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Background document

IMPROVING MAINTENANCE IN DEVELOPING COUNTRIES: THE ILO APPROACH*

Prepared by

The ILO Management Development Branch

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Glossary

Abbreviations used in the text

EMI	Ethiopian Management Institute
GNP	Gross national product
GTT	Guided transmission training
HRD	Human resource development
ILO	International Labour Organisation
OECD	Organisation for Economic Co-operation and Development
P&M	Production and maintenance (in "Operation P&M", a training programme described in the text)
PIC	Productivity Improvement Centre (a department of EMI)
PIM	Preventive inspection and maintenance
ROM	Results-oriented management training
ROT	Results-oriented technical training
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organisation
VTI	Vocational Training Institution

Contents

Improving maintenance in developing countries: The ILO approach

(Background paper for the UNIDO Second Global Consultation on the Training of Industrial Manpower)

1. Introduction: the maintenance challenge

A UNIDO Symposium in Tokyo in 1973 estimated that in the developing countries the cost of reduced life of plant and equipment attributable to faulty maintenance practices amounted in total to between five and seven billion US dollars per year. That is to say, simply to maintain their production capacity at the existing levels, developing countries were paying around six billion dollars per year more than they need have paid. And that figure refers only to plant life. It does not include the loss of production due to breakdowns and to plant being forced to run below capacity, or the loss of revenues from both national and export markets because of defective product quality, all of these attributable to defective maintenance. These cannot be quantified, but must easily amount to as much again.

These were 1973 dollars, a very different thing from the 1987 dollar. Notice also that this drain on the resources of the developing countries has not, from all accounts, perceptibly diminished since 1973. So in very rough terms we can estimate that defective maintenance is currently costing the developing countries, collectively, upwards of 20 billion dollars per year.

This lack of attention to maintenance is not confined to the manufacturing industry. It is apparent in tractors and farm equipment lying rusting in fields, in pot-holed roads that were built at great expense only a few years ago, in road transport vehicles scrapped after half or less of their design life, right through to hotels that drive tourists away because of defective plumbing and other services.

Less apparent, but certainly very important, is the effect of faulty maintenance on the costs of oil imports. After the "oil-shock" of 1974 the OECD countries had, by 1980, succeeded in reducing their overall energy consumption per unit of GNP by 18 per cent. The great bulk of this saving came from "good housekeeping" measures, such as repairing and replacing damaged insulation, repairing and re-adjusting thermostats, cleaning lighting fixtures, repairing steam and compressed air leaks, and so forth - all of these simple, basic, routine maintenance chores. If the OECD countries, with their relatively high maintenance standards, were wasting energy at this rate then the wastage rate in the developing countries must have been, and still be, enormous. To give some idea of the magnitude of this a 1984 World Bank study in Costa Rica (population 2,5 million) estimated that savings in petroleum imports of over US$4 million per year could be obtained by applying industrialised-country standards of servicing to the fuel injection pumps of just one-half of the country's buses (Realistically, the study estimated also that no more than half of the country's bus operators would make use of the services of a fuel injection pump servicing centre).

All this adds up to a sombre picture. But it also has its brighter side. The developing countries are sitting on their individual gold mines of resources that can be tapped by simply acquiring a maintenance culture. All that is needed is a certain amount of training, a good deal of education and indoctrination, and competent management. It does not mean working harder, just working smarter. Indeed, instead of working harder it will in most cases mean working easier. The progress of an ILO maintenance project was at one stage imperilled by the threat of strike action by the maintenance workers of the participating factories. The reason for this was that the introduction of preventive maintenance procedures had so much cut down breakdowns that the maintenance personnel were no longer needed to work overtime on emergency repairs, with the result that their take-home pay had been sharply reduced. It is pleasing to report that this situation was resolved by the simple expedient of paying the maintenance workers their previous average earnings including overtime. The factories were gaining because machine availability had been increased and maintenance parts costs had been brought down by using cheap consumables (gaskets, oil filters, etc.) instead of expensive spares like bearings and crankshafts. The maintenance personnel were delivering better results than before, so why not pay them at least as much as before?

The essence of what was said above is that improved maintenance in the developing countries can only come from changed behaviour in the workplace, and this change must be present throughout the whole organisation. Certainly the maintenance personnel must be properly trained, but if they are to be able and willing to do their job properly they must have the active support of everyone else. The production personnel must be trained and motivated to handle the equipment properly and be alert for incipient trouble. Production management must be prepared to collaborate actively with maintenance services in arranging production schedules so that machines can be made available for overhaul. The accountants must be able to give the maintenance manager the cost data he needs to understand the financial implications of various maintenance approaches, and to justify his budgetary requests to the finance department. Top management must explicitly state and demonstrate in action that maintenance is a fundamental function, which enjoys full moral, technical and financial support and authority commensurate with its responsibility. The whole organisation, in short, must be oriented towards keeping its assets in peak operating condition, and developing a real "maintenance culture".

Of course, this maintenance culture must also apply outside the organisation. A trainee in a vocational training institute in which half or more of the equipment is unusable for lack of maintenance is unlikely to take a maintenance culture with him into his future job. Similar influences can be obtained even down to the primary schools. At the government level, policies that grant concessional tariffs and exchange rates for the importation of capital equipment but penalise the importation of spare parts do nothing to inculcate a maintenance culture amongst civil servants and administrators.

2. Maintenance and the ILO

Effective maintenance in industry and other sectors is almost in its entirety a "people" problem, a problem of acquiring a maintenance culture, a problem of human resources development and of competent management. Therefore ILO's human resource development activities must play a key role in helping to achieve these fundamental improvements. Another reason for the ILO's interest in better maintenance rises out of the Organisation's concern with conditions

of work and life. Here good maintenance plays a substantial role. A poorly-maintained machine, frequently breaking down and needing constant adjustment, is a source of frustration for the worker. With many types of equipment poor maintenance leads to injury and can cause even death. The level of pay that the worker can receive is affected by maintenance: in the long run pay depends upon productivity, which in turn depends upon good maintenance. All these factors constitute a very strong reason for the ILO to be deeply interested in maintenance.

The ILO experience: historical context

The ILO programme of technical co-operation in human resource development began in the 1950s, with the setting up of vocational and technical training centres and with the sending of productivity missions to show what could be done to raise productivity at the shop floor level by better management. Because of the very limited funding then available through the Expanded Programme for Technical Assistance (EPTA) these were usually very small projects, of brief duration, and often national participation was not guaranteed. Thus, although many of these "demonstration" projects produced very good results while the experts were in post, there was a tendency for activities to disappear when the projects terminated.

