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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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INVESTMENT IN MAINTENANCE: ECONOMIC STAKES AND POSSIBLE STRATEGIES*

Prepared by

Claude Pichot

UNIDO Consultant

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One frequently encounters discouragement in the industrializing countries: the majority of the plants are operating at only 30 or 40 per cent of their capacity and at least 30 per cent of the vehicles are immobilized. This situation has various causes - supply deficiencies, the absence of product marketing channels, absenteeism and the lack of personnel training. But in the case of at least 80 per cent of production shortcomings one of the factors is maintenance: the absence of a maintenance, and especially a preventive maintenance, policy; facility repair that is unsatisfactory (in terms of duration, quality, cost, etc.); inadequate personnel training; and shortages of spare parts and repair equipment.

In the light of this situation and against the background of UNIDO's activities in the maintenance area, the purpose of this contribution is to suggest a number of considerations on which to base a discussion that it is hoped will lead to the formulation of industrial maintenance training projects. The presentation that follows is divided into three parts.

In the first part we shall discuss a number of well-documented, typical and even caricatural situations illustrating the adverse effects of the absence of maintenance on industrial facilities. We shall describe this situation in broad outline, in which connection it might be noted that the lack of overall statistics on which to support this description ought not to be surprising at this stage, as the data we do have would appear to be of too heterogeneous a nature to be genuinely significant. Following this, we shall attempt to analyse the industrial practices that are responsible for these situations.

In the second part we shall endeavour to demonstrate the advisability of introducing maintenance-related measures as a means of ensuring a profitable return on, and the preservation of, the means of production, while at the same time controlling the related costs.

Finally, we shall propose an action-oriented method involving:

- Seven countries and seven pilot plants for comprenensive action in the area of maintenance training, targeted on priority objectives.

CHAPTER I. OVERALL VIEW OF MAINTENANCE DEFICIENCIES

Section 1. A site survey

In one particular Maghrebian country the cement factories are producing at only 40 per cent of their installed capacity. This is also true of the cement works of the United Arab Emirates, which are operating at 50 per cent of their potential.

Disorganization

What confronts the specialist visiting one of these plants is a picture of disorganization: paralysed machines, abandoned crushers, tons of parts lying idle in the sun, torn conveyor belts, bags of cement scattered about the workshop floors, cement dust everywhere (including outside the plant), factory areas with burnt-out and unreplaced light bulbs ... And machines that have been pushed beyond their capacity, to the limits of their endurance; equipment units that, to look at them, one would imagine were very old, whereas in fact they have not yet been paid for.

Abandoned machinery

Consider also the case of the mechanical workshops. At least 50 per cent of the total number of lathes and milling machines are standing idle. Numerically controlled machine-tools lie motionless under a heavy layer of dust, while high-capacity reamers have for months been awaiting the arrival of a foreign specialist. If the right spare parts catalogues were available, it would be possible to order the needed components. And during all this time the units to be repaired pile up. A portion of the equipment pool serves as a source of spare parts for the machines that are still in operation. In fact, it is only through this kind of "cannibalization" that the remaining equipment can be kept running.

All of this is in addition to the fact that the cutting tools are frequently improperly suited to the tasks to be performed. The right kind of milling head is no longer in stock? A pump shaft is machined using whatever can be found and, as a result, the part surfaces are not cut to specification. Accordingly, the shaft is remounted on the pump, but is soon returned for repair. This is an example of snowballing deficiencies: The machine is about to give out, the tools are not of the proper kind, and the repairing of the defective part succeeds only in aggravating the process of deterioration. The end result is that the entire equipment pool is subject to premature aging and may even be entirely lost.

Beyond the limits of safety

In steelmaking, the installations are taxed beyond the limits of acceptable safety standards. At one large steelmill it is the belt conveyor used to transport the crushed iron ore to the storage bins that gives way. A certain amount of the ore is spilt alongside the belts, which rapidly wear out. The short-term outlook is for the facilities to remain idle for six months; the entire foundation system supporting the conveyor frame requires overhaul. Cost: the loss of six months' blast furnace production of one million tons/year plus the cost of the repair.

