UNIT 6 PRINCIPLES OF MAINTENANCE

Structure

6.1 INTRODUCTION

Planned maintenance is the method of ensuring that maintenance requirements of equipment, plant, services and utilities are adequately covered. Ideally, all maintenance should be of the preventive nature and that planned maintenance should meet this requirement.

The process of deterioration is often so slow that it passes unnoticed unless observed by systematic maintenance at stated intervals. Most equipment failures start from minor causes which can be readily eliminated if their presence is known. An equipment which requires very little maintenance is more liable to major breakdown, due to complete neglect, than an equipment in which many minor faults demand continued vigilance. Systematic maintenance on a scheduled basis will, by its regularity, prevent such conditions fully developing and, at the same time, control the expenditure of money on the equipment, so that they are maintained at optimum production level for the minimum cost.

Besides maintenance planning from an engineering standpoint, there are two other major considerations for introducing planned maintenance, namely, (1) need for effective utilisation of manpower and resources, and (2) possibility of reducing maintenance costs. Whatever one's maintenance responsibility, it is worthwhile to carry out a review of one's activities to ensure that the maintenance programme is adequate, and that labour and resources are effectively utilised. This means planning control of maintenance activity. It is known that the greatest single reason for failure of any planned maintenance programme is the error of not establishing a reliable control method.

Objectives

By the end of this unit, you would be able to explain what is meant by

- routine maintenance,
- periodical maintenance,
- preventive maintenance,
- maintenance after breakdown,
- maintenance records,

- major repairs and overhauling,
- replacement of components,
- replacement of equipment, and
- maintenance of tyres, batteries and wire ropes.

6.2 ROUTINE MAINTENANCE

The backbone of any planned maintenance programme is the effective utilisation of maintenance routines. The most commonly used routines are :

1) Examination at a set frequency with subsequent defect reports and work orders.
2) Examination at a set frequency with immediate rectification of minor defects and a report on major work necessary to be done on work orders.
3) Systematic withdrawal of equipment for major overhaul.
4) Replacement of functional parts at prescribed intervals.
5) Scheduled lubrication and cleaning.
6) Spares scheduling and stock control.

A fully comprehensive planned maintenance programme will provide for the following :

1) Detailed examination and listing of each section of the equipment to determine what has to be done and when it should be done.
2) Work classification by trade.
3) Individual and group man-hour requirements by trade.
4) Organisation of material and labour for individual jobs, job priorities and overall shop loading.
5) Preparation of master overhaul, inspection and lubrication schedules for each item of the maintenance inventory.
6) The integration of the preventive maintenance programme with other maintenance work so that it becomes part of the overall planned programme.
7) The provision of maintenance records including breakdown reports and cost allocations, from which decisions on equipment replacement, service frequency, spares and manning requirements can be made.

Generally, the programme will be so designed that, having built up a work-load by trade against requirements, these requirements are translated into a shop loading which can be controlled.

SAQ 1

i) What are the most commonly adopted maintenance routines?

ii) What does a comprehensive planned maintenance programme offer?

6.3 PERIODICAL MAINTENANCE

Equipment manufacturers assist organisations in developing a planned maintenance programme. What the manufacturer cannot do, is to establish and carry out the necessary controls. This is done by the organisation owning and using the equipment.

The main control needed for any maintenance system is a planned and effectively carried out periodic and systematic inspection of all the mechanical equipment. The aims of inspections are as listed below:

1) Ensure that proper preventive maintenance services are being performed by the user group or section.
2) Determine the action to be referred to higher management in order to assist units, sections of groups in improving maintenance.

3) Instruct each user unit, section or group in correction of deficiencies in the maintenance procedures, and in the utilisation of current maintenance literature.

4) Ensure the correct use of equipment and compliance with the organisation's maintenance principle.

5) Determine the adequacy and effectiveness of the user units, their technical personnel maintenance practices and of tools, and other facilities.

6) Ascertain equipment serviceability and anticipate future maintenance and supply requirements.

The importance of inspections cannot be overemphasised. Inspections are designed to set and maintain high standards of maintenance of equipment and also of the user personnel. Separate inspection schedules shall be ensured for each item of equipment.