By the end of the 1950s the resources available for technical assistance were greatly increased with the establishment of the UN Special Fund, later to become the UNDP. This made it possible to mount larger projects, with a wider range of expert skills and of much longer duration. At the same time it became the practice for governments to participate, providing buildings, support services, offices and salaries of national staff. This was the start of extensive "institution building" in which technical and vocational training centres and productivity and management development centres were set up on a permanent basis.

This was an immensely fruitful period. The institutions set up with the help of the ILO Vocational Training Programme qualified tens of thousands of young people as skilled workers, while the productivity and management development centres set up or assisted by the Management Development Programme were instrumental, through direct consultancy services and management training, in improving the economic performance of thousands of enterprises.

At the beginning, the Management Development Programme focussed on productivity improvement at the shop floor level. As the clients of the newly established productivity centres became more sophisticated in their management skills, other areas of management expertise were added (marketing, finance, business strategy, computers, information systems, etc.), although industrial engineering and productivity improvement remained major activities. Since effective maintenance is an integral part of productivity improvement, maintenance management training was seldom identified as a separate activity in the projects. Training in maintenance techniques and management was thus often provided as part of training in industrial engineering, production management or productivity improvement. There were, however, several projects devoted exclusively to maintenance. One of these, in Thailand, among its activities gave maintenance assistance to a sugar mill, which was so successful that a local shortage of sugar-cane was created, resulting in increased prices having to be paid to the farmers.

This predominantly institution-building period lasted until the late 1970s. By this time almost all countries had their own management training and/or productivity centres, and the ILO role became that of helping these centres to expand their activities into sectors other than manufacturing industry. These areas include construction and road transport, in both of which maintenance is a key issue. Another new area of emphasis was on organisational performance improvement, by putting into effect what has been learned through training, through a combined effort of an organisation's management and staff, and with the support of external consultants if necessary.

The Vocational Training Programme of the ILO also started its activities in the early 1950s. It worked mainly in pre-service training (apprenticeship training being taken as pre-service), assisting in the establishment and development of vocational training institutes (VTIs). At the beginning the training given in the VTIs was traditional in form, preparing trainees for employment in well-defined categories of trades, using long-established criteria. This training was not explicitly divided into maintenance and non-maintenance areas, although of course some trades are by their nature concerned entirely or almost entirely with maintenance and repair (for example, automotive mechanics, radio and TV servicing) while others, such as most of the building trades, are predominantly production-oriented. In the

case of the engineering trades (mechanics, welders, electricians, fitters, etc.), although few tracer studies were carried out, it is likely that the majority of those graduated found employment related to maintenance and repair.

This programme was well suited to the conditions that existed. The traditional trades were what was needed by the traditional industries of the developing countries. As time went on, however, the existing industries were modernised and new industries with newer technologies were introduced, and a discrepancy started developing between the skills needed by industry and the skills being imparted in the VTIs.

The ILO field projects responded to this new challenge by progressively moving away from the traditional curricula towards competencies-based and individualised training. To enhance flexibility in adapting to labour market requirements, modular vocational training programmes were developed and introduced in many countries. This was an important development for training in maintenance. Skilled maintenance workers have to possess multiple skills. With the increasing application of various forms of automatic control they also have to understand the principles of electronics, hydraulics and pneumatics. Modular and flexible training methods are increasingly required.

The ILO experience: current approaches

Maintenance improvement (and maintenance training) can be visualised as taking place in three stages:

Stage 1: Basic maintenance management (good housekeeping), which consists essentially of moving from a breakdown maintenance practice to a preventive inspection and maintenance (PIM) practice. Inspection and servicing schedules must be set up and followed. Maintenance workers must be retrained in PIM techniques. Production personnel must be checked for practices which abuse machinery, retrained if necessary, and sensitised to the need to detect and report incipient breakdowns. The whole enterprise must acquire a maintenance culture.

Stage 2: Minor modifications to plant and equipment to improve maintainability and reduce the incidence of breakdowns. Possibly introduction of more sophisticated maintenance technologies and management systems.

Stage 3: Evaluation of new equipment purchases for maintainability and reduced cost of maintenance.

Of these three, Stage 1, basic maintenance management, is by far the most important, because without a PIM system in place the other two are almost irrelevant. With a PIM system operating the other two stages, maintenance engineering and technology, have contributions to make. The ILO approach, therefore, is to focus on Stage 1 first of all, and this approach is reinforced by the observation that in enterprises in the developing countries PIM is often totally absent and when it is present it is often poorly carried out. This is coupled with our experience that it is in installing PIM that the commitment of scarce training resources gives the best results in real terms of production and productivity improvement.

In preparing maintenance programmes (and indeed all technical co-operation programes) the ILO, in common with most international agencies, makes use of project documents and proposals drafted according to a rather comprehensive set of rules, governing the definition of key factors such as objectives, activities, inputs, indicators of achievement of objectives, and so forth. This is useful in avoiding possible confusion and misunderstanding, and the use of a standard format is also helpful for the donor agencies when they come to evaluate programmes and project proposals. By its very nature, however, it cannot contribute very much to the actual design of a programme. This design, which covers such things as the training and other activities to achieve the programme objectives, choice of training methods, ways of motivating the trainees, etc. is critical to the success of the programme, and must take into account all particular local circumtances. As such it cannot be done "by the book" according to some kind of standard programme design manual.

However, it is useful to follow certain guiding principles, which have been identified by examining and analysing successful field interventions. These principles apply to management development and training in general, and to training in maintenance in particular. While they are not absolute rules like the proverbial laws of the Medes and Persians, ILO's experience has been that the greater the degree to which they are satisfied by the programme the more likely is the programme to be effective, and to render a good service to the "client" (which can be a government, an enterprise, a training institute, etc.).

(1) Results-orientation. The programme must be designed so as to obtain desired, beneficial results in the participating enterprises. This has been a consistent feature of ILO programmes since the earliest days, when direct consulting services and training of consultants were given priority over training productivity-centre personnel for merely giving courses. In recent years additional emphasis has been placed on results measurement, to strengthen the results-orientation. In some cases this measurement might be satisfactorily expressed in technical terms, for example "machine down-time reduced from 20 hours per month to 6 hours per month", but as far as possible the results should be expressed in terms of money, i.e. as money saved and/or as revenues increased. Thus, the down-time reduction above could also be expressed as "sales value of additional production due to reduced down-time US$5,100". This is important for various reasons. The idea of human resource development as an investment rather than just an added expense receives much more credibility when benefits are reported in money terms. Also, once a set of results has been reported this becomes a new standard against which future performance can be measured, and will tend to prevent backsliding to the "old ways " when the enterprise ceases to receive assistance from the training institution. As a final bonus, once the operations managers have learnt to work with useful operations reports (which are needed for measuring results) this will, it is hoped, lead them to demand meaningful management accounting reports from their accounting colleagues. At present management- and cost-accounting are very deficient in most developing countries.

