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Background document

AGENDA FOR ACTION IN THE FIELD OF HUMAN RESOURCES DEVELOPMENT FOR INDUSTRIAL MAINTENANCE IN DEVELOPING COUNTRIES*

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S U M M A R Y

Abbreviations

HRD : Human Resources Development

D.C. : Developing Countries

CMMS : Computerized Maintenance Management System

I. INTRODUCTION

The aim of this paper is to establish a guide for the Regional Expert Group Meeting to be held in Nairobi 23rd-27th June 1986 on the subject : Human Resources Development for Industrial Maintenance in Africa, preparatory to the Second Consultation of UNIDO on the Training of Industrial Manpower which is planned for September 1987. It gives a summary outline of the maintenance problems in developing countries in six priority areas, identified during the high-level expert group meeting in Paris in January 1986, and proposes practical solutions and means to solve the problems in the Human Resources Development (HRD).

This paper is intended for the experts who will attend the Regional meeting in Nairobi in order to guide them in the formulation of a concrete plan of action. It is to be considered as a study to generate ideas based on available experience in various developing countries, and will enable the experts to prepare themselves more thoroughly to take part in the discussions and working groups. The proposals and plans of action described in this paper should be seen as an exchange of ideas and experience between experts and developing countries, and should be completed during the Nairobi Meeting. On the basis of the conclusions and recommendations of this meeting the present paper will be finalized in the form of a guide to help policy makers and entrepreneurs to make the right decisions and implement concrete measures in the field of HRD for industrial maintenance. This document will be one of the principal papers to be presented at the Second Consultation on the Training of Industrial Manpower.

The six priority areas in which preparatory studies for the Second Consultation should be carried out according to the recommendations made by the experts at the Paris meeting are as follows :

1. maintenance policy and strategy
2. organisation and maintenance methods
3. technical documentation
4. spare parts
5. negotiation and acquisition of equipment
6. training policy for maintenance.

In the following chapters, the problems arising out of each subject will be briefly analysed. A series of proposals will be put forward to improve the existing situation and a plan of action at different levels will be suggested. It is understood that each of the suggested proposals will involve the development of human resources for the area concerned.

II. MAINTENANCE POLICY AND STRATEGY

II.1 Problems

The poor functioning of many industries in developing countries originates, in the majority of cases, from the lack of maintenance of the production equipment. Complying with appendix I of the report issued by the Paris meeting of experts in January 1986, the principal causes can be put into the following five groups : acquisition, design and use of production equipment; organisation and management of maintenance; material resources for maintenance (technical documentation, spare parts, financial means, tools and measuring instruments, maintenance equipment); human resources; social economic and cultural environment of developing countries.

All these factors are interdependant. Their origins can be found in insufficiencies or lack of arrangements at different levels of operators and decision-making centres, both in the developing and industrialised countries : the investment planner, the designer of plants and machinery, the customer and equipment supplier, the company and its production units, the government as well as organisations for financing and development aid.

Further it seems that maintenance problems found in the industrial sector exist in many other economic sectors which use technical equipment : agriculture, transport, energy, telecommunications, public works,scientific research, education, health and meteorology. Moreover, maintenance problems touch many other fields such as banking, the customs service, administration and national education, etc.

Consequently maintenance of production tools in the D.C. (Developing Countries) takes on a macro-economic dimension. It

has a direct bearing on plant productivity, and thus an important effect on the balance of payments and external debts of the country.

From the above it is evident that an improvement in maintenance is paramount. But these actions must be cohesive and must cover all maintenance problems in general in various economic sectors as well as on different levels. Because of the interdependence of the factors that occur in the problem of maintenance and the relationship of cause and effect between these factors, little purpose would be served in improving one without the other. This would not even produce a palliative effect.

In spite of the fact that a good number of developing countries have understood the seriousness of the situation on their national economy, few have undertaken the necessary steps for improvement based on a overall approach. The limited experience available, for example in the definition and implementation of a national maintenance strategy is, however, encouraging and calls for similar applications in other D.C.'s. Further, one finds that on the level of organisations for financing and bilateral, international or other development aid, a maintenance policy or an overall strategy is non-existant. In general not enough attention is paid to the maintenance problem at the project stage. It is only during the last few years that some of them have introduced actions, often isolated, in this area. This has been insufficient and in many cases inadequate because of a lack of co-ordinated global strategy.

II.2 Proposals to improve the situation

A maintenance policy should be determined at a national level, as well as at company or plant level and at the level of organisations for financing and development aid.

This policy must lead to an implementation strategy which will define a plan of action for the levels mentioned above.

The maintenance policy must rest upon a pragmatic approach and must form a link between the diverse operational levels in such a way that the implementation does not become impossible.

The HRD should automatically be part of this maintenance policy at each level and the proposals in the following paragraphs should be accompanied by appropriate measures for the development of the necessary capabilities.

<u>At a D.C. Government level</u>, a national policy of maintenance should be one of the components of the development policy.

The national maintenance policy should be aimed at :

1. increasing the present production by enhancing the value of the existing equipment by revamping, re-newing or modernising the production equipment;

2. Safeguarding of the production in the future by :
   - conservation measures (thus better maintenance of equipment)
   - suitable measures, when purchasing new equipment and implementing new projects.

This national policy should culminate in an implementation strategy in the short, medium and long term.

In the **short term** there is a need for :
- qualified personnel, motivated and conscious of the importance of good maintenance;

- complete and appropriate documentation;
- organisation and management methods to ensure efficient maintenance;
- necessary spare parts;
- well equipped maintenance workshops;
- sufficient financial means.

In the **medium and long term** arrangements should be made concerning :

- contractual negotiations and preparation of model terms of reference when purchasing equipment;
- the extension or construction of new maintenance capacities, i.e. integrated or regional workshops;
- the assessment of an HRD policy.