Unlocatable spare parts

In the hospital sector a number of radiology equipment units remain unused. The reason: a defect was spotted on an electronic chart and a replacement part is desperately being sought. Somewhere at the back of a hangar there are dozens of cubic metres of untouched crates filled with spare parts. These crates have never been opened, and yet the needed component is surely in one of them.

Section 2. The responsible practices

The preceding observations draw the picture of a situation that is unfortunately chronic. They testify to a grave lack of maintenance in the industrializing countries.

This deficiency is characterized by two principal aspects: the absence of preventive maintenance and a reliance on improvised repairs.

1. The absence of preventive maintenance

What this means is that the tendency is to wait for a failure to occur, shutting down the entire facility, before an effort is made to repair a specific machine. Equipment is pushed to the limits of its endurance, even to the point of destruction. The consequence of this practice is that it causes all the machines available to wear out before their time.

Example: The maintenance of the electric circuit boxes at a cement plant has been neglected. This continues until a short-circuit destroys all the cable ducts and immobilizes the plant for several months - production had to be maintained at all costs.

Why do the industrializing countries so often follow this path? There are two reasons: the logic of "production at all costs" and the renewal of capital assets as a substitute for repair.

1.1 Quantity above all

The first reason is that in many industrializing economies concern is given only to the quantity produced and not to the quality. As a result, out of a desire to achieve the quantitative targets of the production programme there is a reluctance to shut down the facility. Even when the product no longer satisfies the manufacturing standards.

For example, at a particular cement factory the usual cement additives are no longer being mixed into the mass because the batching units have broken down. Production continues for several days at the rate of 2,000 tons per day, but the cement produced under these conditions lacks the desired mechanical strength. Nevertheless, it still finds buyers. Houses and civil engineering structures are built, to the detriment of their solidity. Later, however, the building maintenance specialists will turn this to their profit.

Then there is the case of a gas liquefaction plant built on an island in the Arabian Gulf. Within a few years of its construction, the plant's foundations had been corroded under the effect of the seawater; the cement, locally produced, had been below the required standards. Underpinning was required for all the reinforced concrete blocks: three years of work at a cost of 300 million French francs - nearly as much as the initial cost of the original civil engineering project.

When the philosophy is to accord priority to the quantitative aspect of production, there are two serious economic consequences: sooner or later the equipment is sacrificed and the quality deficiencies of the products manufactured have a negative impact on the entire economic chain.

1.2 Replacement rather than repair

A second justification is often advanced for the absence of preventive maintenance: It turns out to be easier to replace a piece of equipment in its entirety than to maintain it in a proper state of repair. The reason for this is

that in order to implement a system of preventive maintenance, it is first of all necessary to devise a prevention programme, i.e., to have available personnel capable of determining the kind of work to be performed on the machinery, the frequency of these operations and the parts to be replaced. Such personnel are not directly productive.

Next, parts must be available for replacement before they fail. This requires operating in the face of severe constraints. The machinery's technical documentation must be available and current, for it is indispensable in identifying both the part and the supplier. This means overcoming the administrative and customs formalities required for placing the order. But, frequently, these stages involve such bureaucratic obstacles that the purchase of spare parts - even simple fuses, joints and bulbs - becomes a nearly insurmountable undertaking. Once the foreign supplier has been located, one discovers that he is unwilling to deliver because the quantities ordered are too small. At this point it may become simpler to repurchase an entire equipment unit because of a defective fuse or a worn seal.

In Saudi Arabia, for example, irrigation pumps were regularly being replaced because of defective seals or bearings. Cost: 20,000 francs for a new pump instead of 1,500 francs for the seal.

2. Improvised repairs

Makeshift repairs represent the normal practice. The consequence is that the remedy is worse than the evil one is seeking to eliminate.

2.1 The "approximate approach" in the replacement of parts

To begin with, defective parts are replaced by others with the wrong fitting tolerances. This leads to a build-up of vibrations within the machinery until they reach the point at which the unit is ruined.

For example, the wrong electrodes are used for welding the wearing plates on the blades of a dust-removal fan. After a few weeks of operation an accident occurs: the 17-ton turbine, turning at 1500 rpm, slips its bearings and destroys the ventilation housing. The result is that the installation remains inoperative for three months, although luckily no one was injured.

