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A strategy for introducing systems of maintenance and repair in developing countries

by B. N. BHATTASALI*

THE NATURE AND CLASSIFICATION OF MAINTENANCE AND REPAIR SERVICES IN THE DEVELOPING COUNTRIES

In general, most developing countries have to import their capital equipment—plant, machinery, appliances and their spare parts. Almost all of them lack capital. Whatever liquid capital they may be able to mobilize is not readily convertible into foreign currencies because of their trade deficits and unfavourable balance-of-payment position.

In spite of such basic handicaps, the industrialization of developing countries and the modernization of their agriculture and public utilities obviously must proceed. In the developed countries the models for maintenance, repair and replacements are based on high labour costs. In other words, the relatively high cost of maintenance and repair often makes it economically necessary for industrialists in the developed countries to discard their equipment and replace it at a rather early point of the actual physical lifetime of the equipment. In the developing countries, where labour costs are relatively low, such equipment could be used substantially longer through care in labour intensive maintenance and repair. This can be properly realized only if satisfactory systems of maintenance and repair can be organized and manpower trained to operate them. In this connexion the systems of the developed countries may be accepted only as broad guides, and they have to be adapted imaginatively so that they will conform to the needs and economic realities of the developing countries.

Some of the most prominent features of the maintenance and repair services in most developing countries are the following:

(a) Although the need for maintenance and repair in the developing countries in both quantity and quality is by far greater than in the developed countries, services in this field are completely unorganized.

(b) The workers, supervisors and managers do not always have the requisite skills to operate and maintain modern equipment properly, with the result that the machinery breaks down more frequently.

(c) Most of the developing countries import capital equipment. They are unable to keep an adequate supply of spares on hand, and this causes serious economic losses through shutdowns.

(d) Many developing countries buy their equipment in different countries with different sets of standards and specifications. It is often difficult to provide proper technical facilities and skilled manpower to cater for the maintenance and repair of such heterogenous equipment.

(e) The consumption of industrial equipment and spares is limited. In the absence of the benefits of economies of scale, it is difficult for the suppliers to provide facilities for major repairs or after-sale service. The consumer cannot always make proper arrangements for major repairs locally, nor undertake indigenous manufacture of spares—which means more dislocation and interruption in production.

All these factors contribute to a substantial increase in costs for the industries of the developing countries.

* Executive Director of the National Productivity Council, New Delhi, India.

These costs could be reduced by introducing and operating appropriate systems of maintenance and repair. The additional costs thereby incurred would be only a small fraction of the total losses that would result from interruptions in production and shutdowns.

Maintenance and repair systems cover a wide variety of activities at an enterprise. They may be classified into groups according to the areas of coverage or types of services they provide. For the purposes of this article they may be divided into the following six broad categories:

(a) Maintenance of the buildings and grounds;
(b) Maintenance of the plant and equipment;
(c) Lubrication and inspection of equipment, including material-handling equipment and transport vehicles;
(d) Utility generation and distribution services (electricity, water, sanitation and ventilation);
(e) Alterations and additions to the existing plant and equipment;
(f) Alterations and additions to the existing buildings, grounds, utility generation and distribution services.

In addition to the above categories, other related or supporting activities also fall under maintenance and repair services, such as:

(a) Plant protection—fire, sanitation, ventilation, general safety and noise control;
(b) Stockkeeping for maintenance work;
(c) Management of maintenance and repair workshops and liaison with production departments for manufacture of spares, major overhauls and major repairs;
(d) Waste disposal;
(e) Administrative and accounting work.

Depending upon the type and size of the enterprise, it may often be convenient to provide these maintenance services from within its existing structure. For example, maintenance stores could be looked after by the normal stockkeeping organization. Similarly, the engineering departments can also provide plant protection, produce spares, undertake major overhauls and waste disposal etc.

Maintenance and repair activities can be classified not only on the basis of the types of services provided to the different areas of the enterprise, but also on the basis of their functions, as discussed below.