(2) Pressure for change. The client organisation must be under significant pressure for change. This is vital, because undergoing change is always an uncomfortable process, and will only be undertaken if the results of not changing threaten to be even more uncomfortable. The pressure, in a private-sector organisation, will normally come from economic factors, such as lost profits or a threat of bankruptcy. In state-owned enterprises the pressure normally comes from the parent ministry, but it is preferable if such a pressure also comes from the clients and from competition on the market.

(3) Commitment from top management. If the relevant senior managers are not interested in the programme then nothing will happen. At the very least they must be prepared to make the necessary resources available (usually in the form of releasing personnel to work on project activities) and "tolerate" the new programe, but it is obviously much better if they take a direct interest.

(4) Willingness to experiment with new solutions. This usually has to be present in both the client organisation and the training organisation concerned.

These last three principles might be considered as pre-conditions which must be present if the programme is to have a reasonable chance of success. It is not often that all these pre-conditions exist. Sometimes one or more of them have to be "engineered". This can require some skill and subtlety on the part of the programme manager, who has to persuade everyone concerned that the potential benefits he can obtain from the programme are much greater than the costs and risks involved. The advantages of results-orientation and measurement show even at this early stage; persuading people to support a programme is much easier when the potential benefits can be expressed in money terms which everybody understands.

Conditions (3) and (4) above will be recognised as corresponding to the concepts of "godfather" and "champion" which feature prominently in discussion of innovation in enterprises. It is somewhat paradoxical, and from the point of view of international organisations such as ILO and UNIDO, a matter for considerable concern, that while the bodies they usually collaborate with, such as national productivity centres, would normally be expected to play the role of "champion" (i.e. the advocates of innovative training methods), these bodies, as government agencies, are not always in good position to take the risks involved in introducing innovative training and performance improvement techniques, although there are certainly quite a few notable exceptions to this statement.

Thus in "engineering" pre-condition (4), a willingness to experiment, particular attention must be paid to the training institution. The initial steps in the programme should be designed to minimise both the risk of failure and the potential costs of failure. The other side of the coin, of course, is that if the programme is successful the institution must get its fair share of the credit.

The following principles refer to the implementation phase of the programme, rather than to the pre-conditions, and are less absolute than the three pre-conditions described above. They are not rules that must be obeyed under all circumstances. However, they are important enough that every effort should be made to incorporate them.

(5) Problem ownership. Each participant must be working on a live, real problem, a barrier to obtaining improved results concerning his work. He "owns" this problem, and works to solve it in the course of the programme. This means that the programme must be designed around problem-solving activities, and not around training activities. It also means that the first activity of the programme will be fact-finding, discovering what the prospective participants believe to be their principal problems. The situation to be avoided is for the training centre to decide on what it thinks the problems are (without any preparatory fact-finding) and then design a programme around these hypothetical problems. However, there is one exception (but only an apparent exception) to this principle. It will sometimes happen that the training centre identifies the lack of adequate data collection in the client enterprises as a major problem area not noted by the participants. It is not noted as a problem because the participants have become accustomed to working without data and have adopted management objectives which do not require data. In such cases participants have to be persuaded that one of their first activities must be to introduce suitable data collection procedures. Normally little difficulty will be met in this, because participants aiming at improved results quickly perceive that the data are needed to prove that results have indeed been obtained.

(6) Learning from peers. It has been our experience that people learn from their peers (i.e. other people doing similar jobs) much better than they learn from trainers or teachers. By "learn better" we mean that what is learnt is translated more effectively into changed behaviour in the work place. This has implications for training activities, which take much more the form of discussion groups and participative work than traditional classroom teaching.

(7) Practicality of training. Such formal training as is given in the programme is directed at obtaining immediate results in practice. No attempt is made to teach skills or techniques that "might" be needed. When participants find a need for a skill or technique in attacking their problems the training is arranged, but not otherwise.

(8) Recognition of results. When a programme is designed to obtain measurable results and the problem-ownership principle is applied it is easy to evaluate each participant's contribution. This contribution must be recognised. Recognition of success leads to emulation by others. Lack of recognition has the opposite effect.

(9) Success breeds success. If the initial activities give good results this gives the participants confidence and encourages them to continue. It is therefore sound strategy to design the programme so that the first activities have a high chance of success, i.e. select straightforward problems.

(10) Unity of the enterprise. It is extremely difficult to introduce significant change in an enterprise by training only one individual or the personnel of one unit or department. No matter what shape the organisation chart may take, all units and departments are interlinked, sometimes in quite complex ways. So improved maintenance standards will not be achieved just by training specialised maintenance personnel. All employees must develop a maintenance culture. As mentioned earlier, this is not just a matter for the enterprise alone - it is also the responsibility of business schools, engineering schools, and vocational and technical training institutions to inculcate such a culture.

(11) Full-cycle support. Results-oriented training is not complete until results have been obtained. In an enterprise this usually means that new systems, procedures, etc., have been introduced and are operating - that changes of some kind have been implemented. This is almost always a difficult and uncomfortable process, and unless the trainer-consultant remains available to provide support (coaching, encouragement, etc.) the attempts to introduce changes are likely to be abandoned.

(12) Multiplier effect. Training resources are always modest in comparison with the training needs. If training programmes are to have significant impact they must be designed to exploit the multiplier effect. Each person trained must not only be able and willing to train others but also must actually do so.

(13) Sustainability. This means that the organisation which receives training and consulting assistance must be both able and willing to continue the programme itself. This implies that the training methods used should not require highly-specialised training personnel and that the benefits obtainable should clearly outweigh the costs involved.

