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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
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ESTABLISHMENT OF PREVENTIVE MAINTENANCE SYSTEMS TO INCREASE PRODUCTIVITY OF PHILIPPINE INDUSTRIES

DP/PHI/87/008

PHILIPPINES

Technical report: Development of Computer-Aided Maintenance Management Systems and Strategies *

Prepared for the Government of the Philippines
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Mr. Louis M. Burel,
Expert in Computer-Aided Maintenance Management

Backstopping Officer: Anatoli Assabine
Industrial Management and Rehabilitation Branch

United Nations Industrial Development Organization

Vienna

* This document has not been edited.

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INTRODUCTION

The NEC prepared an initial programme for the activities of the computer-aided maintenance expert. (Annex 1). The programme sets out a comprehensive list of Preventive Maintenance subjects directly related to computer-aided maintenance management systems aimed to create awareness among the Philippine Industries of the benefits they could expect from this management tool such as reducing costs and improving maintenance productivity.

In addition to this programme, three (3) lectures have been programmed for a total of 9.5 hours on (Computer-aided maintenance management) on the occasion of NEC Seminar on "Maintenance Management".

In view of to the wideness of this programme and the importance of lectures, it was decided to allocate different priorities to different subjects of the plan regarding their feasibility and the urgency.

The first priority was given to lectures, training of engineers, plant visits, and elaboration of maintenance manuals and guidelines.

Second priority was given to a pilot project on computerization because it is not possible to implement a project in a valuable manner within such a short period. For the same reason, software development for maintenance management systems was also given second priority. In fact, development of a software or creation of a pilot project can take several months and require a full time responsible and a long preparation and organization.

The first part of this report presents point by point the actions performed according to the initial programme (see annex 1). The same numbering has been used to facilitate the comparison.

The second part of this report presents the development of lectures during the seminar on Maintenance Management. It gives some details on the preparation and the performance of these lectures.

The third part of this report exposes the conclusions of this mission. Remarks and comments are made on the actual level of maintenance in the visited industries and needs of improvements are prescuted.

Suggestions are given on actions to be carried out to ameliorate the maintenance management system efficiency by the promotion of computerized maintenance management systems.

I ACTIONS PERFORMED ACCORDING TO INITIAL NEC PROGRAMME

1.0 Development of Maintenance Manuals

1.1 Manual on Computer-Aided Maintenance for Industrial Plants

Action

A Maintenance Manual has been issued to be used by NEC engineers as a guide for preparation and implementation of computerized maintenance management systems in the Philippine industries.

The guidelines proposed in this manual are based on documentation and mostly on basic experiences on development of softwares and implementation of maintenance systems in various industries.

The guidelines give the basic concepts of systems, the different steps in the development and an implementation plan with the different steps and the different requirements of implementing and running a system.

The following guidelines have been issued:

1.1.1 Maintenance Survey or Audit Procedures

A detailed questionnaire "Maintenance Audit For Computerization" regroups the maximum questions an auditor must ask in surveying the maintenance system of an industry.

A summarized questionnaire has also been issued for a first and simple approach.

1.1.2 Procedures in analyzing maintenance management systems.

"Guidelines for Maintenance Audit Analysis", gives pointers to analyze the data collected from the audit. With this analysis an auditing engineer will be able to propose the complete development of a maintenance management system.

1.1.3 Guidelines on Justifying Computerizaion of Maintenance Management System (CMMS).

Guidelines give the engineers the means to demonstrate the major sources of benefits expected from a CMMS.

They not only show the possible benefits but also the requirements of such systems.

1.1.4 Guidelines on Preparing Specification and Implementation Plan.

Guidelines list and explain the reasons of the required actions and the different steps in an implementation plan. Some examples of implementation plans are also given.

1.1.5 Guidelines on Maintenance Systems Software Acquisition.

Guidelines demonstrate first the advantages and disadvantages of an internally developed software and of a ready-made bought system available from the market. They give then a list of criteria and explanations on how to select the appropriate software.

1.1.6 Guidelines on analyzing maintenance data from the generated reports of a computer maintenance system.

Analysis of reports are related to the software used maintenance procedures and company policy.

Usually they are deeply varied and the planning of the mission was so charged that it has not been possible to issue a document on this huge subject. Books and periodicals on cost analysis give several examples on this subject.

1.2 Manual on Software Development for Maintenance Management System.

Due to the short duration of the mission, it was decided to give this subject second priority. The Project Management agreed that development of the Manual in an efficient manner, required a much longer period of time and the full dedication of the expert.

1.3 Manual on Training Maintenance personnel on Computer-Aided Maintenance

Action

Guidelines have been included on the maintenance manual. These guidelines explain the principles of a training on computer-aided maintenance, main points and subjects to be presented. It is also pointed out who needs to be trained and which kind of training could be the most suitable.

1.4 Guidelines and strategies in encouraging and implementing computer-aided maintenance systems in the Philippine industries.

Action

Guidelines on this subject have been issued taking as example the visited plants and the remarks made during these visits.

Analysis of these remarks has been made, comments and suggestions have been proposed. Individual suggestions have been sent to each industry visited and general considerations and suggestions have been recorded in the guidelines.

2.0 Development of Training Materials

The preparation of materials is supposed to be done by the engineers themselves and the PM staff under the guidance of the expert. However, because of the constraints it was not possible to develop a full range of the required formal training materials, although a large part of them have been prepared and can be utilized in training operations of the Centre.

Action

- Transparencies have been prepared and can be used as support to the guidelines issued for the maintenance manual.
- Reports on plant visits can also be used as case studies for training as well as the maintenance audit which can provide the possibility to train people on maintenance auditing.

3.0 Training of PM Engineers

Training has been performed for only one engineer, the one in charge of development of computer-aided maintenance systems in the PM group of NEC. The other engineers did not request training.

Action

Training of the engineer has been on an everyday training basis. He has been involved in the everyday work of the expert including several discussions and exchanges on the subject on the occasion of the preparation of documents or visits to industries.

The main phases of this training have been:

- Preparation of materials for the lectures: Texts and transparencies have been good occasions of exchanges and training.