Preventive maintenance

By preventive maintenance is meant regular inspection of plant and equipment to detect adverse operating conditions or structural or functional deterioration of machinery, and the taking of timely remedial measures such as lubricating, adjusting and repairing. Preventive maintenance involves observance of systematic routines by the operatives as well as by the servicing departments. In some enterprises, preventive maintenance is used in a rather narrow sense: the maintenance department confines its activities to inspection, lubrication, adjustment and testing and informs the user departments of defects that they should correct. This policy is intended to permit better scheduling of preventive maintenance. In the light of the experience of the developing countries, however, it is often desirable to entrust the maintenance department itself with the direction and inspection of repairs and modifications. Without absolving the user departments of basic responsibility for maintaining their equipment, this procedure permits the maintenance department to retain a complete picture of the situation. This topic will be elaborated at greater length later.

Operational maintenance

Production in a factory may be interrupted by accidents or a breakdown of the equipment, power supply, gas, water, conveyors etc. Operational maintenance staff are provided to correct the defects so that production can resume. Some of the operational maintenance staff are required to function round the clock even though the factory may be working only on a one- or two-shift basis. Operational maintenance is mostly linked with breakdown repairs, a subject discussed further later on.

Repair

From a broad perspective, repair services are really part of maintenance services. From a narrower point of view, repair can be classified as preventive and breakdown repair.

Preventive repair

Particularly in the developing countries, an actual breakdown of plant equipment is often the cumulative result of several minor breakages, damage, distortions and maladjustments. Whereas most adjustments can be made on the spot, breakages, damage and distortions may require prompt repair or replacement of parts, if more serious shutdowns or breakdowns are to be avoided. Proper systems of preventive maintenance, therefore, have to be complemented by preventive repair in those cases where wholesale replacement may not be necessary. This is of particular importance to the developing countries, where material is scarce. Technical staff engaged in preventive maintenance can carry out minor repairs or adjustments on the spot, but where this would upset the schedule for preventive maintenance, these repairs should be undertaken separately.

Breakdown repair

Breakdown repair must be carried out when the equipment has actually failed, halting factory operations. Just as the preventive maintenance department undertakes minor preventive repairs the operational

maintenance staff can attend to minor breakdown repairs. When this is not practicable, the defective part is replaced and sent to the factory for repair, if reparable, or scrapped altogether if not. When spares for replacements are not available, as often happens in factories in the developing countries, emergency repairs may have to be undertaken, to reduce the period of interruption in factory operations.

Alterations and additions

Alterations and additions result from periodical reviews designed to bring about the necessary improvements in the operation of the plant equipment, buildings, sanitation, utility generation and distribution etc., so as to ensure an uninterrupted flow of work. Where existing equipment and facilities are manifestly defective or persistently fail, efforts are made to correct the deficiencies through alterations or additions.

THE INSTITUTIONAL ARRANGEMENTS

The institutional arrangements for preventive maintenance and repair services may be organized at four levels: national, industry, regional, and enterprise levels.

National level

Few developing countries are fully aware of the economic importance of maintenance and repair services. Nor do they realize to what extent the lack of these services harms their economies. The primary objective of making institutional arrangements at the national level is to generate a consciousness of the importance of repair and maintenance throughout the country—among corporate bodies, the management and the engineering personnel in various enterprises, public utilities, in fact, in all establishments undertaking sizable technical operations.

The generating of such a widespread consciousness can be achieved most effectively when the benefits of maintaining such services—gains through cost reduction and increased output of better quality—are explained clearly to the business managers, engineers and financial administrators. To make the position clearer, it is desirable to explain the situation in terms of the productivity of the capital deployed for organizing and operating maintenance and repair services. To be really effective, publicity materials on techno-managerial problems should be expressed in the simplest possible language and should include an adequate number of illustrations.

