DEFINITION

Maintenance management is a combination of different skills, including the technical knowledge and experience, necessary to identify maintenance needs and to specify remedies. To apply terotechnology effectively, it also calls for an understanding of the techniques of business management by which data and information may be weighed, and decision made in the light of sound economics.

The basic concepts of maintenance management, as for other forms of management, generally consist of (*a*) setting aims and objectives, (*b*) providing the means of attaining those aims and objectives, and (*c*) decision making.

OBJECTIVES OF MAINTENANCE

The main objectives of maintenance management are as follows:

(*a*) To maximise the availability and reliability of all assets, especially plant, equipment and machinery, and obtain the maximum possible return on investment.

(*b*) To extend the useful life of assets by minimising wear, tear and deterioration;

(*c*) To ensure operational readiness of all equipment at all times required for emergency use, such as standby units, fire-fighting and rescue units, etc; and

(*d*) To ensure the safety of personnel using the facilities.

From the line manager's viewpoint, the reasons for 'improving' maintenance methods include (*i*) protecting the building and plant; (*ii*) increasing utilisation time and reducing down time; (*iii*) economising in the maintenance department; (*iv*) maximising utilisation of resources; (*v*) maintaining a safe installation; (*vi*) preventing waste of tools, spares and materials; and (*vii*) providing cost records for future budgeting.

Keeping in view the trend towards increased mechanisation, computerisation and automation, there will be a new level of responsibility for, and increased dependence upon, the maintainer. For this, some of the reasons are:

(*a*) Increased plant output capacities per unit time, making down time more costly;

(*b*) Dependence on control systems can produce total disruption of output when any machine or element in a process fails; and

(*c*) The possibilities for operator's intervention to compensate for machine errors or failures have decreased.

The demands upon the maintenance department include (*i*) a requirement for new skills in repair of computer-controlled systems, (*ii*) a need for improved multidisciplinary working, and (*iii*) a requirement for a systems approach to maintenance. By adopting systematic maintenance, it is possible to achieve substantial savings in money, material and manpower. Failure or plant breakdown can create problems such as a loss in production time, rescheduling of production, material loss due to sudden breakdown of a process, failure to recover overheads, etc.

SCOPE OF RESPONSIBILITIES

It is possible to group activities and responsibilities of the maintenance department into two general classifications: primary functions that demand daily work by the department; secondary ones assigned to the maintenance department for reasons of expediency, know-how, or precedent.

Primary Functions

The following are the primary functions of the maintenance department:

- Maintenance of existing plant buildings and grounds;
- Repairs and minor alterations to buildings;
- Equipment inspection and lubrication;
- Utilities generation and distribution;
- Alterations and new installations.

Secondary Functions

Secondary functions include the following:

- Storeskeeping;
- Plant protection;

- Waste disposal;
- Salvage;
- Insurance administration;
- Other services.

Care must be taken not to dilute the primary responsibilities of maintenance with those of secondary services. It is important that responsibilities assigned to the maintenance engineering department are clearly defined and that the limits of authority and responsibility be established and agreed upon by all concerned.

MAINTENANCE PRINCIPLES

Maintenance principles remain the same whether a service is provided or the manufacturer and/or assembly of goods is carried out. It is just as important to provide the required environment, internal system of transport, lighting, heating, safety, etc. for an office, factory, hotel, and so on as it is to satisfy the maintenance demands of a complex machine associated with manufacturing processes.

In small units, all the normal requirements of maintenance may be satisfactorily controlled on an adhoc basis by the general manager using a handyman, the local contractor or a specialist from outside the organisation.

Integrated manufacturing plants operating continuous processes/production lines pose a particularly difficult maintenance problem. With such units, there is a demand for an increasingly higher technical support, and for the employment of skilled personnel for maintenance. Where such conditions prevail, they can pose a very demanding management problem necessitating the initiation of an agreed maintenance policy directed by top management. The high wage component of such maintenance work requires to an ever greater extent the examination and comparison of costs, and the decision as to whether maintenance should be fully undertaken by direct labour, or by the use of specialist contract organisations, or by a combination of these factors.

TYPES OF MAINTENANCE

Various forms of maintenance and the relationships among them are shown in Fig. 11.1.