- Evaluation of some demonstration diskettes of computerized maintenance systems including the installated MAPCON II system the project acquired.

- Preparation of training materials and maintenance manual also allowed for profitable communications and training.

- Visits to industries have been one of the most important occasions of practical experience and training. Discussion with maintenance personnel have given foundations to the theories. The different approaches and policies of maintenance managers in different plants have been the best opportunities of questions and exchanges. Maintenance audits have been performed in some plants and have been studied and discussed later on.

- Preparation of the reports on plant visits and the final report gave place to analyses of different situations and to the finding of solutions or suggestions.

4.0 Plant Visits in Various Industries

- Plant visits were planned to familiarize the expert with computer application for Maintenance Management purposes in the Philippines industries.

Action

During the mission 8 plants, 1 central maintenance department and 1 agency were visited. This provided a good opportunity for the NEC engineers to get a general feeling and good "immersion". At the same it should be mentioned that these visits would have been more benefitial if circumstances had allowed for them to take place at the beginning of the mssion.

- Second objective was to assess the potential of computerization and to design strategies and actually establish a pilot project.

Action

After plant visits, reports have been issued for each plant. Each report includes a statement of the actual situation and some general and specific suggestions. A Pilot project has been elaborated. Each report includes a statement of the actual situation and some general and specific suggestions. A pilot project has been elaborated. Its implementation would require additional time frame and Technical Assistance input.

- The third objective was to train engineers during the visits and help them to absorb technology by actually doing the technical services with the guidance of the expert.

Action

All the visits have been conducted in cooperation with the engineer in charge of computerized systems in PM group. For two visits, another engineer joined us. Audit of maintenance, discussions, study of documents and plant visits have been numerous occasions of discoveries, comments, suggestions and trainings. The large diversity of maintenance policies met during these visits has given the opportunity to discover the wideness of the possibilities of improvements in maintenance despite the small number of plants visited.

5.0 Pilot Project on Computerization

Establishing a computerized maintenance system in a selected plant was initially planned in the programme. However, the short period of the mission did not allow enough time to achieve this work.

The only action possible has been to select the plant where the implementation has the best chances of success and where the engineer can gain the best experience. An implementation plan of the project has been prepared and is expected to start after this mission.

6.0 Other Activities

6.1 Serve as a resource person in NEC-PM sponsored seminars.

Action

Two days of lectures have been given during the seminar organized by NEC on "Maintenance Management". Details on the performance of these lectures are given here below in the comments on the mission.

6.2 Articles and papers for Project's Safety and Maintenance Digest and other NEC publications.

Action

Preparation of guidelines included in the Maintenance Manual.

6.3 List of international agencies for training on maintenance management. No element available at present.

6.4 List of books and periodicals on maintenance organization and management.

Action

A list of documents on this subject is given in Annex IV.

6.5 Recommendations on how the project can meet the vital needs of the industries in the Philippines in as far as computer aided maintenance is concerned.

Action

- Guidelines are given in Maintenance Manual on where benefits can be expected.
- Reports on plant visits give details and suggestions to the industries.
- Some additional comments are given in this report.

6.6 Other Tasks which are deemed necessary for the success of the PM project.

II. DEVELOPMENT OF LECTURES DURING SEMINAR ON MAINTENANCE MANAGEMENT

A. Preparation of Lectures

- Preparation of material for the lectures.

  - Some material has been collected from books or magazines and has been modified or adapted to be included in the subject.
  - Some material has been created according to the different chapters to be shown as example or guides for the different subjects.
  - All documents have been typewritten.
  - Transparencies have been issued from these documents as support to lectures.

- Preparation of texts for lectures. All the texts for lectures have been typewritten to be included in the documentary book given to the participants of the seminar.

- Preparation of the "interface" and material (transparencies)

B. Programmes of this seminar are enclosed in Annex 2.

Programme of the lecture were as follow:

1st day 2.5 hours - Maintenance Management Systems

3.0 hours - Developing a Maintenance Philosophy

2nd day 4.0 hours - Computerized Maintenance Management Systems

C. Performance of lectures

These 3 lectures took place in the NEC building on February 13th to 16th. The participants (about 50) came from a large range of industries. All of them were responsible or concerned with maintenance in their respective industries. Subjects were presented with the help of a projector or transparencies.

Conclusions

Participants seemed interested in the subject and asked questions for complementary information. Several participants are already preparing implementation of computerized maintenance management system or simply looking for it. The general trend is to develop an in-house software using the help of a hired programmer. The cost of softwares available on the market are generally considered too expensive compared to an in-house product. The actual cost of an in-house programme is generally not well appraised.

Participants were very willing to learn about this subject but they are generally "action people" and it was sometimes difficult to keep their attention during the whole duration of the lecture.

In my opinion a total of 5.5 hours given by the same lecturer over one day was too long and cannot be very profitable to the participants. Two hour sessions would appear more suitable. The total of 9.5 hours should have been distributed over four or five days thus assuring the full attention of participants.

III. REPORT ON PLANT VISITS

Visits to 11 plants and one agency were initially envisaged in order to familiarize the expert with the practices and states of Maintenance Management in the Philippines industries.

Eight plants have been visited, plus the Central Maintenance Division of a company and one agency. Visits to other companies have been cancelled because their availability was not compatible with the planning.

This exercise was utilized for on-the-job training of the NEC staff. Usually the expert was accompanied by one NEC engineer responsible for computerized maintenance. However two visits were performed in the company of two fellows.

For most of the plant visits, we met the Maintenance Manager and his superintendents.

Maintenance management presented generally:

- Existing maintenance procedures
- Existing or prospected documents and forms used by maintenance for data collection and reporting
- Present computerization if any with the planned developments.

Questions and answers generally followed these presentations and some suggestions have been made on possible improvements in adopted procedures of computerization.

All these suggestions were reflected in the reports on plant visits. On the basis of this study a pilot plant project was ellaborated, its implementation would not be feasible due to the short duration of this mission.