2.2 Unmethodical work

Finally there is the wholly improper way in which the repairs are carried out on the machinery. The work is performed without any prior thought being given to the correct methods or to the necessary tools and parts. The result: disassembled machinery awaiting the proper tool or the arrival of a spare part on order. Production is paralysed and the machinery, exposed to dust or to the weather, deteriorates.

The examples are numerous.

At a repair shop some 100 electric motors are dissassembled without consulting the winding diagrams. When the winding wire arrives, several months later, the motors are rewound. After reassembly, numerous parts, which were used to repair other machines, are found to be missing. The cost of this practice: several score unusable motors and facilities immobilized for a period of several months - until new motors can be repurchased.

Section 3. The economic penalties

Each year in Europe, 7 to 8 per cent of the discounted investment is spent in the engineering industy sector on maintenance, making possible a capacity availability factor approaching 85 per cent. The industrializing countries often spend much more (30 to 40 per cent) for an availability factor that rarely exceeds 50 per cent. The proportions are the same in the other industries as well.

There are two contributing causes for this economic penalty: the accelerated obsolescence of the installations and the underutilization of production capacity.

1. Rapid aging of plant and equipment

Because the cases are so dissimilar, it is not possible to estimate with any reliability by how much the service life of the equipment may be shortened. Machinery is obsolete even before it has paid for itself. New investments must be made and an even higher level of hard-currency indebtedness must be accepted at a time when the earlier loans have not yet been repaid.

An example of this may be seen in the motor coaches whose useless carcasses are strewn along the trails and roads of a number of industrializing countries. For the lack of maintenance costing not more than 40,000 francs, vehicles are immobilized whose purchase price is nearly one million francs. After a few years of waiting for spare parts, these unusable shells are all that remain. The investment has been destroyed; not only must it be replaced, but in addition continued repayment must be made on the loans assumed for the purchase of the original equipment. Or - the other alternative - the Government might resign itself to no new purchases, which of course would be a step backwards in economic terms.

In the building materials sector, one finds plants producing prefabricated concrete panelling that are old before their time. Certain of these facilities, although they were erected less than five years ago, are already almost totally non-productive, operating at less than 10 per cent of their capacity. Their installations are in such a state of disrepair that to rehabilitate them would cost nearly half the initial investment.

One might consider, for example, the case of a particular cement factory. After eight years of operation there are plans to reinject into this facility one quarter of the initial investment cost, since the plant is producing at only 50 per cent of its installed capacity. A portion of the equipment will have to be replaced in its entirety.

2. Production capacities are poorly exploited because of the low equipment availability factor (between 40 and 60 per cent).

The consequences are of three kinds: The manufacturers produce less, they produce poorly and they continue to make hard-currency purchases.

2.1 Less production

The machinery is paralysed or else it is able to operate at only reduced speed. The economic penalty is at least equal to the value of the unrealized production. The cost price per unit produced is far higher than anticipated, but the production is sold at the price the customers are willing to pay. The manufacturer sells at a loss in the local market and is unable to make good on his debts. The impact of this phenomenon is all the greater due to the collapse in petroleum revenues. It is at this point that the inability of the plants to repay their loans through the income derived from the export of their products becomes vividly apparent.

2.2 Poor production

Because of the aging of the equipment, manufacturing standards can no longer be met. This is immediately reflected in the quality of the product. Although it is the user who is directly damaged, the entire economy ultimately suffers.

For example, locally manufactured taps nearly always leak in a particular Middle Eastern country. The result is the wastage of 20 to 30 per cent of water that is scarce, expensive (about 1,000 francs per m^3) and difficult to produce.

Electric cable reels are never of the required length because the machines used in rubber-coating the cables fail every 200 or 300 metres. As a consequence, when carrying out electrical wiring work, intermediate connecting boxes, which are costly and represent an additional source of malfunctions, have to be installed.

At a particular yoghurt plant, the machines used to fill the jars performed erratically. Some of the jars sold were empty. The customers finally grew weary of this situation and the plant closed.

In certain cases, the economic penalty is immediate, in response to the laws of the marketplace; in others it is indirect. Products of poor quality continue to be marketed, with customers buying them for lack of anything better (in one Maghrebian country, for example, it is difficult to purchase a can that does not leak). The situation is even more serious when the product is used as a single component together with others in a larger item; its poor quality has an insidious and sometimes irreparable effect on the final product.