This strategy should be based on :

- cohesive and co-ordinated actions for the improvement of maintenance;
- inter-company exchange of information and experience;
- inter-company co-operation with an accent on the role of small and medium-scale industries;
- discussions with respective competent bodies to alleviate administrative obstacles during implementation

A national institutionalized structure for the promotion and co-ordination of maintenance, including consultancy and technical assistance services for the industries should be created. This structure could be based upon maintenance institutes and associations which exist in industrialised countries.

At company level, a maintenance policy should also be determined. This policy should be integrated into the national maintenance policy and be founded on :

- structural aspects, for example, the creation of a maintenance body at management level, responsible for the implementation of the maintenance policy of the company and assessment of results;
- the assessment of an equipment purchasing policy including arrangements for maintenance and the participation of maintenance engineers in the choice of equipment and contractual negotiations;
- the promotion of awareness of plant managers concerning the importance of sound maintenance;
- stimulation of exchange of experience and statistics between companies and production units.

At plant level a maintenance strategy should be determined within the policy of the company. This strategy should :

- accord the maintenance department equal status with that of the production department;
- choose a proper organisational maintenance structure : centralized, de-centralized or mixed. In fact the best results obtained in the D.C. were found in centralized structures, with de-centralized sections in the production areas reporting to one maintenance manager;
- define a simple but flexible maintenance organisation based on a methodical approach and rigourous data collection;
- furnish the maintenance department with sufficient funds, allowing for the recruitment of personnel and the acquisition of material resources which would guarantee correct maintenance;
- assign highly-qualified personnel to the maintenance department;
- instil a sound belief in the importance of maintenance in both

the workforce and management;
- determine a training policy for maintenance personnel;
- determine a policy of renewal of equipment based on an analysis of maintenance costs.

On the international, regional and bilateral level, organisations for project financing and execution should also determine a policy of maintenance dealing in particular with technical assistance, HRD and the acquisition of equipment.

Further, the maintenance policy of these organisations should include the making of the counterpart aware of the importance of maintenance and the necessity of an initial investment. This is unavoidable when implementing maintenance improvement actions.

The creation of a Maintenance Commission at the highest level of each organisation concerned is imperative. The task of this Commission would be to define a maintenance policy and supervise its implementation. Further it should be a think tank and above all the coordinator between and within the organisations dealing with maintenance problems and strategy. Finally, it should act as consultant to the general management boards.

II.3 Plan of action

At the national level the maintenance strategy should be focused on:

1) at short and medium term

- an institutional framework by creating a National Maintenance Institute charged with :
  - implementing the government's maintenance policy,
  - advising and assisting plants in the field of

maintenance,
- promoting the maintenance function and the actions on a national level
- taking part in the training of maintenance engineers
- establishing a documentation centre including a data bank on maintenance,
- taking part in international activities concerned with maintenance;

- **human resources**
  - by actions permitting a change in attitudes :
    - launching a national campaign of awareness of the importance of maintenance aimed at economic operators and decision makers;
    - taking measures to improve the motivation of the maintenance personnel in the plants,
  - by stimulating enterprises into enhancing the value of human potential already available (re-examination of job descriptions, compatibility between the post and the personal history of the worker),
  - by training, re-cycling and up-grading particularly at the level of the foreman and qualified workers,
  - by establishing a training programme for maintenance auditors, responsible for regular diagnoses in the production units,
  - by introducing maintenance discipline, both in lower and higher grades in the educational system,
  - by creating an Association of Maintenance Engineers;

- **technical documentation and information**
  - by encouraging companies to create a Central Documentation Unit in their plants, to complete the existing documentation of machinery and to introduce a more efficient administration of documentation,

- by stimulating the exchange of information and experience between companies,
- by establishing a data bank on maintenance;

- **the organisation, methods and management** of maintenance
  - by advising the companies of the existing systems of organisation and management methods (organisation charts, data collection, maintenance planning, management of ratios) and assisting them in the implementation,
  - by assisting the companies in defining a maintenance policy (e.g. choice and dosage of preventive, predictive and corrective maintenance) and a policy of renewal of machinery;

- **spare parts**
  - by encouraging the companies to analyse their stock and re-examine their actual needs,
  - by advising the companies on codification and stock administration systems,
  - by assisting the companies in the set-up of a standardization of machines and spare parts;
  - by studying the possibilities of reducing administrative constraints in the supply process,
  - by creating structures for the local manufacture and reconditioning of spare parts;

- **maintenance workshops**
  - by advising the companies on choice of tools, measuring instruments and raw materials,
  - by increasing the capacity of existing stock of machine-tools by re-vamping, modernisation or extension programmes;

- the financial means
  - by studying the possibilities of reducing the financial burden or other measures to encourage investment in maintenance and training,
  - by urging the companies to set up a system of maintenance cost control,
  - by anticipating the necessary amount of hard currency for the purchase of parts, technical documentation, raw material, technical assistance and training in maintenance.

2) at medium and long term :

- arrangements when purchasing equipment :
  - by developing standard terms of reference concerning maintenance organisation, supply of technical documentation and spare parts, technical assistance and training in maintenance, after-sales service, etc.,
  - by assisting the companies with their contractual negotiations when acquiring equipment,
  - by assisting the companies with the determination of a construction strategy for industrial projects and with the assessment of plant and machine design factors which ensure maintainability,
  - by making the manufacturers of machines or engineering companies aware of the necessity of a sound maintainability, a complete technical documentation and reliable information;

- the set-up of regional repair and spare-part manufacturing/reconditioning workshops;

- a HRD policy;
  - by assessing the training needs in industry,

- by choosing efficient training methods,
- by creating a follow-up and control system of fellowship.

At company and plant level, the plan of action should implement, on one hand, the national plan of action and on the other the maintenance strategy defined by the plant. It should deal with the operational side of the actions mentioned above.