Apart from the preparation of publicity materials, the national institution may also initially collect data, undertake research through work sampling, and organize short seminars explaining the benefits and the methods of operating such services to top managers. Once the ideas gain some foothold among the top managers, systematic follow-up to ensure their spr among the middle managers, supervisors and work may be initiated at the national level. But efforts to disseminate ideas, and what is even more important to explain the practical methods of organizing and operating maintenance and repair services in various enterprises require the co-operation of specialized institutions and local organizations as discussed below. The national institution has a basic responsibility to promote such institutions and organizations throughout the country if maintenance and repair services are to be a really effective vehicle for raising the level of productivity of the developing countries.

The national institution may also provide information on the latest developments in the field of maintenance and repair by maintaining contacts with similar organizations in the developed and in other developing countries. It may promote study tours and exchange of experience with other countries seeking to strengthen their maintenance and repair services. It may provide literature and audio-visual aids to various institutions and organizations interested in the subject, and where circumstances permit, it may promote symposia and discussions for exchange of technical and methodological knowledge and experience within the country.

Industry level

Although national institutions have a basic role to play in promoting maintenance and repair services, such services will vary considerably in structure in different lines of production. For example, the type of maintenance and repair required in a steel mill will differ substantially from that required in factories producing transistor radios, shoes or optical instruments.

The production processes in the various factories in a country are far too numerous to permit a separate body for carrying on maintenance and repair to be established for each. Nevertheless, it is convenient to classify all production processes under appropriate generic heads for the purpose of establishing maintenance institutions serving entire industries. Classifications of this nature will differ from country to country depending on the type of industries, state of industrial development, resources, climatic conditions etc. of each country. For example, in a medium-sized country, it may be necessary to have an industry-wide institutional arrangement on a fairly broad foundation—e. g. the chemical industries providing coverage to refineries and petrochemicals, pharmaceuticals, fertilizers, rubber and plastics. In a larger country, institutional support can be more specialized.

In view of the special importance of repair and maintenance in the developing countries, one might consider establishing an institution concerned solely with maintenance and repair in industry as a whole, but in practice this is neither desirable nor practicable.

To provide effective maintenance and repair services requires the intimate relationship of such activities with those of other departments of the enterprise, particularly production and engineering departments within each branch. The technological base in most developing countries is very weak. The problems of operating such services can seldom be successfully solved when dealt with in isolation from other activities of the engineering and production departments. A much more effective solution will be to set up maintenance and repair cells in the professional engineering institutions functioning in major technical areas, i. e. Institution of Metallurgy, Institutions of Chemical, Electrical, Civil, Electronic, Ceramic or Aeronautical Engineering. Each one of these could establish its own cell to meet its own specialized maintenance and repair needs.

As distinct from the general coverage provided by the national institution, the types of services provided by particular industries are much more elaborate and specific in character. These professional institutions could conveniently organize short-term training courses for the middle managers, supervisors and technicians on maintenance and repair activities in their own areas. They could also assist in publishing manuals and guides for such personnel on maintenance and repair work in their respective fields, and at a reasonable price.

Apart from training activities, such specialized institutions could also become repositories of more detailed information on contemporary developments taking place elsewhere. After developing a satisfactory degree of expertise in different production lines, such institutions could also undertake consultancy assignments. These would not only provide field tests of such information and knowledge, but would also provide valuable feedback and research material for the national organization and for other interested groups.

Regional level

Institutional support at both the national and the industry levels for operating repair and maintenance services have a pronounced promotional emphasis. But support at the regional level has a service emphasis and is primarily intended to provide, on payment of prescribed fees, maintenance and repair services that are normally beyond the capabilities of individual enterprises. Thus, regional maintenance and repair establishments are run on a commercial basis, yet they have a social purpose as well. Small and medium-scale industries do not always possess the requisite technical competence to cope with all their maintenance and repair problems. As mentioned earlier, in the developing countries, suppliers of plant and equipment do not often provide after-sale service or maintain workshops for major overhaul and repair, nor is it always practicable to send the equipment abroad for such servicing, overhaul and repair. This means that in the developing countries, major overhaul and repairs beyond the technical capabilities of the enterprise must be attended to within the country, and at not too distant a place, if serious interruption of production is to be avoided. This is precisely the justification for providing highly developed professional services to undertake maintenance and repair contracts for different enterprises in different regions of the country. Owing to a fairly common tendency for certain industries to become concentrated in certain areas of the country, it is desirable and convenient to operate regional servicing institutions that specialize in maintenance and repair work in one or two major lines of production, such as textiles or metalworking. Indeed, when this is the case, suppliers of plant and equipment who sell these under a guarantee may find it convenient to appoint the regional servicing institutions as their authorized repairers. Many other manufacturers may be quite happy to supply these institutions with the necessary technical information on maintenance and repair to retain the good name of their products in the market.