For example, buildings which were supposed to have been able to resist earth tremors of predictable intensity have been entirely destroyed. The cement used in preparing the concrete was of inadequate mechanical strength. The cost of failures of this kind is difficult to quantify, but the loss is real even if it is diffused.

2.3 Continued hard-currency purchases of unrealized production

The requirements of the market take no account of the level of plant production. If the demand is to be met, there is no choice but to import. This involves a double outflow of currency: first, in order to be able to continue purchasing in part what was to have been entirely manufactured locally, and second, in order to repay the loans already assumed.

This is the situation in a particular Maghrebian country that is still importing half of its cement requirements even though, on the basis of its domestic plant capacity, it ought to be in a position to export a part of its own cement production.

A similar example can also be seen in the case of a major supplier of electricity during the early 1980s. Following the launching of the nuclear programme, the power stations operated at an availability factor of only 60 per cent, with the energy shortfall continuing to be made up by fuel-oil-fired plants. Cost of one day of downtime in 1982: 2.5 million francs in foreign exchange in the case of a 900-MW power station for the purchase of the necessary crude petroleum. All this in addition to the fact that continuing repayments had to be made on the outstanding dollar loans.

CHAPTER II. INVESTMENT IN MAINTENANCE: WHAT BENEFITS?

Maintenance investment is a means of making one's capital assets profitable and of preserving them at the right cost (thus eventually reducing the costs of maintenance).

The first of these two benefits, i.e., the generation of profit from capital investment, is possible because maintenance provides a way of increasing the production output of a plant or factory. The second benefit, the eventual reduction of the maintenance costs, follows from the fact that what is involved is a determination of the financial burden regarded as acceptable for the purpose of bringing a production facility to a desired operational level.

Section 1. Increasing the production output of the facility

This is the most immediate and visible anticipated effect of maintenance investment. The stakes involved are of two kinds: economic and social.

1. The economic stakes

Maintenance investment leads to an increase in the number of plant operating hours. Similarly, there is an improvement in product quality, and this is one of the essential conditions for the ability to sell locally and to export.

Supplying the local market is an essential factor in the effort to achieve self-sufficiency. Selling abroad is also a paramount consideration, since it is through export sales that a country can earn the foreign exchange that represents the only means of payment accepted in international market transactions and, specifically, in repayment of the loans assumed for the construction of plants and factories.

It should be remembered that by producing goods of mediocre quality at a maximum level of 40 per cent of installed capacity, it is impossible to export. It becomes necessary to tap national foreign exchange reserves in order to repay the outstanding loans. Production of this kind can never contribute to making a country more economically autonomous; on the contrary, it very often deepens its dependence in two ways: as a buyer of the materials required for production and as a borrower in the international markets.

The aim, therefore, must be to improve production in not only quantitative but also qualitative terms. Obviously, for the purpose of satisfying the internal demand, but also in order that one's products may be competitive abroad and become sources of foreign exchange.

Consider the case of a large central maintenance workshop (850 persons, six repair shops: rewinding of electric motors, machining, mechanical work, boiler making, welding and hard-surface chrome-plating). An examination of all the available equipment had shown that 50 per cent of the machines were immobilized. Maintenance amounted to no more than makeshift repairs, with the idle machines "cannibalized" to provide replacement spare parts for those that were still in operation, considering that no spare parts had been purchased for the 100 or so equipment units installed in the workshop.

A number of steps were taken to remedy the situation.

First of all, the purchase of the technical documentation, at a cost of 4 million French francs for a machinery investment in the order of 150 million francs. Next, the preparation of a study on spare parts requirements at a cost of about 2 million francs. It has subsequently become possible to purchase the parts and to organize the warehouse operation. Total amount of the orders: about 5 million francs.

The next step was to introduce a system of preventive maintenance. The machines were inspected every day and were lubricated and cleaned on a regular basis, with parts and components subject to unusual wear periodically replaced. Through this maintenance investment it was possible to reactivate 45 million francs' worth of unproductive machinery for a total cost of 11 million francs. A part of this amount was paid for in local currency (the study on spare parts requirements).