At the level of financing and project execution organizations it is absolutely vital that maintenance of equipment be considered of primary importance in the development of developing countries.
In view of this and of a larger campaign of general awareness, **it is proposed that 1990 should be declared the year of maintenance in the developing countries.**
The plan of action to implement the maintenance policy of those organisations should concentrate on:

1) at short term :

- the setting-up of a **"Maintenance Commission"** at management level of the organization;
- the co-ordination of maintenance activities internally and amongst the organizations as well as the exchange of information;
- creation of awareness of governments and counterpart organizations of the importance of maintenance and the necessity of initial investments to ensure good maintenance;
- the provision of a maintenance component sufficiently developed for each new project concerned;
- the provision of detailed technical documentation with each purchase of new equipment;
- the HRD for maintenance by organising seminars, colloquia,

fellowships and on-the-job training;

- the making aware of the machine manufacturers of the necessity of a sound maintainability of their equipment, a comprehensive technical documentation and reliable information.

2) at medium and long term :

- the programming of an assistance for the implementation of national maintenance strategies and the creation of maintenance institutes where the need arises,
- the promotion of maintenance projects, in particular concerning :
  - the awareness of sectors concerned,
  - the development of a maintenance consultancy in the D.C. through the training of a core of consultant engineers,
  - maintenance audits,
  - the setting-up of maintenance structures in the plants,
  - the HRD for maintenance,
  - the establishment of standard terms of reference concerning:
    - the design of equipment from the maintainability point of view,
    - the strategy of plant construction,
    - technical documentation,
    - spare parts
    - training of maintenance personnel,
    - technical assistance in maintenance,
    - after-sales service,
  - the setting-up of pilot projects in maintenance which could serve as an example for other countries.

III. ORGANISATION AND MAINTENANCE METHODS

III.1 Problems

Many maintenance problems originate in the lack of organisation and management.

At plant level :

- maintenance is generally under-estimated and its productive function is not recognised. This has the following consequences :
  - the maintenance department is placed in a minor position on the organisation chart,
  - the maintenance department is placed hierarchically in an inferior position to that of the production department,
  - insufficient financial means are allocated to maintenance,
  - under-qualified personnel is allocated to the maintenance department,
  - insufficient attention is paid to the requirements of maintenance in the pre-investment and engineering phases, as well as during the purchase of equipment,
  - there is a belated preparation of the maintenance function when implementing new projects (human, material and financial means);
- the maintenance organisation chart is unclear or ill-defined; the job descriptions are non-existant;
- the following functions are non-existant or under-estimated :
  - methods,
  - programming,
  - job-preparation,
  - scheduling,
  - maintenance management,

- stock administration;

- **data collection** is insufficient, information flow is not defined and there is no feed-back nor evaluation of data;
- **the internal organisation** is neither established nor registered;
- the aspect **"maintenance management"** is pratically non-existant :
  - establishment of an analysis-chart,
  - management of maintenance ratios,
  - establishment of statistics on the disponibility of production machines,
  - calculations of reliability,
  - analysis of breakdowns (nature, frequency, direct or indirect effect),
  - assessment of maintenance costs and outlook,
  - life-cycle costs,
  - dosage of preventive, predictive and corrective maintenance in maintenance planning;
- **maintenance methods** are under-developed; the consequence is :
  - no maintenance planning,
  - incomplete lubrification planning,
  - no job preparation,
  - no work analysis,
  - no machine history files,
  - no selection of parts or raw material to be stocked,
  - impossibility of making correct estimates,
  - impossibility of indicating or respecting a delay;
- **training** in maintenance organisation, methods and management intended for engineers and foremen is under-developed and often far from reality.

III.2 Proposals to improve the situation

At the national level of D.C., action in the fields of awareness, training and advice must be undertaken :

- awareness of company and plant managers;
- organisation of training courses specialised in maintenance organisation, methods and management;
- advice and practical assistance for plants in the design and implementation of maintenance organisation charts, in the introduction of a planned maintenance system, in the set-up of a section "Methods and Maintenance Management";
- establishment of a data bank (maintenance costs in various industrial branches, information on spare part consumption, on the type and frequency of breakdowns, etc);
- advice to companies in the establishment of contractual clauses when constructing new factories, concerning the obligations of the supplier in the field of maintenance management services.

At **company and plant level** the following improvements should be carried out :

- put the maintenance department on the same hierarchical level as the production department. One person should be in charge of all maintenance activities;
- work out a maintenance chart as well as job description. This chart should be simple at first but must be flexible enough permitting adaptation as the plant develops. In this chart special attention must be paid to the functions methods, maintenance management, stock administration, job-programming/preparation and scheduling;
- prepare a system of data collection and determine an information circuit permitting the evaluation of the collected data;
- introduce a maintenance cost control system;

- develop a training programme for foremen in the fields of methods, job programming/preparation and scheduling, stock administration, and maintenance management.

For **new projects** it is imperative to include the maintenance function in the preliminary studies and to set up the department long before start-up. The sections of maintenance most concerned are :

- the workshops (during plant installation they will be a very useful training site);
- methods (preparation of technical files and maintenance programmes);
- spare parts (coding and stocking of parts supplied by the supplier , preparing of stock control cards);
- maintenance team : the various trade groups must assist with installation and start-up.

Customer requirements on this subject are to be found in the tender documentation and must be imposed on the suppliers.

At the level of **organisations for development aid**, the assistance should mainly concern HRD (engineers and foremen) the advice and technical assistance to the factories, in the fields of maintenance organisation, methods and management. This assistance must be of a practical nature, which means that it can only be given by extremely well-qualified personnel, well versed in the problems of plant maintenance in Third-World countries.

III.3 Plan of action

At the national level, the following plan is proposed:

1) at short term

- organise an annual awareness seminar, intended for company and plant managers (maximum 3 days);
- organise an annual seminar, intended for maintenance engineers and foremen on the organisation, methods and management of maintenance (minimum 4 weeks);
- choose a pilot-plant, where an organised maintenance system and a section "methods" will be introduced. This plant would serve as an example and training ground.