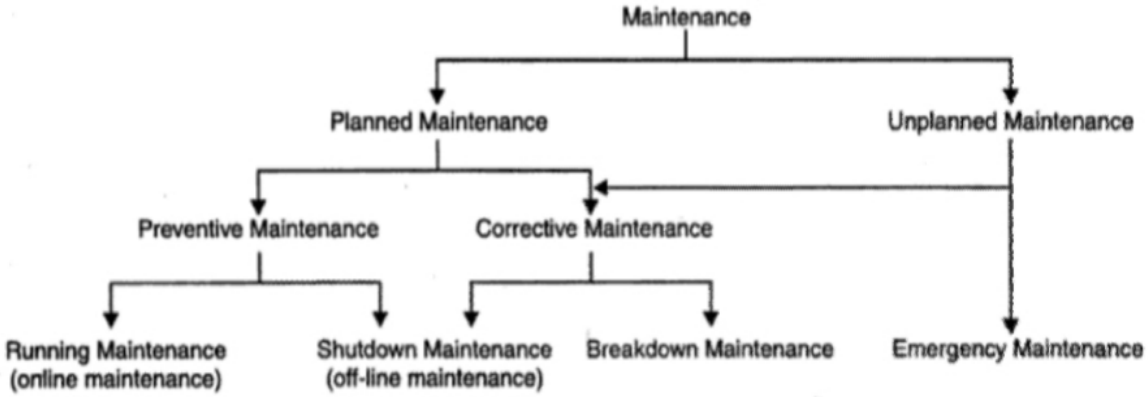

***FIGURE 11.1* Types of maintenance**

The different types of maintenance systems are now defined.

Planned maintenance. The work is organised and carried out with forethought, control and the use of records to a pre-determined plan. This definition is not very explicit and perhaps the following will be more acceptable: 'Planned maintenance is the studied evaluation of all plant and buildings with the intention of carrying out any maintenance before it is actually needed through breakdown or obvious deterioration in performance, with the aim of reducing emergency maintenance and the associated costs in machine stoppages.' This can be classified into two main activities—preventive and corrective.

Preventive maintenance. This type of maintenance is carried out at pre-determined intervals, or to other prescribed criteria, and intended to reduce the likelihood of an item not meeting an acceptable condition. 'A stitch in time saves nine' is the basic philosophy of preventive maintenance. It can be carried out on machines either when running or during shutdown.

Running maintenance. Maintenance which can be carried out whilst the plant or unit is in use. This is also called **on-line maintenance.**

Shutdown maintenance. Maintenance which can only be carried out when the plant or unit is not in use. This is also called **off-line maintenance.**

The preventive maintenance can be time-based or condition-based.

Time-based preventive maintenance. This maintenance is effective when the failure of any item of an equipment is time-dependent and the item is expected to wear out within the life of the equipment. In addition to this, the total cost of replacement of the item should be substantially less than that of failure replacement/repair.

Condition-based maintenance. It is a corrective maintenance resulting from condition monitoring, where continuous checks are made to determine the 'health' of an item and to expose incipient faults. Here, one can also make use of predictive maintenance by using a technique called 'Signature Analysis', which is intended to continually monitor the health of the equipment by recording systematically signals or information derived from the form of mechanical vibrations, noise signals, acoustic and thermal emissions; smell, pressure, changes in chemical compositions, etc. Although this technique is very sophisticated and useful, it is not always used because it involves high manpower and monitoring costs and also it is difficult to monitor some parameters.

Corrective maintenance. Maintenance intended to restore an item to the acceptable standard. It involves minor repairs that may crop up between inspections.

Breakdown maintenance. Maintenance work implemented after failure, but based on advance planning.

Maintenance Policies

Each company/organisation should have a firm and clearly established maintenance policy, and where this is so, the maintenance manager's policies will be in context. The quality of maintenance is greatly dependent upon the suitability of its organisation to the technical problems arising in the plant. At the very outset, for instance, management must choose between centralised and decentralised (or area) maintenance. The former offers greater control, while the latter has the advantage of specialisation and speed.

Other policy decisions involve the reporting level of the maintenance department—whether to the production manager, to a more general 'plant engineering' department, or directly to the manager of operations. Practices vary, being about half and half between keeping maintenance separate from plant engineering or having it unified with that function. Another problem is the question of whether to subcontract various maintenance services (such as electrical or construction) or to perform these services by the plant's own permanent workforce.

Also, the maintenance manager must be able to convince top management that maintenance policies and overall management strategy are inter-dependent, and that his proposals will produce economic benefits. He will need to keep in mind the interaction of the functions covering:

- organisation
- coordination
- control
- retrieval of information
- monitoring of performance

and provide a structure which will combine them in a comprehensive system of management.

Fig. 11.5 shows a number of maintenance policies that can be specified, individually or in combination, for each unit of plant. The rationalised sum of such specified policies for the whole manufacturing plant constitutes the maintenance plan.

The actions carried out before the failure of an equipment/plant can be regarded as *preventive* and those carried out after the failure as *corrective*. Preventive maintenance actions are deterministic and carried out separately according to a preventive maintenance programme. Because of the probabilistic nature of failure, and the uncertainty surrounding corrective maintenance decision-making, corrective maintenance cannot be programmed. However, it is essential to formulate corrective maintenance guidelines for critical units of plant for effective decision-making after failure. In what follows, major maintenance policies are explained in some detail.

(a) Fixed time maintenance
Individual or group, replacement, etc.
(b) Condition-based maintenance
Continuous or periodic, etc.
(c) Operate-to-failure
Corrective maintenance by repair *in situ* or by replacement, etc.
(e) Design-out maintenance

} For complex items and/or continuously operating plant, consider (d) Opportunity maintenance

Fixed-time Replacement (Repair Prior to Failure)

This maintenance policy is effective where the failure mechanism of the item is time-dependent, the item being expected to wear out within the life of the unit, and where the total costs (direct and indirect) of such replacement are substantially less than those of failure replacement/repair. In other words, the item is classified as simple-replaceable.