This replacing in service of approximately 30 per cent of the total installed equipment pool was reflected in a 30 per cent increase in business turnover. An improvement was also achieved in the cost price sector, since one-third of the personnel had previously been underutilized.

Another consequence: By overhauling certain large machines (a vertical lathe with a diameter of 6 m, a boring mill and a parallel lathe with 12 m between centres), it was possible to avoid having to send the parts to Europe for repair. This resulted in a savings of foreign exchange (several million francs a year), but also in a reduction in the time the equipment was immobilized: a few weeks instead of the usual eight to nine months.

Another example. Consider the case of a rolling mill in which a maintenance investment was made, above all for the analysis of production stoppages. This led to an improvement in the quality of the coils manufactured. Cost: 7 million francs. Output: an important export breakthrough (more than 10 per cent of the installed capacity or about 70,000 tons), mainly to Japan and the United States, together with the resultant foreign exchange revenue.

2. The social stakes

Rising production is the proof that it is possible to escape from an inevitable pattern of breakdowns. One learns that it is possible to service the machinery and to master certain kinds of malfunctions, with immediate and tangible results. One also finds that one can bring about changes not only in the quality and the quantity of products, but also in operator skill and motivation.

2.1 Development of know-how

When a worker seeks to understand why a piece of machinery fails, he is on the road to progress. This is because he has a better understanding of its operation and is thus able to use it more effectively.

What is at stake here is a genuine transfer of technology: the acquisition by the equipment operators themselves of knowledge regarding the performance of the machinery on the basis of its behaviour in operation.

Consider, for example, a certain cold-shaping line used to produce galvanized iron panels. When the line was started, there were five foreign technical assistants supervising the work of five nationals. This situation remained unchanged for two years.

At this point, the plant management voluntarily decided to assume the responsibility for management. This enabled the shop-floor workers to improve their understanding of the line to the point where the presence of the foreign technical consultants soon became superfluous.

Cost: five months of on-site training, together with a saving of foreign exchange, plus 3 million francs for technical assistance. End effects of this action: When the time came to double the capacity of the line, all the equipment was able to be designed and produced locally, resulting in a foreign exchange saving estimated at 8 million francs.

2.2 Maintenance as a basis for motivation

Good repair work requires a good knowledge of the machinery, and often the operator becomes involved and accepts the challenge posed by the overhaul of the equipment. Resignation to the inevitability of breakdowns is overcome. What is more, maintenance provides an opportunity for demonstrating the relationship that exists between the condition of the machinery and the level and quality of production.

There is the example of the wager won regarding the repair of a blast furnace in 100 days. The central maintenance workshop personnel had been alerted to the fact that 8,000 persons would be made redundant if the disruption were to last longer than planned. The challenge was taken up: no technical assistance for the repair, but a monitoring function carried out in accordance with international standards.

This is the same philosophy that has been developed in Europe and Japan. Operators are given a sense of awareness and an incentive. The result is measured in terms of the length of time the equipment remains unserviceable. In this way, at a particular lorry manufacturing plant the unavailability factor for certain equipment units was reduced by ten-fold (i.e., from 15 to 1.5 per cent).

Section 2. Eventual reduction of the costs of maintenance

In the field of maintenance the objective to be achieved must be clearly identified. Investment for the sole purpose of increasing the availability of the equipment may produce undesirable effects: maintenance costs become prohibitive and drive up the product sale price. Conversely, refusal to invest in maintenance is equivalent to exposing oneself to the risk of a major accident, whose cost is equally prohibitive. The objective, therefore, should be to control the costs of maintenance, i.e., to strike a consistent balance between the investments allocated to maintenance and the effects of this investment in terms of production hours. By so doing, it is possible to avoid two traps into which many have fallen.

The first trap to be avoided is that of promoting equipment availability at all costs. This was the situation in the case of the power plants already mentioned. These facilities had undertaken an action programme to increase availability (from 60 to 85 per cent). The programme consisted in the purchase of tools to be used in carrying out maintenance operations more rapidly and in an increased reliance on sub-contracting. Maintenance costs went up by 40 per cent (or 60 per cent of direct operating costs apart from fuel). With the slump in petroleum prices, the cost of a nuclear-generated kWh turned out to be too expensive. Maintenance costs had to be lowered without reducing equipment availability (down from 100 million francs to 80 million for a 900-MW plant).