6.3.1 Four Major Types of Inspections

In some respects maintenance in an organisation is in competition with operations. Maintenance takes time and frequently there is a tendency to delay maintenance in favour of getting a few more hours of use of the equipment. Such a practice, if allowed to flourish, leads to rapid breakdown of the total maintenance system for mechanical equipment. All types of inspections require time. Very often this time is classified as lost by those charged with operation and production. It is not so. It has been established beyond doubt, however, that absence of a rigid programme for effective control through inspections is false economy.

Mechanical equipment in many organisations is difficult to maintain because of its wide variety, special nature, different makes and models, and frequently because of its heavy use. The following are some of the indications to suggest that the maintenance system and its control are incomplete and need a change.

1) The practice of cannibalisation, i.e., taking parts from one unit to keep others operating.

2) Repair work done by untrained personnel.

3) Equipment user-units trying to accumulate parts, more than authorised, both in type and quantity.

4) Units not provided with trained operators, mechanics, tools, supplies or repair scheduled work.

5) Sacrificing routine maintenance in order to meet operation deadlines. Delay of routine maintenance can only seriously limit a unit's future capability to accomplish scheduled work and can cause reduction in useful life of equipment.

6) Lack of clearly defined support responsibilities, each unit, section or group using equipment must know at all times who is supporting it with technical maintenance services, parts, replacement equipment, etc.

The overall maintenance system is always in need of attention. Managers must constantly feel the pulse of the organisation's mechanical equipment and initiate change when need for the change is indicated. A thorough, well planned and well carried out maintenance system kept in proper control through inspections is the only way to ensure a full and fair return on the large sums that the organisation spends on its tools. Regular inspection and audits are desired.

There are four basic types of inspections to be planned and effectively executed within an organisation's equipment maintenance system. Each type of inspection has its own specific objectives and provides necessary information to specific individuals in the management group of the organisation. The four types are referred as A, B, C and D types.

A-type Inspections

These are spot-check inspections carried out by a "fact finding" top management representative or personnel. Such inspections are to determine the adequacy and effectiveness of maintenance at various levels within the organisation.

The scope of these inspections includes a systematic inspection of the administrative procedures of the facilities, tools, equipment and personnel provided, and a technical

inspection (Type D inspection described later) of at least 10 % of each type of equipment assigned for use by each unit, section or group within the organisation. Generally, A-type inspections are scheduled by top management staff at least twice annually and therefore include each year in all a technical inspection (Type D) on 20 % of the user unit's equipment. The equipment inspected is selected at random by the inspection team.

The equipment-user team is not notified as to when the inspection will he held. Results of an A-inspection are immediately a matter of record to the top management, who then are in a position to evaluate the end results of the maintenance system and its effectiveness. Such information is vital to the top management in order to change policies, redesign systems, tighten other controls, etc. to ensure total effectiveness of the system.

B-type Inspections

These inspections are formal inspections at regular periodic intervals conducted by the immediate manager or supervisor of a mechanical equipment user-unit or section. Such inspections are also held by the intermediary management charged with mechanical equipment use and maintenance within the area of responsibility. The frequency of such inspections is generally determined by a general top management policy and is dependent largely on :

a) type of equipment,

b) its maintenance requirements, and

c) maintenance results.

Organisations may schedule Type B inspection of motor vehicles, construction equipment and other similar types of motorised equipment on a monthly basis. In many respects the B-inspection is a formalised system of periodically taking a good look at one's own operations as far as equipment preventive maintenance is concerned.

C-type Inspections

This inspection is similar in nature to Type B except that it is informal in nature. It is conducted only by the equipment user-unit as a check on itself and means of determining by a immediate supervisor that the operating and maintenance personnel immediately under him are effectively performing their assigned preventive maintenance responsibilities. Organisations, particularly those that operate sizable vehicle fleets should have well developed C-type inspection procedure.

D-type Inspections

The D-type inspection is a technical inspection. The purpose of this inspection is to assess serviceability and predictive maintenance and exchange requirements. Deficiencies noted in these inspections serve as a means of detecting failure in early stages, preventing major breakdowns, overhauls and the overloading of maintenance, and repair shops and services. The life of the equipment is prolonged and the operating efficiency improved by the early detection in case of neglect or malpractice.