A. LIST OF PLANTS VISITED

DATE	COMPANY	TYPE OF INDUSTRY	CONTACT PERSON	REMARK
2-19-90	SOLID CEMENT CORPORATION Antipolo, Rizal	Cement	Mr. Manuel Macairap Chief Engineer	
2-21-90	ARMCO MARSTEEL ALLOY CORP. Pasig, M. M.	Metal-working	Mr. Rene Santos Mechanical Maint. Supervisor	
2-22-90	NPC - SUCAT THERMAL POWER PLANT Sucat, Muntinlupa	Utility (Power Plant)	Mr. Ernesto Pedron Plant Manager	
2-22-90	NPC - CENTRAL MAINT. DIVISION Sucat, Muntinlupa	Utility (Maint. of Power Plants)	Mr. Nevelo Gensoli Maint. Supervisor	
2-23-90	NPC - KPSPP Kalayaan, Laguna	Utility (Hydro-Power Plant)	Mr. Oscar Lorico Plant Manager	
2-28-90	BATAAN REFINING CORPORATION Limay, Bataan	Refinery	Mr. Macatangay Maintenance Mgr.	
3-01-90	PILIPINAS SHEEL PETROLEUM CORP. Tagangao, Batangas	Refinery	Mr. Joseph Kevan Holden Head - Eng'ng. Services	
3-01-90	CALTEX (PHILS.) CORPORATION San Pascual, Batangas	Refinery	Mr. Antonio Z. Palad Head - Eng'ng. Services	
3-08-90	PHILSTEEL Cabuyao, Laguna	Metal-working	Mr. Remigio Buitizon VP- Operations	

B. COMMENTS ON PLANT VISITS

1. These plant visits were planned to familiarize the expert on the local context of maintenance. The exercise could be more productive if it could have been performed at the very beginning of the mission.

2. Among 8 plants visited, 4 have started computerization of their maintenance and are developing a programme internally. One plant intends to buy an already developed software existing in the market.

   The other plants also intended to computerize their maintenance and thinking of developing a programme internally.

3. The general feeling of Maintenance Managers is that an internally developed system:

   - Will exactly suit their requirements because their requirements and their procedures are too specific.

   - Will be less expensive than a system bought from a vendor because local manpower is much cheaper.

   The question of time spent for the development is normally not taken into consideration. They do not have a precise idea of the duration of the project.

   Most of the maintenance managers do not realize that an internal development always takes longer than purchasing an already prepared and tested system. Because of the duration of the internal development, the cost of implementation can be higher than that of a purchased product.

4. Internal development requires the permanent attention of the maintenance manager. In some cases, some instructions are given to the programmer and he works on his own, without permanent supervision. This attitude can generate frequent misunderstanding and wrong developments. Generally maintenance management does not spend enough time on the project.

   Suggestion It would be advisable to create an "implementation team" with full time responsibility from the maintenance side to guide the programmer.

   Maintenance personnel, other than management, must also be more involved in the development of the computerized system

5. The consequence of the above remark is that most of the programmes are missing a comprehensive view. They are generally developed without overall study and planning.

   Suggestion: assist local industries in overall study of their needs, and in planning/implementation of activities aimed at the development of comprehensive programmes.

6. Procedures are not always well defined and work-order is not always used or is used with adequate information based on real maintenance data/procedures.

   Suggestion: - help industry to elaborate work-order and coding procedures.

   - help industries to clearly determine their needs before launching a computerization programme.

IV. CONCLUSION ON THE MISSION

Some remarks and observations have been made during this mission and particularly on the occasion of Plant visits. General or more specific remarks are listed below and some suggestions are given in the particular field of improvement of maintenance management by computer-aided systems implementation.

A. Training of Engineers

The main goal of this PM Project is to help industries to improve productivity by optimizing their maintenance. Optimization of maintenance is the art of performing maintenance within a set of constraints, in a manner that best achieves the goal of the company.

Management, as well as maintenance management, is an art. Webster defines art as "Skill in performance acquired by experience, study or observation."

Management should be a combination of theoretical approaches and analytical techniques integrated with intuition and judgement derived from experience.

A good experience as well as a bad one is necessary to give the possibility to analyze a situation and propose viable solutions.

One of the targets of this mission was on-the-job training of NEC engineers in computerized maintenance management systems, which was provided by the expert in his lessons, discussions and plant visits. It should be mentioned that only one NEC engineer was in full time involvement in these exercises. The second one participated periodically. The others have not been trained for different reasons not under the responsibility of the expert.

Suggestions:

1. Plant Training or Immersion

- Organize trainings in plants to show engineers the everyday work of a maintenance department, the problems encountered, the solutions adopted.

- Engineers must be involved in a defined work which implies frequent contacts with maintenance personnel. For example; planning, maintenance data collection (work-order monitoring) or maintenance procedure implementation or computerization.

- Training at a plant should be organized for not more than 1 or 2 engineers at once. A bigger team will not be accepted by maintenance personnel and trainees will miss a large part of the local maintenance atmosphere.

- Duration of this immersion must be for at least 3 months and even up to 6 months. This length of time is necessary to become integrated in a maintenance team and to profit from its experience.

- This training must be supervised, for the guidance of the engineer and to demonstrate to the host company the importance of this immersion training.

- At the end of his immersion training the engineer will issue a report mentioning the different fields and the importance of his experience.

- Caution: For most industries, a young engineer fresh from university is considered lakcing in basic maintenance practices and experience. The engineer must be very attentive to his attitude to be accepted by experienced maintenance personnel and get benefits from their experience.

2. General Training and Specific Training

As consultants, engineers will be faced with various maintenance problems in their own specialized and in other branches of maintenance management.

Even if they cannct answer the question, they must have an idea of the different techniques constituting maintenance.

- A good grounding in all maintenance specialties must be given to engineers to enable them to become a good specialist.

- This grounding can be obtained through trainings, through exchange of experiences, and through plant visits.

To summarize these suggestions, engineers must be in permanent contact with industries to improve their practical experience.

B. Organization of the Mission

The initial programme was comprehensive but as already mentioned, different levels of priority were given. The 2 month mission did not allow enough time to accomplish the whole programme, but the general purpose of the programme was achieved.