The second trap is to totally neglect maintenance.

This may be exemplified by the case of a lock in a wide-clearance canal. For 10 years no money was spent on maintenance. Then, one day, there was an accident: one of the chains holding in place a 110-ton sluice gate suddenly gave way. Commercial shipping was disrupted for two months and repairs totalled one-third of the initial investment - 16 million francs.

A desirable objective: invest today in order eventually to reap the fruits.

This involves establishing a maintenance service that, while requiring a sizable initial investment, will over the course of time make it possible to cut back costs.

For the purpose of reducing maintenance costs at a large steelworks, an investment was made in a computerized maintenance management system as well as in a "conditional maintenance" (i.e., maintenance-as-required) programme. Initial cost: aproximately 8 million francs producing a 40 per cent reduction in maintenance outlays in two years.

CHAPTER III. PROPOSALS

In order to make progress in the maintenance area in the industrializing countries, it is necessary to select priority action targets, formulate action programmes and establish the roles of the different participants.

Section 1. Definition of international action targets

To undertake actions in all the countries and in all the sectors would have the effect of fragmenting the international assistance. All risk of such a dispersal of effort should be avoided. What is needed is to select specific priority sectors for the launching of programmes, a number of countries to perform a relay function, and certain pilot plants to be responsible for effecting the transfer of experience.

1. Selection of key sectors

What is the point of investing to increase a plant's production if all that is gained is a piling up of manufactured products due to the absence of adequate transport facilities for distributing them?

The sectors in which action can be usefully and effectively taken are those in which bottlenecks occur, with negative effects on the economies of the industrializing countries.

The production and distribution of electricity

Electricity is needed for powering plants and factories. Nothing will be served by putting into effect an action plan at a plant that in any case will be shut down for several hours a day for lack of electric power.

The production and distribution of water

Similarly, if water is required for the production processes, it will be pointless to undertake a maintenance programme at a plant that lacks a reliable water supply. What purpose can be served by repairing irrigation pumps if no water reaches the ducts?

Rolling stock

Because its state of repair is of critical importance to the supplying of the plants and construction sites and to the distribution of finished products.

There is the example of a spiral tube plant that over a period of two years accumulated 12 months of production (200,000 tons) due to the lack of available rail cars for its transport.

Agricultural and irrigation equipment

Because food self-sufficiency depends on it.

Fertilizer production

Because it determines the size of crop yields.

Cement works

Because production deficiencies here may give rise to bottlenecks in the area of housing, but also in the building of plants and infrastructure.

Production of concrete bars and metal shapes

- Because there is a need for steel for use with concrete and for the manufacture of girders for use in the construction of plant frames.

2. The identification of pilot plants by sector and by country

The work performed must be credible. An end should be put to the habit of arranging innumerable visits by experts, who then spend at most a week at the enterprises inspected and whose reports subsequently pile up on the desks of the officials of national and international institutions without ever receiving any genuine follow-up. Further, it is necessary to break with the practice of submitting general recommendations, which, while they may gain the acceptance of those proposing them, fail to generate any real progress at the enterprises themselves.

An in-depth analysis of the situation at a given plant and of its concrete training requirements requires several months of work by a team of specialists: methodologists, inventory management experts, work preparation specialists, etc.

This is the reason why efforts should be focused on a specific plant in a specific country. The selection of this pilot plant should be based on its determination to put an end to its chronic underutilization of equipment and on the fact that it belongs to one of the key sectors.

The experiment, if successful at one plant, may then acquire the force of example and add to the credibility of action taken at the international level.

3. Publicizing past experience

The thorough performance of any operation takes time. And rather than recommencing the same experiment in each country, it will be enough to make known what has already been achieved. Here, it is the pilot enterprise that will act as the relay point, permitting other plants of the same sector in the same country or in neighbouring countries to profit from its accomplishments.

Section 2. Definition of a framework for the programme of action

This involves defining the areas of action. It is of no use at all simply to train maintenance personnel; in parallel, the machinery must also be overhauled and the organizational structures and existing procedures brought up to date. For these reasons, the need is for the maintenance training initiative to be accompanied by a general and long-term overhaul programme.