2) at medium and long term

- repeat the experiment of the pilot-plant in other plants, belonging to different branches of the industry;
- develop capacities for local consultancy in organisation, methods and management;
- make the maintenance engineers take part in the training courses locally and abroad in the above areas;
- organise information courses to introduce computerized maintenance management systems.

On plant and company level re-organisation studies of maintenance should be introduced and put into effect. In view of this the following scheme is proposed :

1) at short term :

- information supply to the personnel : definition of the objectives, awareness;

- centralization of all maintenance activities;
- introduction of an organization chart for the maintenance department;
- lay-out and introduction of paperwork for data collection and definition of information flow;
- organization and formation of maintenance teams;
- improvement of the spare parts situation;
- improvement of the technical documentation situation.

2) at medium and long term

- organization of job programming, preparation and scheduling;
- improvement of the central maintenance workshop;
- implementation of a preventive maintenance programme;
- organization of sub-contracting for maintenance work.

During each stage permanent training of maintenance personnel should be carried out.

At the level of **organization for financing and development aid**, the actions which should be undertaken comprise an assistance in the implementation of the national maintenance plan and of the maintenance strategy at the company level as mentioned above.

IV. TECHNICAL DOCUMENTATION

1. Problems

An incomplete technical documentation which has not been up-dated or is non-existent is often at the root of many problems in the industries of D.C.'s.

During surveys carried out in industry in Third World countries, it was noted that only about 5 % of the factories have a complete documentation; 15 % possess sufficient documentation permitting correct maintenance; 55 % have an incomplete documentation often in a language other than their own, while 25 % of the plants have no documentation at all.

When purchasing equipment for plants, technical documentation is generally neglected both by the supplier and by the customer.

The supplier aiming at the export market often lacks experience in running plants in a non-industrial environment. The gullible client accepts everything; he has no time during installation to check if the supplier has fullfilled his obligations and notices, too late, that his documentation is useless.

The lack of documentation is one of the major problems which maintenance services in Third World factories have to face. Maintenance without a comprehensive technical documentation is almost impossible. It is necessary to ensure repair work, manufacturing of spare parts, quick trouble shooting, safety of personnel, a better maintenance management, a correct choice and administration of spare parts and an efficient training of maintenance personnel.

In the process of technology transfer, technical documentation is a priority link without which efficient transfer is impossible.

IV.2 Proposals to improve the situation

Proposals to improve the situation of technical documentation concern various levels :

- during **pre-investment studies**, sufficient financial means should be provided for technical documentation. A complete technical documentation, including engineering work and drawings, costs between 8 and 22 % of the value of the equipment depending on the type of plant. Expecting such an investment from a supplier without payment is impossible.

- the **suppliers of plants, the manufacturers of equipment and their subcontractors**, must make a considerable effort to prepare a technical documentation which meets the local operation needs of their clients :
  - technical documentation should be **comprehensive**. Concerning maintenance, it must include, for the main suppliers and subcontractors, the following items :
    - machine records, electro-motor cards,
    - maintenance and lubrication instructions,
    - operation and service instructions,
    - dismantling and reassembly instructions,
    - drawings of assembly, sub-assembly and details with a complete parts list,
    - exploded views, sketches or cross-sectional drawings of components or sub-assemblies,
    - electrical, hydraulical, pneumatical drawings with parts lists,
    - workshop drawings for local manufacture of parts subject to wear and security parts,

  - a selection of spare parts to be stocked for a 2 year operation,
  - check-lists for control and inspection,
  - list of possible failures and indications for trouble-shooting;
- the technical documentation must be in the language of the customer;
- the documentation must be delivered on time (first draft before arrival of machines) permitting the customer to carry out the necessary checks and to prepare the maintenance service and training of the personnel;
- the technical documentation must be up to date at the final acceptance;
- the technical documentation must be clear and comprehensive for a workforce which does not always have the technical knowledge of that found in industrialized countries. Abundant use of photographs, exploded views and explanatory sketches are essential.

- the purchaser of equipment or the plant-operator must clearly specify in separate terms of reference, what he expects from the supplier in the field of technical documentation. He must define the content, the form, the delivery conditions and the penalties in case of failure. Moreover, he must create a correct administration system for his documentation which should be centralized in the plant (coding, classification, updating, system for consultation and distribution, ...). In case of non-supply of machine files by the manufacturer he has to make them up himself at least in the first stage for the priority production machines. For this reason he should send trainees to companies specialized in preparation of machine-files and technical documentation. It should be emphasized that a sound documentation is expensive, so sufficient budgets should be provided.

- **organizations for financing and development aid** should foresee a financial component for technical documentation when purchasing equipment. Delivery of a complete documentation by the suppliers must be insisted upon. Training sessions should be organized in the make-up of technical documentation, in particular machine files. Consultants should be made aware of the necessity of an investment in the setting-up of technical documentation.

IV.3 Plan of action

On the **company and plant level**, the following actions should be carried out :

a) short term

- centralize all technical documentation in one area of the plant;
- codify, classify the documentation, create a system for updating and distribution;
- specify priority-machines which cause production bottle-necks and make up machine files for them with the help of a technical assistance;
- establish standard terms of reference for technical documentation which must be imposed on the suppliers of equipment.

b) at medium and long term

- train personnel both in the preparation of machine files and in the administration of technical documentation;
- complete the technical documentation for the machines other than the priority ones;

- assemble workshop drawings for the manufacturing of spare-parts, in particular from those manufacturers who have disappeared from the market.

At the level of **organizations for financing and development aid**, the following actions should be undertaken :

a) short term

- include in each investment budget a provision for technical documentation;
- establish standard tender documents for technical documentation which has to be supplied by machine manufacturers or plant constructors;
- organise training sessions or specialized fellowships in
  - the making-up of machine files,
  - the administration of technical documentation;
- assist the companies in setting-up Centralized Documentation Units in their plants;
- assist the companies in completing and up-dating the existing documentation

b) medium and long term

- programme and promote projects in HRD and technical assistance for the above fields concerning technical documentation;
- create, in each delivery of equipment project or plant construction, a unit which must check the technical documentation, supplied by the manufacturers.