Remarks:

- Plant visits familiarized the expert with the state of practice of preventive maintenance in the Philippines industries. They would have been more beneficial if programmed at the beginning of the mission to give the expert more time to apply the experience gained to the requirements of this project.

The number of plants visited was very limited and gave only a partial view of the situation. Perhaps a plan arranged in advance would have given more opportunities to more plants.

- Lectures given by the expert provided opportunity to get a first systematic approach to maintenance management computerization to a large number of maintenance responsible persons from the local industries.

  As it is difficult to maintain the attention of trainees for a long period of time (statistically 20 to 30 minutes) it would have been more advisable to distribute the total number of hours of the seminar over a period of four days.

- The duration of the lectures totalled 9.5 hours and their preparation required considerable time. Although this preparation was a good opportunity to create contacts between engineer and expert, it would have been more advantageous for the porject to utilize this time for training, plant visits and preparation of pilot project.

- It would have been more andvantageous for the project if the expert would have been informed about planned lessons well in advance, allowing him time to prepare some additional training material.

- Permanent contact with the engineer in-charge of computer-aided maintenance in PM project has been a very positive source of training and frequent occasions of beneficial experience for both parties.

C. Promotion of Computer-aided Maintenance Management Systems

Promoting of a product requires "Marketing". NEC services must be known by the largest number of industries. Reliability of services can be proved by references and experience. The best way to promote services is to show successful results.

In the particular field of Computer-aided Maintenance Management, NEC can use different means or materials to support its marketing.

1. Present a comprehensive and complete software to industries to demonstrate the possibilities of such system and its potentiality to reduce costs. Use of the software MAPCON II can be presented to industries, first of all through the available video tape and then through transparencies (prepared during the mission) in plant offices. A demonstrationr can be presented to industries in NEC offices.

   Caution: For computer demonstration:

   - Present the system to small groups (5 to 10 persons maximum).
   - Try to group persons having the same maintenance objectives and policies to be able to go more into specific details.
   - Present only the "user side" of the system. Do not try to go to database files or other system-manager facilities. Doing this you may let the user think that the use of a computer is reserved to specialists and he will not think that he is concerned with computerization.
   - If the customers are not familiar with computer, try to go slowly and be sure that every step has been well understood.

     It is often more profitable to show less detail and have it understood.

2. Visit as many industries as possible and try to find the best examples of successful implementations.

- Study and analyze the reasons and the policies of this success.
- Present these implementations to other industries as locally and successfully implemented systems (obviously approval of industry is required).
- Try to show figures of the benefits gained through the computerization.

3. Advise industries on different errors made by other in implementing computer systems in maintenance.

Mistakes by one can serve to avoid others making the same mistake. Here below are some of the common errors I faced:

- Develop a system with no or less involvement of maintenance management.

  Result: System working and giving several uselss and voluminous reports with a relatively small interest for maintenance. A programmer was not properly supported by a maintenance manager. Often maintenance managers think that if they do not know programmeing they cannot guide the programmer. That is wrong, they can guide the programmer or the "implementation" even with no knowledge on computer.

- Implement a system before a good definition of needs and requirements are given.

- Implement a system without definition of its general concept and a comprehensive structure.

- Implement a system without a good definition of procedures, (work-order coding, etc.).

Result of these 3 errors:

- Delay in implementation
- Several programmes with no evident relation and difficulty for the programmer to draw up a performance programme. The response time in this case is generally very bad.
- Frequent modifications of the programme.

- If the programmer resigns, it will be very difficult for another programmer to continue or modify the programme.

- Implement a system which is the exact copy of the manual system.

Result: a heavy system, with an uncertain time.

The maintenance manager must take the opportunity of computerization to try to simplify some procedures or reporting which are sometimes obsolete or useless.

4. What is generally required by industries and where NEC can help industries.

- Audit of their maintenance to define the level of their organization.

- Analyze this audit and propose improvements.

- Help to determine their needs and requirements.

- Help to define Procedures: manual procedures oriented to computerization computerizable procedures.

ANNEX I

PROPOSED ACTIVITIES FOR THE COMPUTER-AIDED MAINTENANCE FOREIGN EXPERT

prepared by: Rowaldo R. del Mundo

1.0 DEVELOPMENT OF MAINTENANCE MANUALS

Manuals which will serve as guidelines in the preparation and implementation of computerized maintenance systems suited for the Philippine industries.

The manuals will be used by the project engineers in effectively implementing computerization of maintenance systems in the Philippine industries.

1.1 Manual on Computer-Aided Maintenance for Industrial Plants

This manual should feature the following:

1.1.1 Maintenance survey or audit procedures to be used by the PM Project Engineers in surveying maintenance systems of the industies in the Philippines. The manual should provide details on how to quantify the state or level of maintenance systems, applicability of computerized maintenance systems, and potential savings of computerizing maintenance systems.

1.1.2 Procedures in developing and designing maintenance management information systems and decision support systems.

1.1.3 Guidelines on justifying computerization of maintenance systems.

1.1.4 Guidelines on preparing specifications and implementation plan in computerizing maintenance systems.

1.1.5 Guidelines on maintenance systems software aquisition.

1.1.6 Guidelines on analyzing maintenance data from the generated reports of a computer-aided maintenance system

1.2 Manual on Software Development for Maintenanance Management Systems

1.2.1 Developing a maintainance management information system database

1.2.2 Designing a user-friendly algorithms for the maintenance information and decision support systems

1.2.3 On data structures

1.2.4 On interfaces and networking

1.2.5 On Software customization

1.3 Manual on Training Maintenance Personnel on Computer-Aided Maintenance

1.4 Guidelines and Strategies in encouraging and Implementing Computer-Aided Maintenance System in the Philippine Industries

2.0 DEVELOPMENT OF TRAINING MATERIALS

The expert shall design training materials which will be used by the Project Engineers in training maintenance personnel of the industries in the effective planning, implementation, and use of computerized maintenance systems. The preparation of the materials may be done by the engineers themselves and the PM staff under the guidance of the expert.