These principles have been described as applied to management development. While they apply equally to vocational training, they appear in ILO vocational training programmes with, in some cases, slight differences in phrasing and emphasis. Thus, the "unity of the enterprise" principle is usually rephrased as the principle of involving management in training. The reason for this is that whereas changing the working behaviour of a manager will almost always involve changing his working relationships with the managers of other departments, this does not apply in the case of shop-floor workers. In their case the working relationships with their supervisors and managers change, but not those with workers in other departments. ILO vocational training programmes also include an additional principle, that of career-long training. In the case of management training this is taken for granted, as management development centres and business schools are accustomed to providing courses for practising managers at all stages of their careers. Very few vocational training institutions in developing countries, on the other hand, provide skills up-grading or skills-broadening opportunities for people already in work.

The main difference between management-level and worker-level training design is in creating the pre-requisite condition that the training institution be willing to innovate. This is usually more difficult in the case of vocational training institutions. There are various reasons for this, such as the lack of suitable training equipment and the absence of working contacts between enterprises and institutions, but the principal reason appears to lie with the trainers. They are accustomed to working with young, inexperienced trainees, and may be concerned at the prospect of having to work with supervisors and foremen, people who have more practical experience than they themselves do. However, the evidence suggests that once having taken the plunge the trainers find that working with the experienced people, training them to carry out in-service training of their subordinates, is most stimulating and professionally rewarding. It may well turn out that the documentation and publication of a few successful innovative vocational training programmes will do much to reduce reluctance to innovate in the future.

3. Case history: the maintenance improvement programmes of the Ethiopian Management Institute

The application of these principles will be illustrated by the experience of the Ethiopian Management Institute (EMI, previously the National Productivity Centre, NPC) with international technical co-operation provided by UNDP/ILO. This project started in 1978 and is still continuing, although its thrust has changed considerably over the years. Experience has led to gradual improvements and variations in programme design have been needed to cope with different tasks assigned to EMI.

At the start this was a technical assistance project in the classic style, aimed at improving productivity through consultancy assignments by EMI personnel and set courses in EMI with courses based on textbooks. Within a very few months it became obvious that this approach was not satisfactory. The consultancy assignments required far too much scarce expert time, the consultants' recommendations were rarely implemented, and the courses were received with only polite interest. Something else was needed.

Results-oriented maintenance (ROM)

Since it had also become obvious that faulty maintenance was the factor principally responsible for the low productivity in the industrial sector, a fact-finding exercise was carried out. Maintenance managers in 60 state-owned factories were sent a questionnaire listing a large number of maintenance-related problems, asked to assess how severely these problems occured in their own factories, and invited to attend a one-day workshop to discuss the results. The workshop was attended by 43 maintenance managers.

By the end of the day the group had identified 15 problem areas which were agreed to be of first priority. The next step was for EMI to develop a problem-solving course around these 15 items. An attractive leaflet describing this course was prepared and circulated to the top managers of the factories represented by the 43 participants, requesting them to release their maintenance managers to attend the course. All the top managers agreed.

The course, which was highly participative, was well received by the participants. As a follow-up, in order to give a greater sense of realism and to reinforce the teachings of the course, the participants were formed into six groups and each group assigned a maintenance consultancy in one factory. During these assignments, which lasted six weeks, the group leaders met weekly with EMI personnel, who acted as coaches rather than trainers. Whenever a participant asked for information or for help, the EMI personnel refused to answer directly. Rather, they urged him to find out for himself, by self-study, or more usually from other participants present at the meeting (an application of the "peer-learning" principle and of increased responsibility for one's own learning).

At the end of the assignment, which was signified by the endorsement by the manager of the client factory that the group's recommendations were ready for implementation, formal presentations were made by each group to the management of the factory. Representatives of the factory's parent corporations and of the Ministry of Industry were also present. This exercise had gone well, and so the EMI team was encouraged to repeat the programme (with the necessary adjustments) for the maintenance foremen and the production managers of the 43 factories. The need for this had not been foreseen: it was done at the request of the original set of participants, who had quickly seen that they would be unable to effect any significant improvements in their factories by their own unaided efforts ("unity of the enterprise" principle).

As a training activity the programme was a success. But in terms of practical results it was, to say the least, disappointing. Very few of the improvement projects developed by the programme were implemented. When the EMI support was cut off as the participants returned to their jobs the impetus that had been generated slipped away (failure to apply full-cycle support).

To remedy this fault, EMI added a fourth stage, Step 4 (internal consultancy) to the existing three stages (fact-finding, problem-solving training and external consultancy) of the programme. In the next two programmes, for maintenance foremen and production staff clerks, the participants were required to implement a maintenance improvement project within four weeks of the end of the programme. With follow-up from EMI, almost 90 per cent of the participants had produced and implemented projects by the end of four weeks. These involved 26 factories.

Thus far, the results obtained, although considerably better than would be expected from the original consultancy-plus-classroom-training approach, were still disappointing. Out of a target population of 140 state-owned factories only 43 had shown any interest in maintenance improvement and of these only 26 had actually done anything about it. In retrospect it is not difficult to see what had gone wrong. Of the three pre-conditions, pressure for change, top management commitment, and willingness to experiment, only the last was present to any degree. Of the implementation principles, problem ownership (principle 5), was applied only to a small extent. The fact finding part was done well, but only in the last two programmes were the participants made to feel personally responsible for actually implementting a needed improvement. Principles 6 and 8, peer-learning and recognition of results were implemented well, but the training was still on problem-solving rather than on actual implementation of the solutions, so that principle 7 was only partially fulfilled. Of the remaining principles only the full-cycle support (principle 11) was fulfilled and then only in the last two programmes. Most important, the over-riding principle, results orientation (principle 1), was not applied consistently.

However, EMI had already learned a good deal from these exercises, and it was at this stage that it introduced the principle of results orientation, which transformed the whole approach. The start was to evaluate the results obtained in the programmes to date. In six of the factories it was found possible to evaluate in money terms the effects of the actions implemented. These gave annual contributions of US$1.3 million, made up of increased production, expected extension of machine life, decreases in rejects, and reduced spare parts consumption.

This was a very encouraging result in its own right, showing EMI that they were on the right track. It aroused, somewhat to EMI's surprise, great enthusiasm among the personnel of the six factories, who became very proud of their achievements. It also attracted the interest of the Ministry of Industry, which later was to profoundly affect the programme.

These findings led to a major reorientation, within EMI, of the thrust of the programmes. Step 1, problem identification, now focussed much more strongly on the estimation of potential results (in money terms), and an additional step was added, measurement of the results actually obtained. The whole programme now received the title Results-Oriented Maintenance, or ROM.