Complete D-type inspections (technical inspections) consist of thorough examination and tests of equipment to determine: the serviceability, completeness and readiness of the equipment for intended use; and whether an item of equipment should be continued in service or withdrawn for overhaul or replaced. Technical inspection may take the form of the examinations and tests of the equipment under conditions of normal or abnormal use to discover causes of deficiencies in the field.

It is essential that D-type inspections are carried out by highly competent and well trained technical staff. Generally, such technical inspectors serve on a staff role attached to middle and top managers. The information gathered from D-type inspections is immediately made available at the lower level, to the equipment user-unit supervisor and at the higher level, to the superiors. Frequently, the inspection report becomes the basis for writing up a repair work order. If too many deficiencies appear on D-type inspections, they may indicate a need to look critically at :

a) personnel assignments, and

b) competency of the equipment user-unit and its supervisory managers.

Equipment manufacturers' technical representatives can be of assistance to an organisation in planning and setting up D-type inspection procedures for each type and kind of mechanical equipment. It, however, is the responsibility of the management to administer the inspection system and secure the help that such representatives can render to the organisation.

SAQ 2

i) What are the objectives of carrying out inspections?

ii) Name the four major types of inspections.

iii) What are the indications that a maintenance system and its control are incomplete and a change is needed ?

6.4 PREVENTIVE MAINTENANCE

Preventive maintenance includes all types of planned maintenance works performed in order to prevent breakdowns, ensure optimum production by the equipment and extend its life. By reducing the chances of downtime it helps increasing production and keeping operating costs low. Thus, it has two principle objectives: technical, which ensures breakdown-free operation and ensures optimum life of equipment, and financial which reduces costs by reducing downtime. A sound programme of preventive maintenance gives less downtime, few large scale and recurring repairs, low repair cost due to timely action, less overtime wages to maintenance and repair staff, and better spare parts inventory control.

It must be mentioned that very elaborate preventive maintenance programme may result in unduly high cost, thereby offsetting much of the advantage in cost reduction in equipment production. Each project should fix its own standards of preventive maintenance consistent with the objective of safety and performance to get optimum results. The need for proper planning is, therefore, apparent.

Planning for preventive maintenance begins with an assessment of scheduled maintenance of every machine from daily to yearly maintenance requirement. Based on this assessment the requirements, of men, material, tool and spare parts are worked out so that these things can be arranged in time. Workshop and stores facilities are essential in the planning for preventive maintenance.

An efficient preventive maintenance programme should be well planned and organised. It should be systematic and thorough, and adherence to it should be ensured through proper supervision. The personnel employed on this programme should be skilled and devoted to duty. All necessary materials and tools, including spare parts should be available as also the maintenance manuals, charts, etc. supplied by manufacturers of equipment. Adequate workshop facilities, as also mobile servicing units should be arranged.

An important aspect of equipment selection is the ease and simplicity of its maintenance while in use. The built-in maintenance features of the machine should be looked for while buying a piece of equipment. The design features which are compatible with overall economy in running, maintenance and repairs are conducive to low cost operation. A machine fitted with life-time lubricated bearings would reduce maintenance effort to a great extent as compared to another machine with conventional bearings requiring lubrication every 8 or 16 hours. Under powered and overloaded equipment increases maintenance requirement.

SAQ 3

i) What is preventive maintenance and what are its principle objectives ?

ii) How will you plan for preventive maintenance ?

iii) What do you understand by efficient preventive maintenance ?

6.5 MAINTENANCE AFTER BREAKDOWN

When unexpected failure occurs, speed is the essential factor, the repair being carried out during production working hours and probably continuing into an evening- or night-shift, leading to high labour costs with, possibly, little supervision. Some people make the faulty assumption that the cost of the breakdown is the only cost incurred in getting the equipment back into service, but, in fact, the true cost is considerably higher. To the direct cost of the repair must be added the on-costs of wages paid to idle operatives, the cost of production spoiled and the cost of production lost. It will also follow that the magnitude of the breakdown repairs is greater than if the rectification had been carried out under controlled conditions, so preventing premature failure. Furthermore, if spare parts are not immediately available in the event of an unexpected breakdown, one may face the extra costs of sub-contracting production of a lengthy period of shutdown if necessary while the spare parts are manufactured and fitted.