1. The objective: to combine maintenance recovery and training

It will hardly be satisfactory to provide training on the one hand, while carrying out separate recovery operations on the other. But this is precisely what happens in the majority of cases. A group of experts analyses the spare parts

requirements, organizes the storage facility and establishes a system for the coding of the parts. In parallel, the future warehouse foreman is sent abroad for training. The design of this training is divorced away from the actual work-place at which he will be called upon to perform his duties.

The result is that, upon his return, the individual in question will have to adapt himself to an organization in which he may be completely lost.

Thus, it often happens that following the departure of the technical assistants the transfer of technology breaks down: the national staff have at their disposal tools with which they are not always familiar for the reason that they themselves did not produce them, and also because these tools, although designed by highly qualified foreign specialists, are not always optimally suited to local conditions.

For example, when drafting technical documents, such as guides, notes and organizational manuals, consideration must be given to the culture and language of the country concerned.

Paralysis of the technology transfer process can be avoided by providing on-the-job training, while at the same time undertaking the restoration of a given maintenance function or the repair of a machine.

In this way, warehouse workers will be trained in the techniques of storing and preserving parts, while simultaneously participating in the task of putting the warehouse in order.

Those responsible for the preparation of the work will be trained in the techniques of estimating the time required for repairs, while at the same time participating in the drafting of the equipment maintenance guides.

The maintenance mechanics will additionally be trained in working methods (e.g., the alignment of a lineshaft) in parallel with the performance of maintenance operations on turbines, diesel groups, etc.

2. "Action-training"

This is action-oriented training in the various maintenance skills or occupations that are required. The idea is to call on technicians specializing in a particular skill area to impart work-place training to their counterparts and at the same time to contribute to the recovery of the enterprise.

2.1 Twinning

It is possible to imagine that this training might be based on a "twinning" of the selected enterprise with another enterprise in which a well-developed maintenance programme is in effect.

2.2 Instructors

Exchanges of operators might be arranged on a position-by-position basis.

For example, the warehouse foreman of one electric power plant might be assigned to a sister plant for the purpose of learning together with his counterpart at that facility.

This approach is interesting in that it makes it possible to identify the difficulties encountered in the performance of a specific occupation (skill area) and to devise a training plan geared to address these difficulties.

The idea is to propose the method recently applied successfully in France (the Schwartz mission). Through this method, young persons have been trained on the basis of the acquisition of a specific skill area. An instructor (French: "tuteur"), a journeyman worker responsible for a specific position in the plant, is given the responsibility of working with each of the trainees and of helping him acquire the skills of the occupation in question. A professional trainer monitors and provides hands-on support for the work of about 12 young persons. Required time: two years.

2.3 Exchanges

These exchanges could take place in the following fashion. Instructors, specializing in a particular maintenance skill area, might spend regular periods of time at the enterprise to be assisted. This implies the presence of at least one trainer with a specialist's knowledge of the skill areas and as many instructors as there are skill areas. The specialist trainer will both analyse the technical problems to be dealt with and will implement the training plan. The instructor is responsible for systematically monitoring the work of his counterparts in the immediate job environment.

3. Training for which skill areas?

It would be wrong to wish to provide simultaneous assistance for all the maintenance functions. In order that the needed repairs can be carried out, certain tasks must be performed. These are grouped together and classified within the major maintenance functions. What this means is that proper repair requires that certain functions be handled on a priority basis and that it is these that should be tackled ahead of the others.

We propose carrying out the following activities on a priority basis:

- Diagnostic survey and inventory of the condition of the machinery, installations and technical documentation;
- Diagnostic survey of the organizational structures in place, procedures and human resources.

In the light of the above, it will then be necessary to deal successively with the following functions:

- Supply of spare parts, inventory management and storage;
- Formulation of the preventive maintenance programme (methods function);
- Preparation of the maintenance work and establishment of the maintenance guides;
- Scheduling and initiation of the work;
- Maintenance cost management and accounting;
- Physical execution of the actual maintenance operations on the machinery.

