conditions in order to fulfill their duty properly.

- f) **Personnel.** Any organization is as good as the calibre of the personnel handling it. It is the maintenance management's responsibility to see that the maintenance department has the right personnel in number and quality at all levels, from the managerial level, the supervisory level to the technicians and skilled labour levels. Training programmes should be established and use should be made of other training facilities in the country. Training and the formation of maintenance personnel takes time and a plan should be made to cope not only with present demand, but also with future demands in continuously changing market and technology.
- 3) **Repair and adjustment work:** Good planning and management is of little use unless it is accompanied by good implementation. An important part of this implementation is the actual repair, overhaul and adjustment of equipment when this is needed either according to planned work or emergency stoppage. In this respect the following is required:
- a) An efficient spare parts and repair material procurement, storage and flow within the enterprise. It is not only important to control the stock so that it makes parts available in the stores, when required and does not pose a financial burden on the enterprise due to overstock, it is also very important that the part or material is dispatched

speedily to the right place at the right time when it is required for a repair operation. An appreciable savings in time and maintenance cost is obtained by paying attention to the ordering system from the stores and quick response to it.

- b) The time has gone when maintenance work can be carried out by a couple of spanners and an oil can. Maintenance management should see to it that the maintenance department is adequately supplied with the machines and tools necessary for the job. Equipment of today needs special equipment for dismantling and adjustment and also for quick diagnosis. Technical data and information about all equipment should also be made available. It is wrong management policy to try to economize on these items.
- c) Repair work and even emergency operations can be planned with great benefit to the enterprise in cost and time saving. This is particularly true for major shutdowns and major overhauls. It is important that management organize who is doing what in an emergency and who is responsible for planning and controlling emergency work.

The above gives a bird's eye view of the objectives and the activities entailed in maintenance planning and management. To conclude, I would like to pass on some general remarks.

Management and planning does not only deal with what is required to be done today or tomorrow, but it would deal much more with what is to be done today to cope with the tasks of the future. In the field of maintenance, this is of particular importance because of the rapid change in technology and production equipment.

Maintenance management should stop looking at themselves and their work as an entirely engineering job. They should start associating themselves with management techniques and stop hating paperwork. Better engineering is certainly needed, but it should be complementary and not a substitute for management. Good maintenance management will guarantee good maintenance engineering, but good engineering does not guarantee good management.

First step towards good maintenance management is the adoption of the right attitude by the management of the enterprise. They should become aware that maintenance is as important as a cost saving area as any other, and perhaps more. They should give the maintenance management personnel and particularly the maintenance head the status he deserves and he requires to cope with his duties. They should include him in top management committees and be acquainted, like other managers with the commercial side of the company's activity and the market conditions.

The exposition given above on maintenance management and planning may give the idea that a complicated system is required with unnecessary paperwork. The set up of a maintenance organization is determined by the size of the plant and the variety and nature of engineering and operating problems. The system may vary from a computerized system in a very large company to a simple chart in a two or three machine shop. The important thing is to remember that true aims of the maintenance activity and to avoid the pitfall of making maintenance an aim in itself.





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