V. SPARE PARTS

V.1 Problems

Spare parts cause major headaches to the operators of industrial installations in D.C.'s. It has been found that at least 50 % of unavailability of production equipment in D.C.'s is due to a lack of spare parts. It is thus necessary to pay more attention to this problem.

Problems which have been noted at plant level are as follows :

- a great **variety** of equipment manufacturers and little effort made to standardize machinery and components, resulting in a large investment in spare parts stock;

- poor **selection** of stored spares. This is due to on the one hand a lack of information in technical documentation given by the manufacturer and on the other hand to a lack of experience in plant operation by those who make the choice;

- incorrect **designation** of spare parts. The designations are mainly done, based on the information supplied by the manufacturer. In most cases, they only give the designation of the machine manufacturer and not of the spare part manufacturer. The use of designations in conformity with international standards hardly exists because manufacturers think they can protect the spare parts market by doing so. The problem exists even more for the spare parts of sub-assemblies or individual components (from which the suppliers are sub-contractors of the machine manufacturer, often to the third degree);

- non-existent in-plant **codification** of parts. The reasons

are :
- non-existent internal coding system (codification grids),
- ill-identified spare parts,
- poor application of codification grid, if it exists;

- insufficient or non-existent **stock administration**, due to a lack of stock administration systems or to a lack of information concerning the administration parameters (average monthly consumption, price, delay, mini-maxi stocklevels, ordering point). A poor data collection (issuing or entering quantities, repairability, etc.) or a belated treatment (manual or by computer) jeopardizes reliable data. Moreover, unreliable information about frequency of part-replacement or priorities for planned overhauling, do not allow for the determination of consumption parameters;

- lengthy **re-ordering delays**, due to protracted internal delays in the plant, delivery delays by the supplier, delays in payment or in the setting-up of financing (mainly for imported parts in countries with non-convertible currency), custom delays (heavy administration, work overload of custom services, ...) and finally due to transport delays between place of arrival and destination;

- lack of **hard currency** for imported spare parts which has obliged plant management to reduce their stock. This reduction is done indiscriminately, which leads to stock-outs of vital parts;

- random allocation of **import quotas** in certain countries;

- poor **storage** due to insufficient storage and handling facilities or due to a lack of part conservation arrangements (cleaning, anti-choc or anti-corrosion, protection and

coating). It has been found that approximately 15 % in the value of the stored spare parts is useless when they are needed due to storage conditions;

- poor **knowledge of stock**. There is an important percentage of dead stock (often between 15 and 20 % of the items). Stock analysis (i.e. method of Pareto) is not carried out and therefore spare parts for machines after demolition continue to be stored.

Apart from the above problems, it must be stressed that detailed **contractual clauses** concerning spare parts are missing or are unclear when purchasing equipment. Separate tender documents rarely exist in this case.

Added to these problems there is a lack of facilities and capabilities for **local manufacturing** of spare parts. The industrial network around the factories in Third World countries is very limited. This often forces the factories to become self-sufficient in this field. But this is still not enough to encourage adequate investment to meet these needs. In order to be able to manufacture spare parts locally the following conditions should be fulfilled :

- knowledge of technical information for manufacturing (workshop drawings, material, tolerances, heat treatment, etc.);
- availability of machine-tools;
- availability of cutting tools and measuring instruments;
- availability of raw material;
- availability of qualified workforce.

Techniques for reconditioning of spare parts (protective coating through welding techniques, metallisation, application of antifriction metal, adhesives, Metalloc system, etc.) are little known and almost no effort has been made to develop them.

Nevertheless they represent a cheap way to make up for the lack of spare parts in many cases.

Finally very little action has been taken in the field of HRD for :

- the choice, codification and designation of parts
- stock administration.

V.2 Proposals to improve the situation

At **company or plant level** 4 fields of improvement are proposed :

- for **new projects**, the purchaser should prepare separate terms of reference for spare parts in which his requirements would be detailed :
  - the way to designate parts,
  - various information such as, manufacturer of the part with his reference number, drawing and item number of machine manufacturer, unit weight and price, estimated average monthly consumption, quantity of parts to be stocked for a 2 year operation, custom code, etc.,
  - supply of workshop drawings for spare parts manufacturing,
  - delivery conditions,
  - guarantee of spare parts supply during a certain period,
  - price determination and outlook,
  - payment conditions

  The purchaser must create a team for each new project to study drawings and technical documentation of the installations in order to complete the list of spare parts, selected by the manufacturer. This team must also check if the supplier is respecting the agreements in the field of spare parts.

Moreover, during construction, the purchaser should establish long before start-up of the plant the department for Stock Administration and Storage which will be in charge of :

- quality control of delivered spare parts by the supplier;
- design of a coding system and codification of all spare parts;
- estimation of stock administration parameters for the delivered parts;
- classification of parts in the stores;
- making arrangements for conservation of parts (application of a coating of oil or grease; application of an anti-corrosion product, putting into plastic bags, ...)

- for **existing plants**, management should make arrangements to improve the situation concerning spare parts by :
  - studies to complete the selection of parts to be stocked;
  - analysis of existing stock, leading to the elimination of dead stock;
  - revision of parts identification/designation;
  - design or improvement of the coding system, codification of all stored parts;
  - updating or estimation of stock administration parameters;
  - the setting-up or improvement of a data collection system;
  - arrangements for conservation of parts;
  - improvement of storage facilities (space, adequate racks and bins, etc.);
  - studies concerning standardization of spare parts;
  - in the long term, introduction of a computerized stock administration system.