The fixed-time replacement principle is shown in Fig. 11.6. In Fig. 11.6(*a*), an item failure distribution is shown, which is time-dependent. The problem is to find the fixed-time replacement period which minimises the sum of fixed-time and failure replacement costs. The data of Fig. 11.6(*a*) is used for calculating the probable failure rate as a function of replacement period. This is then combined with cost data to give total expected cost rate as a function of replacement period [Fig. 11.6(*b*)]. The indicated optimum-frequency periodic replacement will only be the 'best' maintenance policy if it is of lowest cost. The cost and problems of collecting the required statistical data is also a factor to be taken seriously into account.

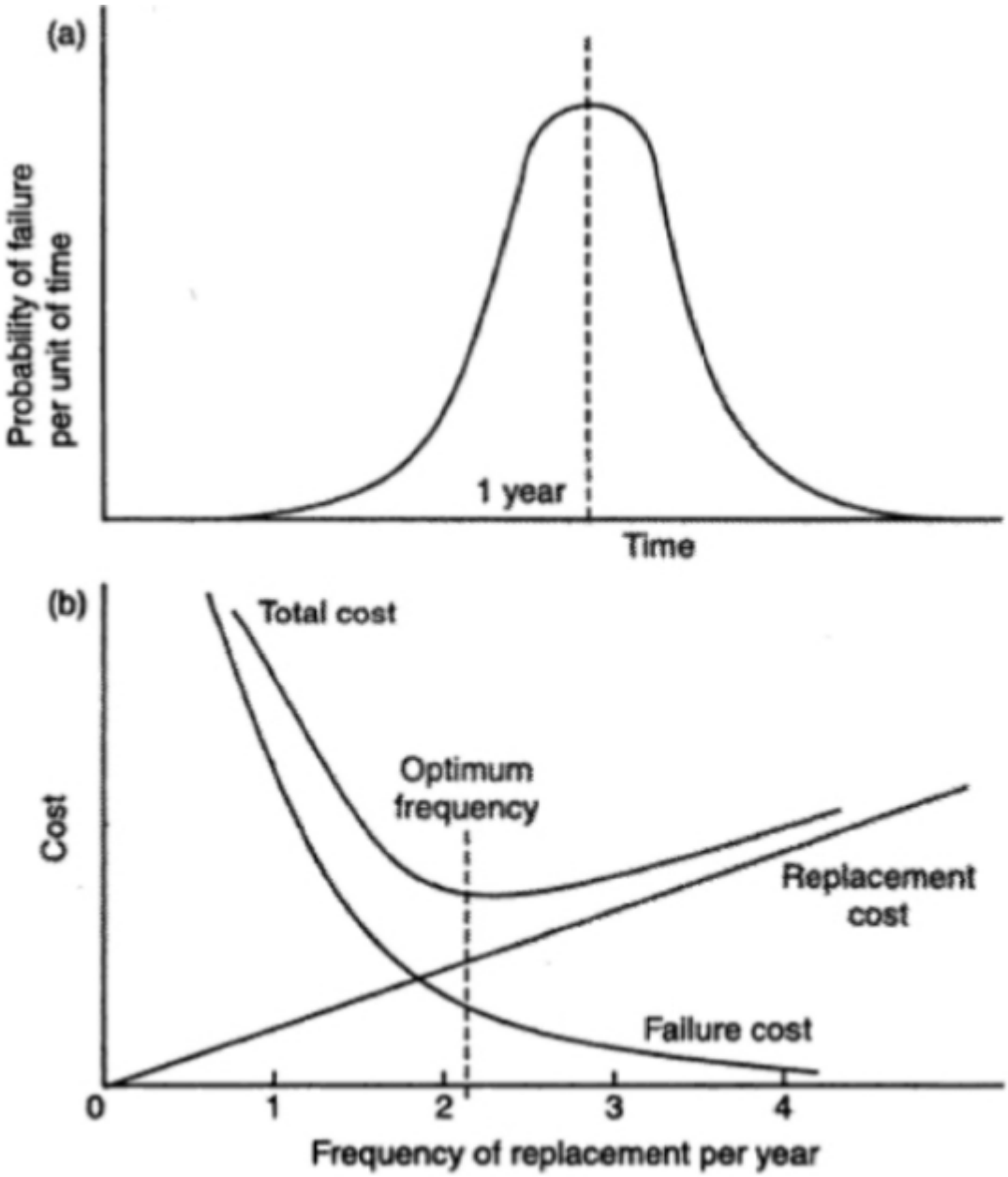

***FIGURE 11.6* Fixed-time maintenance principle**

Fixed-time replacement policy is inappropriate for complex-replaceable items because of two main reasons. First, the more complex the item the less likely it is to exhibit a failure pattern, which is time-dependent. Second, complex items are expensive to replace or repair and subsequently exhibit 'finger maintenance' problems. One of the alternative policies for such items could be 'condition-based maintenance'.