The above functions will require training in the following occupations (skill areas):

- Maintenance audit for the diagnostic survey of requirements;
- Code clerk, inventory manager, purchasing agent, warehouseman and controller (for the supply, inventory management and storage functions);

- Workers in charge of the prinicipal functions;
- Methods preparer, by technique;
- Drafter of guides and documentation, by technique;
- Scheduling and initiation officer;
- Manager;
- Technicians and operators, by technique.

4. What products are to be produced for the transfer of experience from the pilot plants to the enterprises of the same type?

A number of key sectors have been chosen in order to avoid repetition of the same operations. In order that each experiment may be of profit to enterprises of the same type, the pilot plant must specifically develop certain reports that contain a record of its accomplishments.

Three remarks:

These reports are crucial to the success of the transfer of experience between plants and between countries. The targeting of a plant by key sector and by country can only be effective if the action is subsequently replicated by other enterprises in the same sector. The experience gained by the pilot plant must be retransmitted. Hence the need for reports, which remain necessary even if the transfer process must in turn involve exchanges of persons.

The preparation of these reports necessarily involves the need to adapt them to the individual conditions of each enterprise and each country. The documentation prepared at the pilot plant may always be used as a working basis, thus eliminating the necessity of beginning again from scratch.

For example, the establishment of maintenance guides for an electric power plant represents between 40 and 70 man-years of work. Hence the interest in saving a substantial part of this time by drawing on the documentation that another enterprise of the same kind has produced at the end of the programme.

The preparation of these reports by the pilot enterprises of the industrializing countries is an indispensable stage: because they give concrete expression to the know-how acquired by the enterprise in question; because they provide a possible basis for the training of other agents; and because they facilitate the transmission of the skills acquired to other enterprises. Finally, these records are more closely geared to needs of the industrializing countries than those of a model enterprise, whether in Europe or Japan.

The kind of documentation referred to might include maintenance guides for a given family of equipment (steam turbines, cement-works furnaces, etc.), as well as rules for the coding of spare parts, warehouse management manuals, handbooks covering procedures for maintenance organization, the training programmes for specific skill areas, audio-visual training techniques devised, etc.

Section 3. Definition of programme guidelines and the role of the various participants

1. Guidelines for the establishment of the seven pilot projects

The proposals formulated above may be developed around the following phases:

- Selection of the countries accepting the co-operation programme, with the specification of the industrial sector and the pilot enterprise;
- Establishment of a local structure to support the operation and to act as a focal point for the transfer of experience within the industrial branch in the host country and as an element of an international maintenance information network;
- Preparation of the diagnostic survey of the situation at the pilot enterprise, conducted in parallel with training in maintenance auditing; the pilot enterprise is assisted by the local support structure;
- Formulation of a recovery plan, quantification and completion of implementation planning. This concerns simultaneously the overhaul of the machinery and installations, the revamping of the organizational structures already in place, the training for different maintenance skill areas, and the preparation of documentation and procedures;
- The formulation of a plan for the financing of the pilot enterprise recovery programme (national and international assistance);
- Execution of the plan with the support of the local structure; publication and dissemination of the documentation and procedures developed;
- Transfer of experience to the enterprises of the same branch within the country with the support of the local supporting structure; later on, transfer of the experience to the other countries.

2. The role of the different participants

It will be up to the Governments of the industrializing countries to create a supporting structure for the operation, which might represent the first step towards the establishment of a maintenance institute. The purpose of this structure will be to assist the pilot enterprise, a voluntary entity, during the different phases of the programme.

It will also be up to the Governments to bring together the financial resources for the implementation of the pilot enterprise recovery plan.

It will be the task of the sectoral enterprises to indicate their interest in the operation and to determine what working procedures should be followed within the branch for following up the progress of the operation.

Countries desiring to develop technical co-operation will be called upon to determine the modalities of assisting the programme: help in the establishment of local maintenance institutes, the provision of specialists and trainers, sponsorship of a pilot enterprise by national enterprises, granting of loans for the implementation of the recovery plan.

UNIDO's task will be to take charge of the pilot phase and the promotion of the operations. Specifically, UNIDO would be responsible for the publication of the documents, the preparation of the audio-visual materials, their translation and their dissemination. The Organization must provide the means necessary for promoting the transfer from one country to another of the experience gained through the pilot experiments.

The international financing agencies can contribute the funds required for the execution of the co-operation programme.