He should be able to prepare syndicated exercises for different maintenance levels which should be used as cases for the design of computerized maintenance systems. The exercises should demonstrate the practical use of the manuals or guidelenes in item 1.0.

Training materials may be in the form of demonstration softwares, slides, videos, and transparencies, etc.

3.0 TRAINING OF THE PM ENGINEERS

The expert is also expected to train the Project engineers on computer-aided maintenance.

The following are the suggested forms of training:

3.1 Lectures, group discussions and syndicated

exercises

3.2 Actual maintenance audit of selected industries with the end view of preparing them for computerization

3.3 Actual preparation, documentation, and implementation of computer-aided maintenance of a pilot industrial plant

3.4 Actual use of a computer-aided maintenance software

4.0 PLANT VISITS IN VARIOUS INDUSTRIES

The plant visits in different industries will serve as input to the expert in order to familiarize him of the practices and states of maintenance in the Philippine industries. The trainings and technical services he shall provide should be contextualized in order to be effective.

In the process of the plant visits, the expert is expected to provide technical services in the form of assessing the potential of computerization, designing strategies of preparing and implementing computerized systems, and actually establishing a pilot project in one of the industries.

In all of the activities of the expert, he should be accompanied by the Project engineers so that they will be effectively trained. The enigineers are expected to absorb the technology of computer-aided maintenance from the expert by actually doing the technical services with the guidance of the expert.

Prospective industrial plants to be visited are the following:

a) Solid Cement Corporation
b) ARMCO Marsteel
c) Philsteel
d) Philippine Airlines
e) NPC Central Maintenance Divison and Power Plants in Metro Manila
f) Shell
g) Petron
h) Caltex
i) SMC Polo Plant
j) Coca-Cola
k) PDC/DAP

5.0 PILOT PROJECT ON COMPUTERIZATION

A project on computerization will be established in one of the visited plants. The project shall include all the phases of computerization such as the following:

1. Maintenance audit
2. Preparing a justification report
3. Designing a maintenance management information system to be computerized
4. Preparing specifications
5. Preparing an implementation plan
5. Developing or selecting maintenace software
6. Installing maintenance software
7. Training in the use of installed software
8. Analysis of generated reports

6.0 Other Activities

6.1 Serve as resource person in NEC-PM sponsored seminars

6.2 Contribute articles and papers for the Project's Safety and Maintenance Digest and other NEC publications

6.3 Prepare list of international agencies and firms conducting training on maintenance management specially on computer-aided maintenance

6.4 Prepare list of books, periodicals, manuals and other similar materials on maintenance organization and management

6.5 Prepare a recommendation report on how can the project meet the vital needs of the industries in the Philippines in sofar as computer-aided maintenance is concerned.

6.6 Perform other tasks which are deemed necessary for the success of the PM Project.

ANNEX II

SEMINAR ON MAINTENANCE MANAGEMENT
National Engineering Center
U.P. CAMPUS, QUEZON CITY
FEBRUARY 13, 14, 15, 16, 1990

P R O G R A M M E

TIME	ACTIVITY/TOPIC	RESOURCE PERSON
First Day 13 Feb 1990 Tuesday		
8:00 - 8:45	Registration	
8:45 - 9:00	*Opening Ceremonies* National Anthem Welcome and Opening Remarks FRANCISCO L. VIRAY Executive Director and Project Director NEC-UNDP/UNIDO Project on Preventive Maintenance (PM) Course Overview RAMON S. PUBLICO Course Director & Project Engineer NEC-UNDP/UNIDO Project on PM Master of Ceremonies LYNNORE B. CINCO Training Specialist NEC-UNDP/UNIDO Project on PM	
8:45 - 10:15	MAINTENANCE CONCEPTS • Types of Maintenance • Characteristics of Equipment Maintenance • Planned vs. Unplanned Maintenance • Terotechnology Concepts • Total Productive Maintenance	RENATO SANTOS Mech. Supervisor ARMCO MARSTEEL ALLOY CORP.
10:15 - 10:30	Coffee Break	

TIME	ACTIVITY/TOPIC	RESOURCE PERSON
10:30 - 12:00	MAINTENANCE MANAGEMENT SYSTEMS : Maintenance Productivity : Maintenance Management Functions : Administrative Structure : Organization of Maintenance - : Management System - Work Order System	LOUIS BUREL Computer-Aided Maintenance Mgmt. Consultant NEC-UNDP/UNIDO PROJECT ON PM
12:00 - 1:00	Lunch Break	
1:00 - 2:00	Continuation of Lecture	
2:00 - 3:00	DEVELOPING A MAINTENANCE PHILOSOPHY : Optimization of Resources : Involvement of the Boardroom : Maintenance vs. Production : Motivation and Training for PM	LOUIS BUREL
3:00 - 3:15	Coffee Break	
3:15 - 5:15	Continuation of Lecture	

Second Day
14 Feb 1990
Wednesday

8:30 - 10:00	PREVENTIVE MAINTENANCE SYSTEMS : Breakdown Maintenance vs. Preventive Maintenance : How much PM is needed : Setting up a PM program : Equipment Identification	RENATO SANTOS
10:00 - 10:15	Coffee Break	
10:15 - 11:00	Continuation of Lecture	
11:00 - 12:00	ADVANCES IN MAINTENANCE TECHNOLOGY	P. R. SRINIVASAN Chief Technical Adviser NEC-UNDP/UNIDO PROJECT ON PM
12:00 - 1:00	Lunch Break	