Then a stimulus was given from outside EMI which led to the full formulation of ROM. In February 1982 the Ministry of Industry had issued a set of Production and Management Guidelines to be followed by all the state-owned factories. These were essentially standard procedures, governing production scheduling, work ordering, capital budgeting, and so on, that one would expect in any well-run factory. Most of the 140 state-owned factories found a good deal of difficulty in implementing the procedures, however, so in November 1982 the Minister of Industry asked EMI for help in getting the guidelines installed and operating.

This was a new situation for the EMI team. Here the task was clearly defined, but the scope was massive. The four members of the team could not deal with 140 factories by themselves. ROM would be needed, with the implementation to be done by factory personnel. However, a modification was needed in ROM. Previous programmes had aimed at identifying and solving individual problems. Here the problem was common, failure to implement the guidelines. So Step 2, problem-solving training, was replaced by implementation training under the title of Step 5, Step 3, external consultancy, was dropped from the programme, and Step 4, identification of an internal problem and implementing a remedial project, was replaced by Step 6, accelerated implementation of the guidelines. Evaluation was done in two stages, Step 7 which evaluated the degree to which implementation of the guidelines was achieved, and Step 8 which measured the results obtained in monetary terms. (The various steps were numbered as indicated instead of being re-numbered as Step 1, Step 2, etc. in order to avoid confusion in the documentation). Here at last was a programme structure which incorporated the elements of all the principles described earlier. Some refinements and extensions were still to come, but all the basic structure was now in place. It was as follows:

Step 1: Fact-finding. In this case, failure to implement the guidelines was already known to be the problem.

Step 5: Implementation training. A course specifically on how to implement the guidelines.

Step 6: Accelerated implementation. An agreed schedule was drawn up detailing each step in the implementation procedure, when it was to be completed, and who was responsible for carrying it out.

Step 7: Implementation evaluation. This was a report for the client, the Minister of Industry, detailing the extent to which the guidelines had been put into practice.

Step 8: Results evaluation.

Principles applied in ROM

It will be interesting to review at this point how the new structure reflected the 13 principles explained in the previous section of the paper.

Results orientation. In the course of studying the problems affecting implementation of the guidelines, the EMI team estimated the potential results of full implementation. These (admittedly very rough) estimates amounted to US$100,000,000 in increased production and a saving of US$25,000,000 (all in foreign exchange) in consumption of spare parts.

Pressure for change. The above figures were equivalent to about 7 per cent of the GNP of the Ethiopian economy or, more strikingly, to a 40 per cent increase in the country's industrial production. The fact that the factory managers knew that the Minister of Industry also knew these and the above figures certainly exerted no little pressure for change.

Top management commitment. The potential results amounted to almost one million dollars per factory. Only the most complacent managers could ignore this.

Willingness to experiment. This was already present in EMI and started developing in the enterprises concerned.

Problem ownership. This was now fully implemented for the first time. Each factory was responsible for installing the procedures in the guidelines, and EMI's role was simply that of helping it do so.

Peer learning. Highly participative training and peer learning had been a feature of the EMI programmes from the beginning.

Action-oriented training. This was now taken to its logical limit. The purpose of the programme was to implement the guidelines. So each participant was given a 31-step implementation schedule form and the training concentrated on the meaning of each step and how to prepare the schedule. Apart from this the only other instruction on the course was about overcoming resistance to change.

Recognition of results. Arrangements were made for all the participating factories to present their results. At this the Minister of Industry was present, and personally presented gold plaques to the 15 factories with the best results.

Success breed success. Since only three months' time was allowed for the implementation step it was impracticable to expect the full set of guidelines to be installed. EMI personnel counselled the factories on the choice of implementation sequence.

Whole-enterprise involvement. It was obviously not going to be possible to give training, even sensitisation training, to all the 85,000 employees of the state-owned factories. However, to ensure that at least all the key personnel in each factory understood what was going on, 15 people, one from each corporation (the 140 state-owned factories are organised under 15 corporations) were appointed to act as liaison officers with the EMI team and given the responsibility of providing sensitisation training to at least six people in each participating factory. This was the forerunner of what later became Guided Transmission Training (GTT).

Full-cycle support. EMI stayed with the programme all the way through; team personnel even attended the weekly implementation progress report meetings.

Multiplier effect. This was applied in the form of the 15 liaison officers. Although not fully implemented (they only gave a limited degree of training) this nevertheless constituted a model for full implementation in later programmes.

Sustainability. As this was a campaign programme, to be completed in three months, no attempt was made to incorporate sustainability. This would have required much more training of the liaison officers. However, it is clear that sustainability could easily be incorporated by providing such training.

Transition from ROM to Operation P&M

The programme was carried out in the form of a campaign under the title "Operation P&M" (because the guidelines covered both production and maintenance). Participating factories were considered to have completed the exercise when they had carried out Steps 7 and 8. This consisted of filling out two forms. Form A was a self-evaluation of the extent to which the guidelines had been implemented, while Form B dealt with an evaluation (in money terms) of the results obtained. Those factories which completed both forms were later evaluated by the EMI team to verify the reported results.

The reported participation and completion levels in Operation P&M were as follows:

	Training	Completed		Evaluated
		Form A	Form B	by EMI team
Operation M	110	66	33	27
Operation P	110	75	45	45

At first sight this looks disappointing, only 27 factories out of 110 completing Operation M. But in comparison with conventional training and consulting approaches it is very good indeed since conventional approaches rarely produce actual changes at the workplace. It should also be noted that EMI had specifically asked the Minister not to order the factories to participate, so that dropping out of the programme was relatively easy, with no stigma attached. On the positive side, the two Operations created an ample "critical mass" of top and middle managers who had gone through the implementation exercise, could act as an example to other factories' managements, or could be transferred to laggard factories.

The most striking outcome was observed when the EMI team visited a number of the factories concerned at their invitation to validate the accuracy of the estimates made in completing Form B. For Operation M, the maintenance-related activities, the results of comparing the second quarter of 1983 with the fourth quarter of 1982 were:

Result obtained	US$
Production increase	5,916,000
Waste reduction	223,700
Saving on spare parts	498,600
Value of extended machine life	323,100
Total	6,961,400

A similar validation of the effects of Operation P, carried out in 45 factories, showed results totalling US$8,270,000.

These are very good results for a campaign which only lasted three months, carried out by a team of four people. To make the point even more clearly, we can note that for the 27 factories audited under Operation M the average result was US$258,000 while for the 45 audited under Operation P it was US$184,000, so that the average factory which completed both operations was showing results totalling US$442,000. Now, recall that EMI had estimated that the "slack" in the 140 state-owned factories was US$125,000,000 or US$893,000 per factory. It can be seen that those factories which had completed both operations and which before were operating very poorly had in one 3-month spell of activity made up almost exactly half of the way to the standard of competently run equivalent factories in the developed countries. This is a remarkable improvement in a very short time.