Enterprise level

Maintenance and repair services at the enterprise level should be of particular concern to factory managers in the developing countries. In practice, however, maintenance and repair services are often performed in a perfunctory manner, with an overwhelming preponderance of breakdown repair carried out by the production and the engineering departments without any systematic planning, implementation or keeping of records. Regardless of whether maintenance concerns the testing of lifting appliances, servicing of conveyors or checking of gauges, it is necessary to drive home at all levels of the enterprise the extent of losses it would suffer without maintenance and repair services and how safety, health and smooth functioning at the enterprise would be affected if these services were not carried out properly. Apart from educating and training the managers, supervisors, and workers as to the importance of these services through lectures, demonstrations and film shows, the co-operation of the workers' organizations should also be sought in this regard. These aspects, however, have been elaborated later on. It is sufficient here to stress that maintenance and repair services in enterprises need to be planned and organized with special care.

A STRATEGY FOR PROMOTING THE CONCEPT OF MAINTENANCE AND REPAIR

Maintenance and repair services have been known and provided in almost all societies in some form or other from the remotest days of antiquity. What is new

is that they are considered today from a scientific point of view with respect to both planning and organization and in terms of rapidly advancing technologies. This article, however, is not concerned with the technological aspect of maintenance and repair services, but with the popularization and extension of such services.

In most developing countries, there are sufficient published materials available on maintenance and repair services. Yet interest in this subject has not been aroused. Some sort of shock treatment to make people "wake up" to the importance of repair and maintenance may be necessary.

The deplorable state of maintenance and repair in a developing country could be dramatized if the Finance Minister, Minster for Industry or even the leader of the opposition were to issue a stern warning to the public that the country is losing so many million rupees, pounds or dollars every year because of failure to operate proper systems of maintenance and repair. Data for this could be gathered through work sampling and scrutiny of past records on interruptions and stoppages of work in a few representative factories.

When the political leader creates a public sensation with his indignant statement about the losses the country is suffering through inadequate maintenance and repair, he should also be able to present a broad outline of the solution to the problem. He may urge the establishment of a national association of managers, engineers and scientists to provide the country with the necessary leadership and guidance in the field of maintenance and repair. It would be desirable if he could announce a grant for setting up a national institution or at least for adding a new department to an existing national institution in the field of engineering or management. He may also wish to announce that a national conference or a seminar of top technocrats to study ways to organize maintenance and repair services at the industry, regional and enterprise levels will be convened and that a few national awards will be made annually for contribution towards the improvement of maintenance and repair by engineers, scientists, managers and workers.

When preparations are being made to convene the national conference, it must be ensured that the participants represent various industries, the geographical areas where sizable engineering and manufacturing works are carried out or are to be carried out, various professions and occupations (managers, scientists, engineers, trade unionists, manufacturers or importers of capital goods and spare parts etc.). Such a national conference should produce some specific plans and recommendations for setting up organizations at the industry, regional and enterprise levels and also subcommittees to follow up these recommendations systematically, reporting results to the national organization at periodic intervals. It would be very useful if this conference should decide to publish a quarterly, if not a monthly, journal on repair and maintenance under the auspices of the national organization that would disseminate relevant information at home and abroad, publish important contributions by the technocrats on the subject, and report progress on the various aspects of the movement at the national, industry, regional and enterprise levels.