When these additional costs are added to the emergency repair cost in terms of material and labour, the cost of the breakdown can be quite substantial. It can, therefore, be stated that normally, unless an item of equipment is so situated that it will not interrupt the equipment production, breakdown maintenance is inherently, inefficient on all accounts, creating an indeterminate workload on the maintenance staff and there is no justification for its continuance in construction. Even in the case of many of the uncritical units it may be cheaper to bring them under a planned schedule of replacement than to allow them to run to ultimate failure.

SAQ 4

i) **What are the essentials of maintenance after breakdown?**

ii) **What are your objections to breakdown maintenance?**

6.6 MAINTENANCE RECORDS

The operation of an effective maintenance records system provides the following information :

1) The percentage of planned work achieved in the period.
2) The ratio of planned to unplanned work.
3) Downtime for the period.
4) Ratio of preventive work to corrective work.
5) Maintenance requirement comparisons between individual equipment, between types of equipment, or between groups of equipment.
6) Indicators for reliability of the products of particular manufacturers.
7) Trends in spare parts consumption.
8) Equipment failure patterns.
9) Performance detail for personnel, by individual or by trade group.
10) Materials used, for guidance on re-stocking policies.
11) Indicators on possible standardisation policies.
12) POL consumption.
13) Cumulative hours equipment in service.

Records are kept in many different ways, ranging from card files to computer data stores. The labour required for updating records or work done can only be justified if use is made of the information. If a computer is used, lengthy printout sheets can be time consuming also. However, the computer is a useful tool for providing summary information on a regular basis so that trends can be observed. Whatever system of record is used, detailed investigations have to be reserved for individual equipment for which the cost is justified.

In a simple system a practical level of recording is obtained by writing on the actual work

their predecessors' comments. This can be useful in passing on the defect history or wear trends. Other simple systems provide for the issue of new cards each time but for upto 6 or 10 of the complete cards to be retained in the control office at any time to give short history record. Thus, with a 2-monthly activity, the continued retention of 6 cards would produce a 1-year history. These systems do not provide detailed financial records, which would be provided on separate cards or as a function of the construction equipment accounts department.

SAQ 5

i) What information do you obtain from an effective maintenance record system?

ii) How are maintenance records kept?

iii) Can you suggest a simple system to keep record of maintenance carried out on an equipment?

6.7 MAJOR REPAIRS AND OVERHAULING

Major repairs and overhauling are problems faced by a machine owner after an equipment failure, or after normal service life of a machine has been achieved.

Major remedial repair work is needed to restore a component which has failed prematurely due to improper maintenance, lack of inspection and adjustment, or machine abuse. Remedial repairs often are needed immediately .

Proper equipment maintenance and inspection and regular system analysis can hold remedial repair to a minimum. The hydraulic cylinder wiper seal is a good example. Seal wear is unavoidable. Therefore, as one part of preventive maintenance, the wear progress should be monitored and replacements made where necessary. If this is not done, the hydraulic pump, control valve, and cylinder will soon need repair because contaminants will have entered the hydraulic system. In this case, repair of the pump, valve, and cylinder constitutes remedial repair.

Essentially, remedial repair has two objectives: First is rapid return of the equipment to operational condition; second is to determine the reason for failure and make correction to avoid a repeat failure. A typical example is a worn hydraulic pump due to dirt. Replacing the pump without finding and correcting the dirt will result in an early repeat failure. Troubleshooting information available from the equipment manufacturer will help determine the initial cause and contain instructions for correcting the problem.

Generally, major repairs correct premature failures resulting from error or oversight in the preventive maintenance programme. This underlines the importance of a well planned and well executed maintenance.

Equipment overhaul restores the machine to an acceptable level of productivity and availability, and assures it additional normal and predictable wear life.

Overhauling consists of that repair work necessary to restore a machine component to productivity after its normal wear life. In overhauling, individual components and parts are inspected, measured, and tested. Decisions are made to reuse repair and reuse, or replace the parts. The goal is restoration that will assure additional trouble-free performance.

By system analysis and an effective preventive maintenance programme, the need for component overhauls is determined prior to a breakdown. Overhaul work can then be scheduled at an opportune time.