Spurred on by the success of Operation P&M, the Ethiopian Management Institute then initiated Operation PMS. This was to act as a sort of Phase II to Operation P&M with two objectives, to extend the performance of the factories that had performed well in Phase I, and to give those that had lagged behind a chance to implement the guidelines. However, halfway through this programme the Supreme Council, reacting to the very serious problems (including drought and famine) which were affecting Ethiopia, instructed EMI to stop working with the industrial sector and concentrate instead on the agricultural and transport sectors.

An immediate effect of this decision was that Operation PMS was abandoned. This was a convincing illustration of the importance of the principle of full-cycle support. It must be reiterated that introducing/implementing changes in an organisation is a difficult and uncomfortable process and the actors concerned need all the psychological and other support they can get.

Equipment maintenance in agriculture: the ROT-GTT scheme

EMI now turned its attention, as instructed, to the agricultural sector, or, more specifically, the state-farm sector. In Ethiopia there are 45 state farms, organised in groups of 4 to 6 under 9 enterprises, which in turn report to the Ministry of Agriculture. On each farm there is a workshop for minor repair and maintenance, under a maintenance manager. This manager reports to the farm manager for operational purposes, but in technical matters he reports to the technical manager at the enterprise level, who manages a workshop intended to carry out major repairs. This time EMI organised its campaign under the title "Operation MTO", standing for maintenance management, technical skills training, and operations.

Following its now standard practice, EMI started its assignment with the 45 state farms with a fact-finding study. This showed that the primary barrier to increased production was concerned with mechanisation. At the key times in the farm calendar machine availability, particularly of tractors, was much too low. This in turn, was caused by inadequate, or even totally absent, periodic preventive inspection and maintenance procedures.

In facing up to this situation EMI realised that it had to provide result-oriented training for the maintenance managers at the 45 state farms plus the technical managers at the 9 enterprises and some at the Ministry level, for the corresponding stores managers, and for a very large number of mechanics and tractor operators, around 5,000 in total. The EMI team could handle the training of the managers, but not of the mechanics and operators. Thus, out of necessity, was born ROT-GTT.

ROT, Results-Oriented Technical Training, is aimed at up-grading the skills of people already employed. It is a form of in-service vocational training. Unlike other forms of vocational training, however, ROT is not designed around a curriculum or job descriptions. Instead it is designed around the trainee's existing job, either to enable him to do this job as near perfectly as possible or to up-grade him to the next level. In the state-farm programme the objective of ROT was to make the mechanics into "High-quality inspection mechanics", capable of carrying out, with a high degree of competence, routine preventive maintenance and inspection on tractors. The operators received similar training on daily vehicle inspection and good operating pratices.

GTT, Guided Transmission Training, whereby the actual training of the mechanics and operators was done by the maintenance foremen of the farms, was necessary because of the large numbers of people involved. It brings with it, however, many benefits which make it desirable even in cases where the numbers are more manageable. These benefits arise from the fact that the transmitter is the immediate superior or boss of the trainees. Thus:

(1) The boss is not bypassed by the scheme, as is often the case in direct training exercises. Since he is both the trainer and the evaluator of the immediate results of the training he will ensure that what he teaches is put into practice.

(2) The scheme effectively makes the boss more knowledgeable than his subordinates. So instead of feeling or even resenting that his position is being undermined by the new knowledge imparted to subordinates the boss actually aquires more knowledge authority.

(3) The time required to train the boss as a transmitter is short, because the boss is already experienced; the time required to train his subordinates is also short, because the training covers only directly relevant topics.

(4) The scheme forces the boss to analyse his subordinates' work in detail. This tends to lead to improvements in the procedures used, to eliminating procedures which are no longer useful and to a general improvement in management.

(5) The new training capability remains with the unit concerned. The boss can quickly train new workers up to the required standards. Also, if performance in the unit falls off he is in a position to find the reasons and take remedial action.

THE ROT-GTT activities were organised as follows. A 55-step vehicle inspection procedures was developed, together with accompanying detailed manuals and training materials. This was done by the Productivity Improvement Centre (PIC) of EMI which had recently been created out of an existing vocational training centre. The transmitters (at least two from each firm) then attended a 20-day course. The first 10 days were devoted to explaining the inspection procedure (the purpose of each step, the consequences of not following the instructions precisely, how to carry out each step), and the second period concentrated on basic training techniques and on the use of the training materials. Each transmitter then "transmitted" the 10-day procedure course to 60 co-workers. An important point in this respect was the EMI persuaded the farm managements that the transmitters should be paid at double their normal rate for this.

A key factor is that every one trained by a transmitter is given an "Achievement Book" in which are recorded the results of the next 50 inspections carried out by him (if a mechanic) or the next 50 days' operations (if a driver). Up to 60 points can be obtained and recorded in the Achievement Book, points being lost because of faulty performance (breakdowns, reduced tractor availability, etc.). If sufficient points are obtained the individual can present himself for practical and theoretical examinations, at which he may obtain up to 40 points. Depending upon his total points he receives a certificate either as a "Quality vehicle inspector", "High-quality vehicle inspector", or with over 90 points, "Super-high-quality vehicle inspector". Those receiving the last are recommended for promotion.

This Achievement Book system is found to be very effective in motivating the trainees to perform to the best of their ability. It also disseminates the "result-orientation" of the programme to personnel at all levels, and functions as an excellent check on the quality of the training provided by the transmitters.

Steps 7 and 8 of Operation MTO, the final evaluation and presentation of results, were to be done in February 1987, as this paper was being prepared. For this reason the final results cannot be reported here. However, there has been virtually no slippage in the implementation schedule. Personnel enthusiasm is high and some farms have already reported that they now have surplus tractors.

4. Lessons for the future

The set of 13 principles described earlier and documented by case studies from Ethiopia, does not in itself constitute a programme design. Rather, these principles provide a checklist which the programme designer can use to decide whether his design is well conceived. Many different designs can satisfy the principles. Indeed, if the principles were to dictate the design, so that there was only one possible alternative, they would be worse than useless. Just as no two countries are alike, so no two programmes face the same set of circumstances, and each programme has to be designed according to the situation. ILO and other agencies' programmes in maintenance can thus take a wide range of formats. Some of these formats, however, while retaining a good deal of flexibility in the details of their application, are sufficiently distinctive that they have been given identifying names.