That governmental support is provided for maintenance and repair services or that some public funds are used for this purpose should not be construed to mean that responsibility for introducing and operating such services rests with the Government. Nothing could be further from the truth. By and large, most of the developing countries are emerging from feudal conditions. Few of them have organizations of technocrats that could stand on their own feet without government support. Government support of maintenance and repair services is therefore not only necessary but also desirable to ensure smooth functioning and broad acceptance of maintenance and repair systems at different levels of the country's economy.

A STRATEGY FOR OPERATION

After modern maintenance and repair services have been introduced to the enterprises and engineering establishments through the activities mentioned earlier, they have to be organized and put into operation, at least in a few model plants on a selective basis to start with. In applying the principle of selectivity to the process of organizing and operating such services, the basic objective should be to generate multiplier effects. To choose plants suitable in this respect, the following points should be kept in mind:

(a) The plant should have progressive managers known for their techno-managerial excellence.

(b) The plant should have a high turnover, and there should be scope for demonstrating the effectiveness of maintenance and repair systems in terms of financial gains that could impress and inspire others.

(c) The plant should be in a major line of production in the country so that its example and experience could be readily followed by other firms in similar lines of production.

The principle of selectivity can be applied in another way and one that is especially important in the initial stages of development, when additional resources for operating maintenance and repair services, including trained manpower, are rather meagre. This refers to selecting crucial areas of plant operation on which to concentrate improved maintenance and repair services and to giving less attention to other areas. The underlying principle can be stated simply: the higher the cost of breakdowns, the greater the attention required. To determine which areas are critical, the following questions may be asked:

(a) Is this a critical item? If failure will cause a major shutdown or costly damage or harm to an employee, maintenance is essential.

(b) Is standby equipment available in case of failure? One can often rent air compressors or package boilers on short notice. If the load or duty can be easily shifted to other equipment, the need for maintenance is contingent on other factors, such as the cost of "breakdown" maintenance.

(c) Does the cost of maintenance exceed the expense of downtime and the cost of repair or replacement? If so, the value of maintenance is questionable.

(d) Does the normal life of the equipment without maintenance exceed manufacturing needs? If obsolescence is expected sooner than decay, maintenance may be a waste of money.

In the context of the information elicited from the above scrutiny, maintenance and repair work for the entire plant may be divided into four categories on the basis of what may be popularly called a VEIN analysis:

V = Vital, E = Essential, I = Important, N = Normal.

VEIN analysis

Vital areas

Vital areas may be defined as areas where any breakdown would result in very costly repair or replacement and almost a complete closure of the plant for a considerable period and for which no standby facilities are available. An example of this is a cupola in a foundry or a turbine in a thermal plant for which local repair facilities may not be available.

Essential areas

Essential areas may be defined as areas where any breakdown would result in expensive repairs and replacements and cessation of work for a substantial period in a major area of the plant for which no standby facilities are available. Such an interruption could be caused by a failure of the main power unit in a conveyor system or the failure of a major heat-treatment furnace used for softening forged materials before machining in the direct line of production.

Important areas

Important areas are simply major areas in the operation of an enterprise. Although standby or local repair facilities may be available, a breakdown in these areas would still involve substantial expenditure for repair or replacement and a serious interruption in production.

Normal areas

Normal areas of maintenance operation are those in which a breakdown will entail nominal expenditure for repair or replacement or minor interruption or delays in plant operation.

Economic considerations

The VEIN analysis takes into account the direct costs involved in repair or replacement, as well as the indirect costs arising from interruptions in plant operation. In developing a model for classifying the maintenance and repair services in terms of direct and indirect costs into four categories as mentioned above, a broad analytical estimate is all that is needed initially. Such an analytical estimate will no doubt vary with the enterprise and the facilities, particularly stores and repair facilities that could be mobilized both within and outside the enterprise.

The operation of maintenance and repair services must ultimately be based on economic rather than purely engineering considerations. It may be possible for the engineers to eliminate breakdowns even of ordinary items, but it may often not be economic to do so, as it is futile to spend pounds to save pennies. It should be repeated, however, that the method of determining the economic feasibility of maintenance and repair work must be the developing country's own and cannot be copied even from similar factories in the Western countries, where labour costs are high and replacement costs often less high.