In overhaul, a careful inspection of all parts may reveal impending service needs on other components and systems. Each overhauled component must be tested in operation before it is installed in the machine.

In a complete machine overhaul, not every part will have to be replaced. Each system of the machine should be tested, its condition diagnosed, and remaining service life estimated. When a complete machine overhaul is in process, all wearing parts that will not last for an acceptable time period should be replaced. Thus, parts with some remaining life will be replaced.

SAQ 6

i) When is major remedial repair carried out on an equipment?

ii) How can you hold remedial repair cost to a minimum?

iii) What are the objectives of remedial repairs?

6.8 REPLACEMENT OF COMPONENTS

Component replacement or exchange is a method of rapidly returning the machine to productivity. The principle is simple. The worn or failed component is removed and directly replaced by a unit that was previously rebuilt and tested.

The failed component, in turn, is sent to the service shop and carefully rebuilt, tested, and stored for future replacement needs. Two advantages are obvious: downtime is reduced substantially, and repairs can be made at a time that is convenient.

Large equipment owners and most equipment dealers maintain component replacement inventory which includes major components such as engines and transmissions, and accessory groups such as generators, starters, and pumps.

The price of component replacements is usually based on the actual time and parts needed to restore a failed component to "like new" condition. Since paying overtime can be avoided, it normally costs less than doing the repair work at the time of the failure. In addition, the reduction of equipment downtime makes component replacement the major trend today in equipment repair.

On large earthmoving projects, some users replace engines at regular intervals to assure continuous machine availability. They replace drive trains and transmissions by the same method. Theoretically, through component replacement, the life of a machine could be infinite.

SAQ 7

i) What are the advantages of replacement of components on a construction equipment?

ii) How will you price replacement of components on a machine?

6.9 REPLACEMENT OF EQUIPMENT

When procuring an equipment or a group of equipment for a project, the number and size should be so selected that 75 per cent of the economic life of the equipment is spent on the project. If a fleet larger than the required number is procured the utilisation will be less. However, the maintenance and repairs required will be less. A smaller number of equipment will allow a larger part of the useful life of the equipment to be utilised but the wear and tear and consequent maintenance will increase.

Working on equipment beyond its economic life will reduce the production. If the balance amount of work can be done by the remaining number in the fleet, it should be encouraged so as to minimise cost of procuring additional equipment. However, if a substantial amount of work remains to be done and there is a likelihood of the same equipment finding use on a subsequent project then the spent machine should be replaced by a new one.

Selection of the optimum time at which to replace a piece of construction equipment may greatly increase the profit that the machine returns to its owner. In spite of this, many owners replace equipment rather haphazardly. Typically, these owners replace equipment when it requires major repairs or an overhaul, when extra funds are available for equipment purchase, or when preparing to start a new project.

SAQ 8

i) What happens if an equipment is worked beyond its economic life?

ii) When should an equipment be replaced?

6.10 TYRES, BATTERIES AND WIRE ROPES

The principles of maintenance of tyres, batteries and wire rope if followed would increase the life of the components and also provide better performance. These are discussed briefly in the sub-sections given below.

6.10.1 Maintenance of Tyres

To effect economy in the operation of tyred equipment, it is very essential to make somebody responsible for tyre maintenance. The strength of the crew should be compatible with the number of vehicles under operation and the crew must possess all necessary tools and facilities meant for the purpose as efficient tyre maintenance cannot be carried out without proper tools. Many times tyres get affected in the construction site during operation of the equipment. The repairs may have to be carried at the site of the breakdown in most cases. At other times the tyres may be inspected when the equipment is brought to the workshop for routine maintenance.

For attending to tyre problems in the field it is recommended to have a tyre service truck equipped with loading and unloading arrangement of tyres, and all the tools necessary to dismantle, inflate and assemble the tyres. The inspection and maintenance of tyres includes: inflation pressure; irregular tread wear or cuts; embedded stones, nails, etc., and oil and grease contamination; damaged, bent or distorted rims, locking rings or flanges; tightness of valve cap; etc. Health and safety practices in operation should be encouraged.