Prospective approaches

The combination of approaches that was evolved and applied by EMI is of considerable interest. This combination is appropriate to a campaign-type programme, where a number of enterprises are all attacking the same problem. Indeed, it may be the only approach suitable for mounting such campaigns in large and medium-scale enterprises. It is, however, also valid where only one or a few enterprises are involved. In the form described earlier it is not suitable for application with small-scale enterprises.

There are, however, other methodological tools that can be used in structuring and launching a maintenance improvement programme, even though they were not originally developed specifically for this purpose. Those described below are of the "distinctive" nature noted above.

Quality Circles (QC). This approach mobilises the skills, interest and experience of groups of shop-floor workers to improve aspects of enterprise performance. As its name implies its original application was in finding ways of improving product quality control, but it is equally applicable to improving the standards and quality of maintenance. It is, after all, the people who actually work with the machines who best know their individual idiosyncracies, and who are in a position to know how to organise their own work so that it proceeds smoothly. QC can give good results, but require careful support by management.

Action Learning (AL). This was originally developed by Professor R. Revans of the United Kingdom. It has been used in a wide variety of situations, from very large to very small enterprises, in hospitals and in rural communities. In large firms AL may take the form of interchanging senior personnel for periods of six months to a year, to carry out work on perceived problems in the host firms, while in small-scale enterprises the entrepreneurs usually work on problems in their own enterprises. In all cases a feature of the approach is regular (e.g. monthly) meetings of the participants, at which they report their progress, discuss problems encountered, and exchange advice. These meetings are important in maintaining the motivation of the participants. The approach works well provided some care is taken in selecting the participants, as the groups have to be reasonably homogeneous. It has been adopted by the Association of Repair and Maintenance Workshop Operators in Costa Rica as its preferred methodology for entrepreneurial and management development.

Interfirm Comparison and Business Clinics (IFC/BC). In this approach each one in a group of participating enterprises receives a periodic report in which its performance, expressed in terms of productivity and performance ratios, is compared with that of other participating firms. Since a money value can be placed upon the relative performance in respect of each ratio the IFC component constitutes an advanced form of ROM. For example, if a truck operator has a "vehicle availability" ratio of 70% compared with the group average of 85% he can see at once that in a 20-day month he is losing 15% of 20, i.e. 3 days of service per vehicle per month, and multiplying 3 days by the average daily gross profit (revenue less direct operating expenses) for his enterprise he arrives immediately at a very good estimate of how much defective maintenance is costing him.

The BC component is very much like Action Learning. It consists of a series of meetings of the participants at which those with poor ratios seek and discuss the advice of those with above average values for these ratios. The only difference from AL meetings is that the topics discussed, rather than being chosen according to the personal perception of each participant, are virtually decided by the periodic performance reports.

The principal limitation of IFC/BC is that for the periodic reports to be meaningful all the participating firms in each group have to be in the same type of business i.e. all metalworking firms, or all shoe manufacturers, or all truck operators, etc. This is relatively easy to arrange in the case of small-scale enterprises, but less easy in the case of large enterprises, if only because in most developing countries not more than one or two large enterprises operate in the same line of business. One way to avoid this problem would be to organise IFC/BC on a regional or sub-regional scale; problems of different currency rates or different tax incidences, which can affect performance ratios measured in money terms, can be avoided by using physical measurements. Thus, for bus operators, the cost of diesel fuel per litre might vary by a factor or two or more from one country to another, so that comparing fuel cost/100 km run would be meaningless while litres of fuel consumed/100 km should be about the same in each country and so useful comparisons can be made of this ratio.

Planning for Improved Performance (PIP). This is a form of Organisation Development (OD) characterised by a strong "do-it-yourself" format. The organisation itself identifies and diagnoses problem areas (which might be maintenance standards, quality control, or even customer relations), and develops and implements actions to remedy them. In effect, PIP results in an up-grading and "tightening-up" of overall management performance in the enterprise. PIP helps by providing a framework for carrying out the diagnosis - fact finding - action plan development - implementation, and by providing process consultancy assistance to help the participants overcome any barriers encountered in the process. It is equivalent to a management consultancy plus implementation exercise with the difference that the participating managers act as their own consultants. It has given good results in a wide range of applications, and has the advantage that the "self-consultancy" skills acquired remain in the organisation, available for use in other, future problems.

These approaches are not mutually exclusive, and can often be combined. It would be perfectly possible, for example, for a PIP exercise to lead to setting up a system of QCs in the organisation.

Setting up a maintenance improvement programme

The first step in setting up a new maintenance improvement programme, at a sectoral or national level, is to find out who needs help in maintenance and who wants such help. The two are not necessarily the same; indeed, it will often be found that many of the enterprises which most need help are quite unaware of the seriousness of their maintenance problems.

It may not be straightforward to identify those enterprises which need help, nor even those which want help. Many of those who might want help will not know where to look nor whom to ask. Of those who need help, few if any, will have cost-accounting or other reporting systems sufficiently sensitive to tell them how much poor maintenance is costing them. So they will not be alerted to the fact that they need help.

Perhaps the best method of fact finding in this area is to discuss maintenance problems and practices with progressive business owners and managers, the sort of people who take an active part in trade and employers' associations. Such people will usually have their own maintenance problems under reasonably good control, but they will also have a good idea of the situation in the less progressive firms, and are thus useful sources of information.

These sources of information only apply to the private sector. In state-owned enterprises, where the need for help is usually greater, other sources must be found. In this case, however, interest in setting up maintenance programmes usually arises out of disquiet in the parent ministries about the performance of their affiliated enterprises, and the ministries are able to ask for reports on maintenance-related factors such as machine down-time and production loss. Such reports will normally make the situation clear.

The next step is to decide, on the basis of the information obtained, whether or not to set up a maintenance programme. If the decision is positive then suitable training and consulting resources must be identified. These may be already available in the country. If not, help can be sought from international or bilateral donors, unless foreign exchange is available for engaging a foreign maintenance consultant directly, or a funds-in trust arrangement can be made with an international agency. ILO's regional advisors in management development and vocational training can be asked to help in identifying needs and preparing action proposals and requests to donors.