Organization of maintenance work

Although both preventive repair and breakdown repair must be carried out according to appropriate priorities whenever replacement is not economic, it may not be practicable to meet the need for preventive maintenance for the whole establishment all at once. The VEIN analysis applies the principle of selectivity in terms of economic considerations and not of the physical or functional divisions of the enterprise. The question here is to determine how maintenance work should be organized, and how much of this work can be carried out by the shop managers or supervisors of different work centres.

Normally, maintenance work at an industrial enterprise covers the following areas:

(a) Process equipment – furnaces, heat exchangers, piping, pumps, compressors, motors, stills, instruments;

(b) Safety equipment – vacuum and pressure-relief valves, flashback or flame arrestors, breathing and emergency relief equipment;

(c) Utility equipment – main boilers, electric generators, supply, storage, distribution systems for water, steam, and compressed-air pipelines;

(d) Tanks and auxiliary equipment – storage tanks, pipelines, dikes, drains, gauges, measuring instruments;

(e) Plant buildings – shipping and storage areas,

transport equipment such as tank cars and transfer pumps;

(f) fire-protection equipment: water supply and pipelines, pumps, permanent fire-extinguishing installations of foam, fog, gas, spray, or dry powder, first-aid extinguishers, fire trucks, alarm systems.

During the early stages, when maintenance staff are still being mobilized and trained for the job, it will be desirable to entrust "vital" and "essential" items from the above lists to the centralized maintenance organization, delegating the responsibility for the maintenance of "important" and "normal" items to the shops. As experience is gained the division of responsibilities can be adjusted accordingly.

The VEIN analysis classifies maintenance work in terms of economic factors. This leads to the question of reducing losses by adjusting the frequency and depth of inspection of equipment, which is a technical question requiring systematic engineering analysis on the following lines:

(a) Age, condition and value. Older and poorer equipment needs more frequent service. But if the equipment is ready for the junkpile or soon to be obsolete, it may be cheaper to inspect on a skeleton basis or not at all.

(b) Severity of use. More severe applications of identical equipment require more frequent inspections. In a process plant a critical pump may need to be inspected every day; the same type of pump in a metalworking plant may need to be inspected only once a month.

(c) Safety requirements. A wide margin must be allowed for safety. For example, one plant inspects the solenoids operating the clutches on presses every two weeks.

(d) Hours of operation. Many manufacturers suggest frequency cycles based on an eight-hour day, others on usage (such as mileage).

(e) Susceptibility to wear. How great is the exposure to dirt, friction, fatigue, stress, corrosion? What is the life expectancy?

(f) Susceptibility to damage. Is the equipment subject to vibration, overloading, abuse?

(g) Susceptibility to maladjustment. How will maladjustment or misalignment affect it? Where manufacturing tolerances are tight, a shorter inspection cycle is needed.

In the developing countries, experience has shown that many items that the manufacturer would suggest replacing after a defect has appeared can be repaired satisfactorily. A critical technical examination of the possibilities for satisfactory repair may result in considerable savings for an enterprise, since manufacturers are often eager to sell extra spare parts and may recommend replacement far too early.

Apart from breakdown repairs, it is convenient for administrative purposes to include preventive and upkeep repairs under repair services, irrespective of whether the work involved is derusting of pipes, painting of buildings, welding, or electro-deposition of metals on worn-out parts. One reason why simple repair work in the developed countries is often not undertaken by the maintenance staff, even when this is well within their technical competence, is that the latter have to work on highly organized and tight schedules. It would not be possible for them to adhere to the predetermined maintenance schedule if they were to undertake even simple, routine repair work. This is not the case, however, in most developing countries, particularly in the initial stages when maintenance programmes have considerable flexibility. What is most important is to keep alive a spirit of service, particularly among the supervisors of the maintenance teams. It should be impressed upon all maintenance operatives that shop managers are their clients and that maintenance staff should make great efforts to satisfy them, winning their goodwill and co-operation in the process.