TIME	ACTIVITY/TOPIC	RESOURCE PERSON
1:00 - 3:00	CONDITION MONITORING • General Process Monitoring Techniques • On-load-off Load Monitoring Techniques • Setting up a CM program • Vibration Monitoring for Predictive Maintenance • Rationalizing the Cost of CM	NESTOR VALTE Supervisor Power & Instrumentation JARDINE DAVIES
3:00 - 3:15	Coffee Break	
3:15 - 5:00	DEMONSTRATION IN STATE-OF-THE ART MAINTENANCE • Thermography • Vibration Analysis • Balancing • Non-contact Measurement	EDWARD R. BONDOC Senior Engineer NEC-UNDP/UNIDO PROJECT ON PM
Third Day 15 Feb 1990 Thursday		
8:30 - 10:00	RELIABILITY ENGINEERING • Concepts of Reliability, Availability & Maintainability • Economics of Machine Reliability	Dr. FRANCISCO L. VIRAY Project Director NEC-UNDP/UNIDO PROJECT ON PM
10:00 - 10:15	Coffee Break	
10:15 - 11:00	Continuation of Lecture	
11:00 - 12:00	SPARE PARTS MANAGEMENT • Parts Classification • Pareto Analysis • Inventory Control Systems • Trend Analysis and Forecasting • Importance of Keeping Accurate Records	VAN VICTORINO Productivity Devt. Center DEVELOPMENT ACADEMY OF THE PHIL.
12:00 - 1:00	Lunch Break	
1:00 - 2:30	Continuation of Lecture	
2:30 - 2:45	Coffee Break	

TIME	ACTIVITY/TOPIC	RESOURCE PERSON
2:45 - 5:00	LIFE CYCLE COSTING : LCC Concepts : The Need for LCC : Role of Maintenance in Purchasing Equipment : Impact of Life Cycle Costs on Machine Maintainability	RAMON S. PUBLICO Senior Engineer NEC-UNDP/UNIDO PROJECT ON PM
Fourth Day **16 Feb 1990** **Friday**		
8:30 - 10:00	ORGANIZATION, PLANING AND SCHEDULING : Principles of Organizing for Maintenance Work : Planning the Maintenance Program : Scheduling Techniques : Control and Evaluation of PM Program	APOLINARIO REYES Jr. Special Project Manager PETRON BATAAN REFINERY
10:00 - 10:15	Coffee Break	
10:15 - 11:15	Continuation of Lecture	
11:15 - 12:15	COMPUTERIZED MAINTENANCE MANAGEMENT SYSTEMS : Advantages and Limitations of CMMS : Documentation Requirements : Organizing for Computerization : Software Selection : Implementation of CMMS	LOUIS BUREL
12:15 - 1:00	Lunch Break	
1:00 - 4:00	Continuation of Lecture	
4:00 - 5:00	*Closing Ceremonies* Closing Remarks Awarding of Certificates	

ANNEX III

MANUAL ON COMPUTER-AIDED MAINTENANCE MANAGEMENT SYSTEMS

Prepared by

LOUIS M. BUREL
UNIDO Consultant

MAINTENANCE MANUAL
ON
COMPUTER-AIDED MAINTENANCE MANAGEMENT SYSTEMS

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CHAPTER I

GUIDELINES ON JUSTIFYING COMPUTERIZATION OF MAINTENANCE SYSTEMS

INTRODUCTION

The first concern of a manager is to get profit from an investment. Computerization of a Maintenance System is an investment and the first worry of the manager will be to evaluate the paybacks.

If one intend to spend money and time, the payback must be attractive to management to justify this investment.

Since every industry and even every plant has its own problems and operates in different condition, it is very difficult to identify the possible benefits without doing a comprehensive analysis of the situation of the plant. To establish this analysis it is necessary to conduct a maintenance audit. The purpose of this audit will be to evaluate the present situation.

After the analysis of this audit, it is possible to locate and evaluate the particular sector where benefits can be expected.

The expected benefits from a computerized maintenance management system have been highlighted by a plant engineering survey, the conclusion of this survey are the following:

- Manpower	10 to 15% improvement
- Machine utilization	2 to 15% reduction in downtime
- Product quality improvement	1 to 3% reduction in scrap/waste
- Energy consumption	1 to 5% reduction
- Deferred capital replacement	10 to 15% reduction

The expected benefits are the basis for the estimation of the payback of the investment. Obviously, the above figures are only given as indication. The expected benefits must be estimated according to the analysis of the Plant Maintenance Audit.

The local environment must also be taken into consideration: local market, employment conditions, taxes policy, spare parts purchase or import, and even the climatic characteristics.

The estimation of the payback must be foreseen on a short term, medium term or long term review to evaluate the widest range of possibilities.

The following guidelines have been established to demonstrate the different fields where a computerized maintenance management system can be a substantial help for a Maintenance Manager.

CHAPTER A: Presentation

CHAPTER B: Maintenance Productivity. Examples of improvements obtained through a better organization conducted after a maintenance audit.

CHAPTER C: Optimization of Resources. Maintenance resources are: manpower, tools, equipments, spare parts and time. This chapter gives guidelines on the best way to improve the utilization of resources and how a computerized system can be helpful.

CHAPTER D: Involvement of Boardroom. Without the involvement of the boardroom it is useless to foresee a computerization because computerization is an investment. Boardroom can be motivated by the payback of an investment. Thus, the analysis of the audit must highlight the payback of the computerization of maintenance.

CHAPTER E: Relations with Production. Production also must be involved in maintenance problems and in the mean used by maintenance to solve it. Relations between Maintenance and Production are often rather difficult. Computerization of the maintenance can be of a mutual benefit for Maintenance and Production. That is the reason why a good communication is required to get benefits from a computerization.

CHAPTER F: Advantages and Limitations of a CMMS. A Computerize Maintenance Management System can increase the maintenance productivity by minimizing the downtime, improving the manpower utilization or increasing the production, but as every system, it does not do miracles. A system can not take decision, the maintenance managers has still to take decisions but the system gives him a valuable help.

Costs of labour and material are continuously increasing, equipments are more and more sophisticated, workloads are always heavier and today's Maintenance Managers are always in a fire-fighting situation.

This situation is a matter of fact and maintenance managers have less and less time to organize their maintenance. Use of Work-Orders and Planning-boards is a first improvement but it still give a lot of paper work. Reporting have still to be done manually and this also is time consuming.

The only way is to collect a maximum information and issue reliable reports on time to prepare, organize, evaluate and improve maintenance work and thus reduce costs.

Maintenance Managers have not enough time to do all this in one go. The solution is organization and computerization of maintenance management.