When some assurance has been received that training resources will be available then the programme design can begin in earnest. The first step here is to select the institution which is to be the operating base of the programme. This has to be done with care. The obvious base in most countries is the national or sectoral management development or productivity centre. Some of these centres are excellent and action-oriented, while some others have lost contact with industry and confine themselves to class-room instruction. The latter group would obviously provide little help in solving specific practical production and maintenance problems, and therefore should be avoided.

If the base institution is good, or if competent international experts can be involved, the greater part of the programme design will be done by them. However, the sponsoring organisation (that is to say, the organisation which originally had the idea of setting up the programme) can make a substantial contribution in helping to ensure that the three pre-conditions noted earlier (pressure for change, top management commitment, and willingness to innovate) are satisfied. Normally, for it to have become concerned about the maintenance situation it would have to be an organisation of national scope, such as a ministry of industry or other economic sector (agriculture, energy, transport, etc.) or possibly an industrialists' federation, and would therefore be able to exercise considerable influence. This influence could help very greatly in "engineering" the pre-conditions.

Conclusion

This paper has been devoted to maintenance improvement, but it will have been noticed that little has been said in it about maintenance techniques or maintenance technology proper. There is a reason for this. Where maintenance is poor this is at root a management problem. Either the maintenance function is not being properly managed, or management is ignoring the maintenance function! There is an absence of a maintenance culture in the organisation or, sometimes, in the society at large. In such circumstances, trying to apply advanced maintenance technologies is like trying to give a smart new paint job to the funnels of a sinking ship; the ship will have sunk before the paint is dry. In a factory where machine availability is between 80-90% applying condition monitoring could well push machine availability up an extra 5%, and improve profitability to correspond, but in a factory where oiling and greasing is only a haphazard affair condition monitoring will only help to prove that machine availability is remaining at its existing level of 30-40%.

Our stance, therefore, is that getting the maintenance function onto a sound footing is a management problem, not an engineering problem, and in this paper we have approached the depressing maintenance situation in the developing countries from this point of view. Rather than discussing, evaluating and recommending alternative techniques of maintenance engineering (which has been covered very well in other papers) this paper has looked at how maintenance can be effectively managed, and how an improved maintenance function can be integrated into the overall management of the enterprise.

One clear aspect of this is that the post of maintenance engineer must be up-graded to at least the level of department or function manager, on approximately the same level as the production, marketing, personnel and financial managers. Like them, the maintenance manager must be able to claim the financial and other budgetary resources needed for the maintenance department's job. This by itself, however, would not be enough. In enterprises where maintenance has been neglected the task of getting it properly functioning will require the full co-operation of the entire management, and, in particular, clear leadership from top management.

It will also, in many cases, require assistance from outside the organisation, in the form of consultancy and training. Changing from a breakdown maintenance system to a preventive inspection and maintenance system is straightforward in principle, but surprisingly complex in practice. People have to be trained and re-trained, inspection and maintenance schedules set up, spare parts stocks rationalised, technical documentation files completed, paperwork processing systems developed and implemented, to name just a few activities. All of these have to be undertaken virtually simultaneously, because they form an interlocking system, none of the components of which can survive in isolation. Machine operators can be trained to detect and report incipient defects, but if the procedures for responding to their reports are not in place they will very quickly stop reporting. It is little wonder that many maintenance managers feel themselves locked in a vicious circle, with no prospect of breaking out. External assistance may be needed to break this vicious circle.

This paper has tried to show how external assistance can be organised and applied to the task of improving maintenance practices. Poor maintenance is a "people problem", and requires human resource development for its solution. However, the HRD needed is far more complex than just training. Indeed, training as normally understood is only a small part of the whole, applied in brief doses as required for immediate direct application to the task in hand. HRD assistance in this context is a carefully orchestrated set of activities, and the HRD consultant has to play a variety of roles as the assistance cycle proceeds through its various phases. Starting with helping to engineer the preconditions for the programme he will be involved (not necessarily in chronological order) in fact finding, problem diagnosis, training needs analysis, direct training, indirect training (training of "transmitters"), coaching, counselling, motivating, and, in some cases, acting as a liaison between the client organisation and outside agencies.

HRD consulting in maintenance is thus a complex assignment. It is complex because it attacks a complex problem, that of helping the client organisation to develop a corporate maintenance culture. Changing a corporate culture is always difficult, but without such a maintenance culture the enterprise will quite simply be unable to keep its equipment in proper operating condition.

A maintenance culture is thus most important for the enterprise. It can be created, as has been seen earlier. But it is difficult to maintain intact if the organisation is in an environment that sets little or no value on maintenance. It is not the purpose of this paper to explore the important but very difficult issues of setting national policies on maintenance and of sensitising the population as a whole to the significance of maintenance. However, there are organisations and institutions, the universities, business and engineering schools and vocational training and vocational education institutions, which will have a strong influence on how easy or otherwise it will be to introduce and maintain a maintenance culture in virtually all sectors of the economy. Because of the formative influence these institutions have upon the people who will play key roles in introducing and maintaining a maintenance culture in the economy they must be priority targets in any national-level programmes of maintenance improvement.

Achieving high maintenance standards in the enterprise is not an easy task. It does demand a great amount of hard work and a great deal of commitment. It can be done, and the rewards of doing it are enormous.

Appendix I

Selected ILO publications related to the topic of maintenance

Abramson A., Halset W.: Planning for improved enterprise performance: A guide for managers and consultants (Geneva, ILO, 1979).

Guthrie C.: Interfirm Comparison and Business Clinics in road transport (Geneva, ILO, 1985). Technical paper SED/10/E.

Introduction to work study, Third (revised) edition (Geneva, ILO, 1979).

Kanawaty G. (editor): Managing and developing new forms of work organisation Second (revised) edition, (Geneva, ILO, 1981).

Kubr M. (editor): Management consulting: A guide to the profession, Second (revised) edition (Geneva, ILO, 1986).

Miles D., Syaga P.: Building maintenance: A management manual (Corby, UK, Intermediate Technology Group, 1987). Published for ILO.

Moore L.S.: How to design interventions for improved maintenance management (Geneva, ILO, 1983). Technical paper MTCE/MGT2.

Powell V.: Improving public enterprise performance: Concepts and techniques (Geneva, ILO, 1987).

Prokopenko, J.: Productivity management: A practical handbook (Geneva, ILO, 1987).

Prokopenko J., White J. (editors): Modular programme for supervisory development (Geneva, ILO, 1981) (Includes a special training module M-III-15 on maintenance supervision).

Results-oriented maintenance management programmes: A preliminary report (Geneva, ILO, 1983). Technical paper MAN DEV/27.