Basic additions to and alterations of the existing plant facilities should usually be specially scheduled. But when the nature of the work involved is such that these improvements could be made without much dislocation of normal work, it would be economic for the maintenance and repair departments to undertake them. Before accepting any such additional responsibility, the top management should understand the precise technical and economic implications of these improvements.

Two other basic issues concerning repair services deserve special consideration. The first relates to the organization of repair work and the second to priorities. It has been suggested earlier that routine and simple repair works should be undertaken by the maintenance staff for which a special maintenance workshop should be provided. Apart from the special facilities a particular enterprise may require, the following equipment by and large would satisfy the general requirements of an average maintenance workshop:

(a) General-purpose lathe;
(b) Drilling machine;
(c) Shaper;
(d) Planer;
(e) Double-ended grinder;
(f) Tool post grinder;
(g) Forge and smithy equipment;
(h) Heat-treatment furnace, cyanide bath and quenching tank;
(i) Gas and electric welding;
(j) Hand and power hacksaw;
(k) Abrasive cut-off wheels;
(l) Assorted hand tools and measuring instruments.

The advantage of having such a workshop under the maintenance department would be that work could be undertaken immediately, depending upon urgency of the situation, without seeking extra-departmental assistance. Naturally, a workshop of this nature will not be able to carry out major repairs. For this purpose, assistance from the regular engineering departments may have to be obtained, and when such repairs are beyond the technical competence of such departments, outside assistance may be necessary. This means that the supervisors in the maintenance shops should be familiar with the technical capabilities of the enterprise and of outside workshops that may be located in the vicinity. Irrespective of whether major repair and overhauls are undertaken, by the enterprise or by an outside shop, an effective order of priorities for their execution has to be established under the authority of the top management.

It will be appreciated that operation of satisfactory systems of maintenance and repair are matured and built up over several years even in the developed countries. The published literature and guidelines on these are vast and complex. In the above paragraphs attempts have been made only to highlight some of the major areas of specific importance to the developing countries.

Cost calculation and evaluation

Cost calculation is an essential part of operating and evaluating maintenance and repair services. Unless the economics of the different aspects of these services are properly understood, it is difficult to operate them on a scientific basis. Unless monetary parameters are used, it is difficult to evaluate their effectiveness. It will be seen, therefore, that without a reasonably satisfactory method of calculating costs the effectiveness of maintenance and repair services may be seriously handicapped.