A. PRESENTATION

Maintenance people have always been experiencing difficulty. This is true in most organizations all over the world. Terrific pressure, not enough people, endless criticism for breakdowns, low priority in the battle for resources, low organizational status and lack of spare parts to mention a few.

The problems facing maintenance cannot be solved overnight. But, the tools for change and improvements are available.

This document highlights the opportunities for maintenance people to gain control of the situation.

A study of maintenance system at 13 industrial plants is presented to show that improvements are possible by establishing an effective maintenance system and how to select the correct elements for different operations and circumstances.

Some practical suggestions in implementing a maintenance management system are also included such as:

- o Figuring-out and proving payback from a system;
- o Selling the System to Management;
- o Determining whether a computerized system is really needed;
- o Getting the right people on board;
- o Figuring-out what to do first

Some Pointers on getting quick payback from a particular system are likewise discussed.

B. MAINTENANCE PRODUCTIVITY

Before discussing the principles of Maintenance Management and other techniques used to reduce the cost of maintenance, it is best first to look at a study which has been conducted concerning Maintenance Productivity. This will certainly help in recognizing points where benefits can be expected from a well managed maintenance.

It should also be noted that "Maintenance" can be "Productive" even other departments think the other way around.

1. A Maintenance Productivity Study

A study at 13 different industrial plants was conducted basically to determine the level of potential benefits from a good Maintenance Management Program, whether these benefits could be achieved and how they can be realized.

The phases of the study included the following:

- An evaluation of productivity levels where the Maintenance System is missing or not effective;
- A determination of how non-productive time occurred;
- Evaluation of the effectiveness of several typical improvement programs; and
- An attempt to identify the actions and conditions which seemed to be effective in a good program.

a. Results of the study

The study resulted in the following conclusions:

1) Productivity is (not surprisingly) low where no good maintenance system exists. "Low" translates to an average of only 30% "Hands On" work time. In other words, 70% of the paid time is not actual work time.

2) 85% of nonproductive time is spent in travelling or idleness. (For number of different reasons.)

3) A well-done improvement program can be spectacularly effective within a surprisingly short period of time. In other words, the program can fail badly if poorly implemented.

   What was done, and how it was done are critically important to success.

4) There are certain improvement activities and approaches which generally contributed to success.

The specific information pertaining to this study follows.

Where are we without a good maintenance system?

The following data was compiled using standardized work sampling methods as applied to thirteen various manufacturing facilities:

INITIAL "BENCHMARK" RESULTS IN 13 PLANTS

PLANT NUMBER	"HANDS ON" WORK (%)	NO. OF MAINT. CRAFTSMEN
1	32.5%	120
2	33.7	340
3	26.4	130
4	36.7	95
5	22.0	230
6	29.0	80
7	22.0	220
8	35.0	320
9	28.0	350
10	36.0	600
11	25.0	(N.A.)
12	31.1	(N.A.)
13	25.0	114

From the above table, the average amount of actual "hands on" time craftsmen spend working is only about 29.4%. This value may seem shockingly low, but has been proven time and again as the "mean" for maintenance departments <u>without an effective maintenance management system</u>.

b. Analysis of the Study

The plant studies indicate that 60% of total paid time is spent in travelling and idle "waiting". These types of unproductive work time can be drastically reduced by proper management techniques.

The following table shows individual studies done on four of the plants that established maintenance managment system:

THE TIME - WHERE DOES IT ALL GO?

PLANT/STUDY	"HANDS ON"	TRAVEL	WAIT	OTHERS
PLANT #1	32.5%	26.2%	37.1%	4.1%
	38.6	28.5	29.2	3.8
	45.4	26.9	20.7	6.9
	40.5	23.0	30.5	6.1
PLANT #2	33.7	31.7	29.6	5.1
	28.0	35.0	30.7	6.2
	29.8	35.0	31.0	4.0
	33.7	26.7	35.5	4.0
PLANT #3	26.4	26.6	41.9	5.0
PLANT #4	36.7	28.8	30.6	3.9
AVERAGE:	32.3%	28.3%	34.8%	4.5%

Negative Maintenance Management Conditions

The following conditions generally contributed to a low maintenance productivity level:

- No Work Order system, or, a little-used one;
- No Planning/Scheduling system;
- Little or no Preventive Maintenance Performed;
- No Maintenance support personnel (Planners, Clerks, Storekeeper, etc.);
- Inadequate/Untrained Supervision or Hourly Lead Men;
- No Repair History Information for the Corrective Maintenance Program;
- Unbalanced deployment of the workforce between "Area" and "Central Shops" assignments; and
- Little concern (and/or support) from the Top Management.

2. Maintenance Improvement Program

The plants studied established maintenance improvement programs. The following data are the quantified evaluation of the effectivity of the improvement programs.

PLANT #1 (125 PERSON MAINTENANCE WORKFORCE)

Success is possible, the following is an example of proper Maintenance Management.

SAMPLE DATE	"HANDS ON" PERCENT	IMPROVEMENT PERCENT	ADDT'L. WORKERS EQUIVALENT
1/86	32.5	BASE	---
8/86	38.6	18.8	24 Workers
1/87	45.4	39.7	50 Workers
12/87	40.5	24.6	31 Workers

a. What was done?

The following items are the reasons why this plant's maintenance system was so successful:

- Installed and used a Work Order System;
- Initiated Planning and Scheduling Procedures;
- Provided adequate support staff for items 1 and 2;
- Started to do some Preventive Maintenance work;
- Converted "group leaders" to salaried foreman to give adequate and effective coverage;
- Reorganized the storeroom function; and
- Received whole-hearted support from both tradesmen and plant management.

Success is not always guaranteed, though.

b. Some Improvement Program Results

PLANT AND SAMPLE #	"HANDS ON" PERCENT	IMPROVEMENT PERCENT	EQUIVALENT TO ADDING
PLANT #1 (120 Man Maintenance Force)			
S1	32.5	BASE	---
S2	38.6	+39.7	23 MEN
S3	45.4	+39.7	48
S4	40.5	+24.6	30
PLANT #2 (340 Man Maintenance Force)			
S1	33.7	BASE	---
S2	28.0	-16.9	< >
S3	29.8	-11.5	< >
S4	33.7	N. C.	0
PLANT #5 (230 Man Maintenance Force)			
S1	22.0	BASE	---
S2	32.5	+47.7	110
S3	32.9	+49.5	114
PLANT #6 (80 Man Maintenance Force)			
S1	29.0	BASE	---
S2	29.0	N. C.	0
S3	45.4	+64.5	45

Some Improvement Program Results (Continuation ...)