- concerning **local manufacturing of spare parts**, plants or workshops should :
  - strength existing capacities by :

- organizing training programmes in the field of methods and work execution (machine-tooling, ...);
- repair, extension or modernization of existing machine-tools and by analyzing the set-up of new workshops;

- undertake actions to obtain workshop drawings for manufacturing of parts by :
  - requesting them from the machine-manufacturers;
  - enquiries in similar plants, using the same equipment;
  - preparation of manufacturing drawings on the basis of model-parts (obtained during dismantling, overhaul or repair);

- methods for **spare parts reconditioning** should be introduced and the necessary equipment purchased. A technical assistance and training should be foreseen if needed.

At the <u>national level of D.C.'s</u>, the following actions for improvement must be carried out :

- advice and assistance to the companies/plants in the implementation of actions for improvement of spare parts in the existing plants as well as in the field of arrangements which should be taken when purchasing new equipment;
- the organization of training programmes in the fields of selection, designation, codification and administration of spare parts;
- the development of local capacities for spare parts manufacturing and reconditioning comprising
  - a human component, by training personnel in the fields of methods, design and work execution
  - an equipment component by revamping, modernising or extending existing workshops or by creating new workshops

throughout the country.

- the study of possibilities of financing and fiscal advantages for the purchase of spare parts.

The **organizations for development aid** must promote projects dealing with the setting-up of workshops for local manufacturing of spare parts and must develop human resources in the field.

Moreover, they should insist in their projects on a rational stock management based on a sound selection and a correct designation of parts as well as on the definition of administration parameters. A considerable effort should also be made to develop human resources in those fields.

The actions must be co-ordinated with those proposed at the company/plant level and national level.

V.3 Plan of action

The plan of action for **companies and plants** is :

a) at short term :

- improvement of the preparation and follow up of the spare parts component in new projects by :
  - setting-up of a team for the checking of the services rendered by the supplier in these fields,
  - setting-up the "Stock Administration and Storage" department, long before start-up of the plant;

- improvement of the spare parts situation at the level of the plant in operation through :
  - studies aiming at completion of the spare parts selection

for priority-machines,
- analysis of existing stocks,
- improvement of codification, stock management and storage,
- the set-up of a sound data collection system;

- preparation of a training programme in the fields of :
  - study and selection of spare parts,
  - codification,
  - administration,
  - stock-keeping.

b) at medium and long term

- preparation of terms of reference concerning the supply of spare parts when purchasing new equipment;
- planning of the building of spare parts stores during plant construction at a very early stage (even before the installation of the production machines);
- completion of the selection of spare parts to be stocked for all machines;
- providing an analysis-chart comprising statistics on spare parts (average consumption, dead stock, stock value, turn-over, etc.);
- launching studies on spare parts standardization;
- introduction of a computerized stock administration system;
- setting-up of a permanent training programme in the above fields;
- undertake actions for the local manufacturing of spare parts by :
  - an assessment of the parts which could be manufactured locally,
  - collecting or preparing workshop drawings as mentioned in V.2,

- training personnel in the field of manufacturing methods, parts design and machine-tooling,
- launching studies for revamping, extension/modernisation or creation of appropriate workshops. These studies should include :
  - a survey of the actual situation concerning :
    - available machine-tools and accessories,
    - cutting-tools, measuring instruments,
    - spare parts,
    - raw material,
    - organization,
    - qualification and number of personnel
  - a proposal for revamping/repair in the short term, for modernization/extension in the medium and long term,
  - an estimation of the investments needed,
- introduction of methods for spare parts reconditioning. Setting-up of training programmes in this field.

The assistance of the <u>organizations for development aid</u> should deal with:

a) at short term

- HRD in :
  - study, selection, designation of spare parts,
  - codification,
  - stock administration,
  - stock analysis,
  - storage systems,
  - manufacturing methods (preparation, planning),
  - spare parts design,
  - various trades of a machine-tooling shop;

- assistance to companies for the implementation of the proposed actions concerning :
  - improvement of existing stock,
  - new projects,
  - manufacturing of spare parts,
  - reconditionning of spare parts.

  In this field a pilot-project could be set up around a workshop for machine-tooling which would manufacture spare parts for the industries and serve as a training ground.

b) at the medium and long term

- an assessment of the needs in industry concerning spare parts which can be manufactured locally;
- the set-up of projects concerning revamping, reinforcement and creation of a spare parts manufacturing workshop;
- the promotion of HRD for the various fields, mentioned above, for the standardization of parts and for the introduction of computerized stock administration systems;
- the initiation of a dialogue with the equipment manufacturers concerning the supply of workshop drawings. In this respect a solution should be found to protect the interests of the manufacturer as well as the customer.

VI. NEGOTIATIONS AND ACQUISITION OF EQUIPMENT

VI.1 Problems

The origin of a lot of maintenance problems can be found at the design stage and before the start-up of installations.

These problems concern essentially the correct adaptation of the equipment to local conditions, the timely supply of all operation and maintenance documentation, the supply and installation of machines, spare parts, training of personnel, technical assistance and after-sales service.

In pre-investment studies, the maintenance factor (budgets, human and material resources) is rarely considered.

The terms of reference and technical specifications deal particularly with the production machines. They never deal in detail with factors such as standardisation, maintainability, technical documentation, spare parts, training of maintenance personnel and maintenance organisation.

During contractual negotiations, maintenance specialists are usually absent. The requirements of maintenance are rarely taken into consideration, on the one hand because of the lack of consciousness of this problem and on the other for reasons of increase in price. The extra cost that maintenance requirements entail is nothing compared to the benefit- financial and moral- of a good functionning plant in a D.C.

Regarding the design of the factory, too little attention is paid to the factors which determine its success, such as location, size, detailed design of the installations and adaptation of the equipment to the environment (human and

climatic). This is often due to the fact that the designer is not a plant operator himself and has insufficient experience of working in a D.C.

Regarding the **choice of adequate technology**, this does not mean outdated technology- not enough attention is paid to the following factors which have a direct influence upon maintenance : distance between the plant and the suppliers, communication deficiencies, severe climatic conditions, lack of qualified work force, operational errors occuring more frequently than in the traditional industrial context, etc.