6.10.2 Maintenance of Batteries

The battery is to be inspected once each week to make sure all connections are tight. All dust or dirt accumulations from the battery top are removed and the battery is washed clean with water and dried with compressed air. At least once each month the acid on the battery cover and terminals is neutralised with either ammonia or sodium bicarbonate solution. The terminals and metal parts are to be kept free of corrosion.

The level of the electrolyte is checked weekly and any water lost by evaporation is replaced. The electrolyte level is never allowed to drop below the top of the battery plates. (**Caution:** The cells are never overfilled. When replacing distilled water that has evaporated the cells are filled only to the underside of the vent well. Overfilling causes loss of acid, thus reducing battery capacity.)

To ensure that the water is thoroughly mixed with the electrolyte, the battery should be charged after adding water. It is advisable to keep accurate records of the amount of water used and the date of each filling, since the water requirements are an indication of battery overcharging. Battery water should be stored in a covered glass, plastic, earthware or other non-metallic container. Each machine shall be provided with separate battery.

It should be made sure that vent plugs are always kept tightly in place and see that the small gas escape holes do not become clogged. If the plugs need cleaning, they should be stood in clear water for 30 minutes or so.

6.10.3 Maintenance of Wire Ropes

It is important to keep wire ropes properly lubricated because the flexibility of the wire is obtained by the wires moving with respect to each other, and this means there is considerable friction which can be handled satisfactorily only by lubrication to assure long life. Sudden shocks, excessive loads, rust, corrosion and the effects of friction, are the main factors which must be guarded against by the operator.

All wire ropes on excavating machines are exposed to the deteriorating effects of the elements, because the ropes are continually coming in contact with sand, dirt and muck of all kinds. This causes abrasion that is very heavy compared with the normal wear on a rope that can be kept clean.

All ropes should be protected internally as well as externally. Care should be taken to select a lubricant of such consistency that it will work readily into the inside of the rope. Any compound that contains acid or any other substance that will attack the chemical composition of the metal should never be used. It should be noted by the operator that heavy lubricants are more suitable in summer and lighter ones during winter.

If excess wear should be noticed in the rope, the operator should immediately inspect the sheaves of the machine. They may have become badly scored or worn, or been thrown out of alignment. Such a condition will cause undue wear on the rope.

Sudden shock is one of the worst enemies of wire ropes. All ropes have a breaking point, and a sudden shock places an overload on them which exceeds the limit of strain expected from a certain strand.

By turning it end for end the life of a hoisting cable will be increased as the place where it passes over the sheaves will be changed.

Correct methods should be used to unreel and uncoil a wire rope. When unreeling wire rope from a reel, it should be mounted in order that it may revolve, pulling the rope off straight ahead. When in a coil, roll it on the ground like a wheel or hoop. After being used the rope can be coiled or reeled by reversing the above operations.

SAQ 9

i) How will you effect economy in the operation of tyred equipment?

ii) What services do you suggest when tyre problems are to be attended to in the field?

iii) How will you inspect maintenance of batteries on an equipment?

6.11 SUMMARY

In this unit you learnt about various aspects of equipment maintenance. What are the various inspections that are to be carried out and how and when are they to be done have been explained. Maintenance done at periodical intervals keeps the equipment in good working condition which is essential for maintaining sustained progress on the project. Data are to be kept in a proper manner of the various maintenance and repairs carried out on a machine to serve as a historical record. Tyres, batteries and wire ropes are important components of any equipment. In order to maintain a steady rate of production of the equipment they need to be inspected and attended to on a daily basis.

6.12 KEY WORDS

Battery Maintenance : Many batteries have been ruined by improper maintenance. The charge/discharge rates specified by the manufacturer should be observed. In addition to charging maintenance, it is important that all battery terminals be clean. The electrolyte level must be inspected, and any lost electrolyte must be replaced to avoid battery damage.

Breakdown : Failure resulting in the non-availability of an item.

Maintenance Records : Maintenance Records play a number of roles in dissemination of information, sharing the data across all maintenance levels and lines, aiding maintenance personnel and repairing systems.

Overhaul : A comprehensive examination and restoration of an item, or major part thereof, to an acceptable condition.

6.13 ANSWERS TO SAQs

Check answers of all SAQs with respective preceding text.