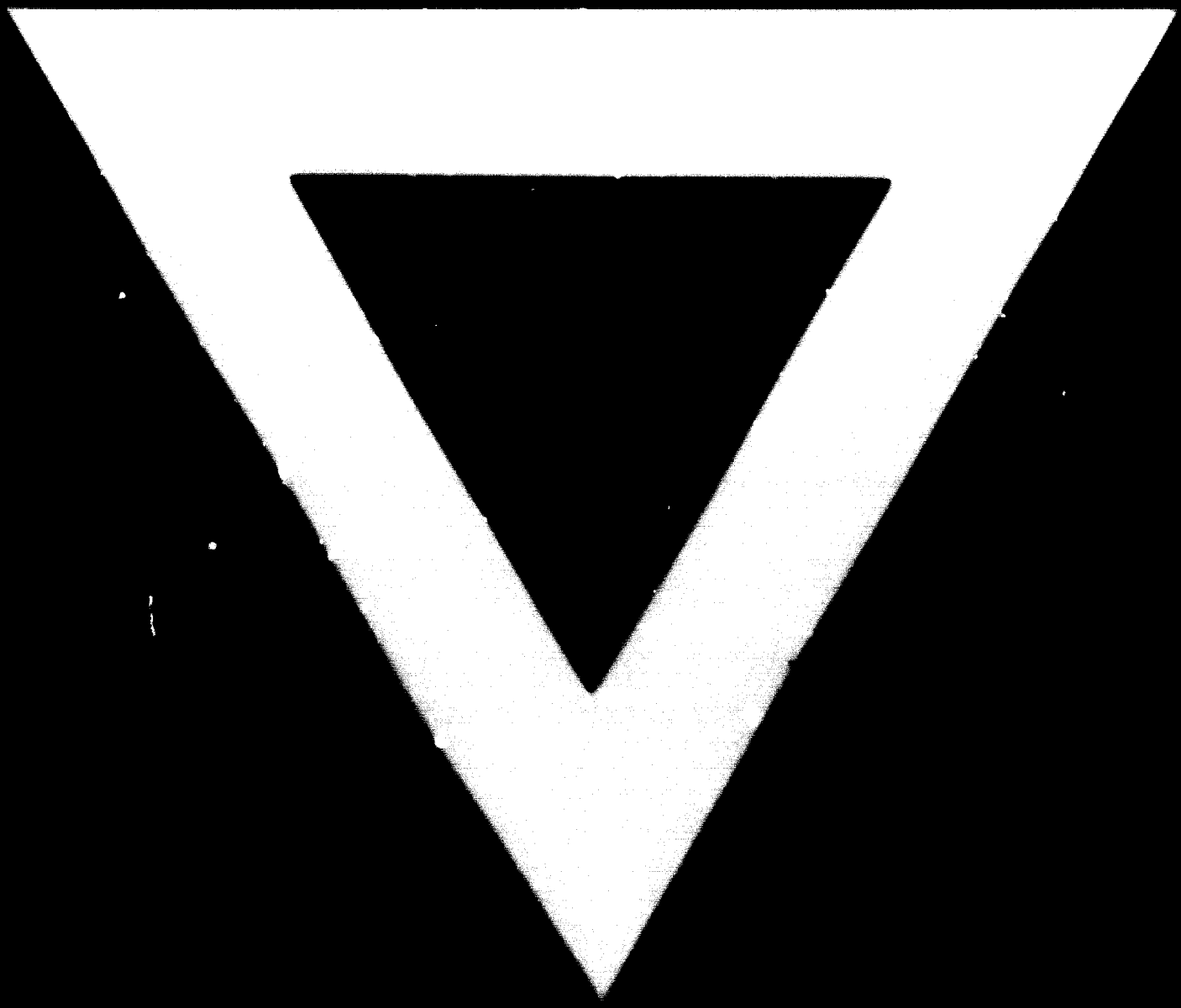
In spite of its basic importance, the calculation of costs that are based on so many variables, some of which are little more than broad approximations if not speculations, can hardly expect to attain the degree of perfection that is normally expected by the accounting profession. Yet this limitation has to be accepted and attempts must be made to make the best of a difficult situation.

The direct costs of maintenance and repair are comparatively easy to compile, since they are based on costs that have occurred in the past. But the indirect costs of shutdowns or interruptions are likely to vary widely unless they are adequately supervised by experts. In any case, the VEIN analysis may be used as a basis for calculating these costs. In doing so the best answer usually is to translate the loss of production in terms of manufacturing costs and add on the proportional overhead costs.

In most factories in the developing countries, records of time spent for routine breakdown repairs may not be available. But as these repairs are carried out throughout the factory fairly frequently, they could be computed statistically through work sampling. As regards major breakdowns or interruptions in production, records may well be available, and in these cases the cost of breakdowns should be computed in terms of money values as suggested earlier. If records are not available, it should be possible to obtain the information necessary for computing the costs from workers and supervisors, since they should know the frequency and extent of such important events as major breakdowns. This would mean reliance on verbal statements, but this is the best that can be done in the absence of more precise information. The importance of keeping systematically records necessary for cost calculation, however, has to be stressed to the management, and perhaps, from then on, cost calculation will become easier and more accurate.

The economic gains generated through strengthening maintenance and repair services can be computed in terms of reduction in interruptions in production, reduction in repair and replacements, including addition of proportional overhead costs to the figures. It is not necessary to add such proportional overhead costs to the additional costs for maintenance and repair, as the latter is a precise figure of actual incremental cost incurred, which would include elements of overhead, if any, that had been spent in the process.

For the purpose of a reasonably satisfactory and broad cost calculation and evaluation, the methods indicated above may be generally accepted. If, however, further refinements are required, they can be easily made on the same foundations.



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