The many implantations in the Third World of **copies of European factories** including their organisations have proven to be unrealistic.

Regarding the **strategy of construction** of a plant it has been found that the auxiliary services (workshop, stores, offices, ...) are built after the installation of the production machines. So precious time is lost for training and for organizing maintenance.

From the **organizational** point of view, the various maintenance sections are planned too late (in many cases just before start-up), leading to insurmountable problems during the start-up period.

The **supervision of plant** installation by the customer concentrates almost only on the erection, commissioning and start-up of the production machines and buildings. The control of services rendered by the supplier in the field of technical documentation, spare parts or training for maintenance for instance is often neglected.

Finally, the construction planning being rarely respected, the contractor tries to make-up for the delay by accelerating the remaining work at the end of the construction. This concerns mainly electricity and instrumentation. It has been found that these measures lead to points of neglect and error in vulnerable installations where Maintenance will have to face most of the problems after start-up.

VI.2 Proposals to improve the situation

The improvement proposals in the field of contractual negociations and acquisition of equipment affect three different areas :

- preparation of the project :
  - provide for maintenance function already at the pre-investment study-stage, eg. through the provision of sufficient budgets for the various maintenance factors;
  - set-up separate terms of reference for services dealing with maintenance (technical documentation, spare parts, training, organization, technical assistance and after-sales service);
  - emphasize during plant and machine design, all factors defining its operationability (location, size, material-flow, standardization, maintainability, reliability);
  - involve maintenance engineers in contractual negotiations;
  - choose as plant designer only those engineering companies which have plant operation experience in similar countries;
  - insist on the choice of adequate technology. This technology should be modern which has proven to be sucessful in a similar environment (so that the increase of the technological gap between D.C.'s and industrialized countries can be avoided).Moreover, technology and work-methods should be adapted to the personnel and

vice-versa;
- prepare maintenance organization and create the following departments immediately at the beginning of construction : methods, stock administration and storage, workshop;
- attention should be paid to an exact finishing-off of construction, in particular in the fields of electricity and instrumentation.

- **plant erection**
  - provide the building of auxiliary services (such as workshop, offices, stores, ...) very early in the construction planning (before installation of the production machines);
  - provide maintenance personnel from the very beginning of construction (eg. maintenance intervention personnel as part of the contractor's mounting crews);
  - set-up a system for supervision of installation by the customer, in particular concerning those services dealing with maintenance. Therefore a "Guide for Project Managers" should be compiled. This guide would comprise eg. a check-list for the supervision of construction.

- **plant operation**
  - make sure that maintenance is operational from the start up; insist from the beginning on availability of spare parts and up-dated documentation.
  - insist on competent technical assistance and on efficient training of maintenance personnel during the period immediately following start-up.

VI.3 Plan of action

At **national and international level**, the following actions should be undertaken :

a) at short term

- **advice** on the purchase of equipment concerning maintenance requirements
- elaboration of **model terms of reference** for the fields dealing with maintenance (see sub. VI.2 above)

b) at medium and long term

- **training**
  - creation of awareness of those who are in charge of planning and pre-investment studies;
  - of those in charge of the drafting of the maintenance chapter in technical specifications or terms of reference and of those in charge of contractual negotiations;
  - in the compilation of model terms of reference for commonly used installations;
  - in the make-up of plant standards for machines and spare parts;
- the opening of a **dialogue** with **plant engineers** and machine **manufacturers** (eg. by assuring a feed-back of operating information) aiming at a better adaptation of the equipment to the environment.

At the **plant and company level** actions should concentrate on:

a) at short term

- the setting-up of a team for on-going projects, which must check the services of the suppliers in particular in the field of technical documentation;
- an important maintenance component to be included in the

terms of reference, in the fields mentioned in V.2;
- separate budgets for maintenance services which should be provided in the contract;
- the involvement of maintenance experts during contract negotiations.

b) at medium and long term

- equipment standardization studies and drawing-up of plant standards for machines, sub-assemblies and components. These standards must be integrated in future contracts for the purchase of equipment;
- training in the fields mentioned above.

VII. TRAINING POLICY FOR MAINTENANCE

VII.1 Problems

The problems which are found in D.C.'s in the field of training for maintenance, can be summerized as follows :

- poor **knowledge of training needs** leading to inadequate programmes;
- poor **knowledge of training facilities** (centres, schools, institutes, ...), existing at national and international level;
- incoherence and poor **coordination** between training programmes of the various training institutes (national and international);
- absence of a **maintenance discipline** in high school education;
- appropriate **training methods** (too far removed from daily practice);
- insufficiency or absence of **training programmes and facilities** for technicians in the following fields :
  - maintenance methods,
  - methods for machine-tooling,
  - stock administration,
  - maintenance management,
  - maintenance organization,
  - instrumentation
  - hydraulics/pneumatics,
  - foundry (modelling, moulding, melting).
- inadequate **training programmes for maintenance engineers**;
- poor **supervision and control** of results of fellowships, mainly abroad;
- poor or insufficient qualification and experience of **trainers**;
- insufficient **budgets** for maintenance training

- in plant construction projects,
- in plants under operation,
- in industrial projects with international financing.

VII.2 Proposals to improve the situation

The problems laid out above concentrate on 5 subjects for which actions for improvement are a necessity :

- information,
- coherence and coordination/planning,
- adequacy/efficiency,
- human and natural resources,
- financial resources.

In the field of training, the following actions should be undertaken :

1. **the assessment of a policy for HRD for maintenance :**
   - on national level of D.C.'s
   - on international level of organizations for financing and development aid.

   This policy should take into account the following factors :
   - the role of education and planning concerning HRD for industry in general and for maintenance in particular;
   - the coherence of a national HRD programme in relation to the existing needs in industry of maintenance personnel;
   - the needs of maintenance personnel in relation to industrial development plans on national, sectorial or company level;
   - the development of appropriate training methods in the field of maintenance;
   - structural and administrative arrangements for the implementation of these methods;
   - the set-up of centres for training and research in

maintenance;
- the organization of training at the company level through appropriate structures;
- budgeting previsions for financing training activities.

2. **Arrangements to make training for maintenance more appropriate** by :
   - adapting maintenance programmes to the needs of industry;
   - supervising fellowships more throughly and checking the results (mainly abroad);
   - integrating trainees into the erection crews of the plant constructor.

3. **Provision of necessary means** for the implementation of the above programme :
   - human (trainees, trainers, administration, ...)
   - material (workshops, equipment didactic aids, centres, ..)
   - financial.

VII.3 Plan of action

At the **national level** of D.C.'s the following actions should be undertaken :

a) at short term

- the setting-up of an inter-ministerial commission "HRD for Maintenance" which must :
  - define a HRD policy for maintenance,
  - encourage companies to promote training for maintenance. The principle of forcing companies to train, for instance, 2 % of their total staff annually should be analysed,
  - study the feasability of fiscal relief for companies

which make the effort to carry out training for maintenance,
  - study financing of HRD for maintenance (international aid, mixed credits, suppliers credits, etc.),
  - coherence of training programmes,
  - control results on national level;
- the assessment of training needs for maintenance in industry;
- the assessment of existing facilities for training for maintenance;
- the compilation of adequate training programmes for the maintenance workforce and trainers.

b) at medium and long term

- the creation of a maintenance branch in high school programmes for engineers;
- the organization of indepth training programmes in the various fields of maintenance as described in previous chapters;
- the organization of in-depth training programmes for trainers;
- the extension or the creation of training centres for qualified workers, foremen and engineers for maintenance.

At **company and plant level** considerable efforts must be made at short term to encourage :
- on-the-job training and apprenticeship,
- fellowships or seminars,
- the setting-up of in-plant training centres in bigger companies.

Moreover, companies should launch training and awareness programmes for machine-operators, aiming at a better treatment

of the equipment.
Each company should also nominate a person in charge of training to :

- inform superintendants and section heads of section of the existing programmes,
- implement in-plant training programmes,
- represent the plant in the inter-ministerial commission mentioned above.

At the level of **organisations for development aid**, the following actions should be carried out :

a) at short term

- the definition of a coherent HRD policy and a coordination between the various agencies and organizations dealing with training;
- the promotion of projects in training for maintenance;
- creation of awareness of governments of the necessity of HRD for maintenance;
- the preparation of a document comprising model-programmes of training for maintenance organized by the agencies;
- the development of curricula for maintenance training;
- organization of annual training sessions, seminars or fellowships for
  - maintenance workforce;
  - trainers;
- the study on international financing possibilities for HRD.

b) at medium and long term

- create pilot-projects for in-plant training concerning :
  - maintenance organization,
  - make-up of technical documentation,

  - stock administration,
  - spare parts reconditioning and manufacturing,
  - computerized maintenance management systems (CMMS).
- promote projects for the training of trainers for maintenance.

VIII. CONTRIBUTION TOWARDS HUMAN RESOURCES DEVELOPMENT BY INTERNATIONAL ORGANIZATIONS

The international organizations have a primary role to play in the HRD for maintenance. Their contribution affects various fields and the actions to be undertaken deal with internal structures of the organization, with the relations between international organizations and with counterpart governments.

1) **Internally in the organization** an **awareness action** on the importance of maintenance for the development of the Third World is urgent. This concerns the following levels :
   - representatives of the organization in D.C.'s,
   - project managers, experts,
   - chiefs of various specialized technical sections,
   - backstopping officers,
   - equipment purchasers,
   - planning and programme coordination sections,
   - decision-making centre and policy-makers.

   This awareness action must eg. highlight the complexity of the maintenance problem and must emphasize the interdependency of the various factors, mentioned in previous chapters.

   A second internal action involves the **coordination** between the various projects of the organization concerning maintenance activities, especially HRD. This will need the setting-up of an adequate information system.

   A third action is the **definition of an overall policy** in the field of maintenance concerning the activities of the organization and its external relations.

A fourth action is the provision of a **maintenance component** in each project concerned, especially in training and technical documentation.

A fifth action is the promotion of projects of HRD for maintenance such as :

- "Centres of Excellence" of UNIDO;
- pilot projects around a plant or a spare parts manufacturing workshop;
- implementation of a national maintenance strategy through the training of a core of consulting engineers or the set-up of a national maintenance institute;
- specialized training programmes for engineers (seminars, fellowships, study tours, etc.);
- training of trainers for maintenance (see for instance "Guide for the Training of Trainers for Seminars on Industrial Maintenance in D.C.'s" prepared by the Training Section of UNIDO).

In order to implement all these actions in a coherent way, and in view of the importance of the maintenance function for the success of projects, the creation of a "Maintenance Commission" or a Maintenance Working Group (eg. "Task Force" of UNIDO) on the management level of each organization is indispensable (see chapter II.2).

2) Regarding external relations between international organization, an action of awareness for counterpart governments and institutions on the importance of

maintenance is urgent. It concerns particularly the need to convince them to use a part of available funds for maintenance, especially for training, choice of adequate technology, maintainability, maintenance organization, technical documentation and maintenance workshops.

In the same sense **projects in maintenance** should be programmed in each sector and sub-sector.

Finally, the **coordination of projects** executed by the various international, bilateral or other institutions is obligatory. This coordination is indispensable to avoid incoherence in the programmes or repetition of mistakes which have already been corrected in the past. A better information flow concerning on-going projects -i.e. through the Maintenance Commissions- would already be a step forward in improving the situation.

The various actions mentioned above will need an **overall coordination**, involving all institutions through their Maintenance Commission. UNIDO could play a leading role and could be put in charge of the general coordination of the HRD for maintenance. A **Central Maintenance Committee** at the United Nations level and under the authority of UNIDO is suggested. This Committee would play a coordinating and advisory role in the various institutions concerned by HRD for maintenance.