PLANT AND SAMPLE #	"HANDS ON" PERCENT	IMPROVEMENT PERCENT	EQUIVALENT TO ADDING
PLANT #7 (220 Man Maintenance Force)			
S1	22.0	BASE	---
S2	34.2	+55.5	122
S3	36.2	+64.5	142
PLANT #8 (320 Man Maintenance Force)			
S1	35.0	BASE	---
S2	47.1	+34.6	111
S3	51.4	+46.9	150
PLANT #10 (600 Man Maintenance Force)			
S1	36.0	BASE	---
S2	36.0	N. C.	0
PLANT #13 (114 Man Maintenance Force)			
S1	25.0	BASE	---
S2	30.0	+20.0	23

The above tables show the change from the initial Benchmark Study during the implementation of a maintenance management system.

3. Conclusion

The study was presented to show through few real examples that improvements are possible. Maintenance can indeed be "Productive".

How to improve the productivity of maintenance? The best way to improve the efficiency of a department, especially of a maintenance department, is through its organization!

The first step in the organization of a maintenance management system is to evaluate by a comprehensive study, the situation of existing maintenance. It is often very interesting to seek advices from people who do not belong to maintenance. The observations and views of a new comer or an outsider can highlight some points that maintenance people usually do not see anymore.

Refer to Maintenance Audit. This audit has been prepared to evaluate the capability of a maintenance department to be computerized and to determine the requirements before computerization.

C. OPTIMIZATION OF RESOURCES

Maintenance Resources

First of all, what is resources? The dictionary defines it as "*source of supply for what is needed.*"

What are the needed resources by Maintenance department to maintain the plant?

- Manpower: Mechanics, Electricians, Instrument technicians, Masons, Painters, etc.
- Tools: Hand Tools and Specific Tools
- Equipment: Crane, Transport, scaf-folding, etc.
- Spare Parts, and
- Time

Which one of these elements is the most important? It is difficult to say because each one is different from the other. But, each one can be optimized.

1. Manpower

Efficiency can be improved by proper training, organization and planning of the work.

How to improve Manpower efficiency

a) First of all, by implementing a good relationship between the different actors of Maintenance, namely: Maintenance Manager; Supervisors; Foremen; and Craftsmen or Workers.

Good relationship means good cooperation. That is, vertically from the Manager to the Worker and horizontally by the cooperation among the different trade technicians.

The manager has to choose the appropriate leadership style among professionals. The choices include autocratic, bureaucratic, Laissez-Faire, and democratic type of leadership

A good leader is a good helper. A good helper is a good Trainer. This increase the motivation of worker as he realizes that his manager knows his job and can help him.

The worker must be confident in his manager, supervisor or foreman. This is the major condition or mode to elicit feedback information. Feedback is absolutely necessary for the improvement of maintenance.

To summarize this relationship, Figure highlights the Positive v.s. Negative environment influence.

b) A second way of improving the Manpower efficiency is Training .

- Technical Training on specific area to increase the technical efficiency.

- Training people showing them how they can be responsible of the results in the company.

c) Thirdly, manpower efficiency can be improved by effective organization of job i.e. by proper planning and scheduling.

Organization of a job starts by Planning and Scheduling. For a fixed date and time according to:

- o Equipment availability (See Production)
- o Resources availability (Manpower, Tools, Equipments, and Parts)

Preventive Maintenance as well as Corrective Maintenance can be planned in certain circumstances.

Emergency works can not be planned but Maintenance Manager or Supervisor must check the Planning to see if jobs have already been planned on this equipment and can be done at the same time.

Maintenance Management Systems are generally designed to take care of Planning and Scheduling according to Resources availability.

The three ways of optimizing manpower must be understood as having the same importance.

2. Tools

Tools are necessary to a craftsman. The proper organization of such tools will insure maximum benefits from them.

Hand Tools such as screwdriver, drill, tester, etc. are under the responsibility of the craftsman. The Foreman has to take care of the permanent availability of them.

Specific tools such as specific wrench, adapter, magnetic support for drill, Oscilloscope and even more sophisticated equipment and instruments must be kept in a specific storeroom under the responsibility of a storekeeper.

The storekeeper has the following responsibilities:

- o Keeps an up-to-date inventory of tools
- o Registers Entries and Exits of Tools with Date and Name of the craftsman using it.
- o Maintains and Controls specific tools to good working condition.

3. Equipment

Equipments are often necessary to perform a specific job. (e.g. Scaffolding, Crane, Transport, etc.) They must always be available in the plant, so they should be under the responsibility of the Tool Storekeeper. This will enable everyone to know where an equipment is located and whether it is available or not.

Equipment can also be on "hire". In this case, the Maintenance Manager must have an up-to-date list of Hiring Companies with full details of the equipments for hire.

Some CMMS offer Contract System which enables the Maintenace Manager to follow the cost of such Hiring contracts and other contracts. With such system, one can know the cost of each equipment on hire and will be able to return the equipment as soon as its use is finished.

4. Spare Parts

Optimization is possible through organization of Stock Control and Purchasing. Spare parts availability is related to purchasing which depends on the Company and Government Policies. Specifically, stock control depends on the efficiency of the purchaser or purchasing department.

This is a very important element regarding the cost of Maintenance.

5. Time

We can not change time itself but we can arrange the way of using it. The use of time can be optimized by Planning and Scheduling.

The basic purposes of Planning and Scheduling maintenance work are:

- o To improve the productivity of Maintenance;
- o To perform work on schedule; and
- o To plan for future requirements before they are needed on a crisis basis.

Planning is the determination in advance of all elements required to perform a task.

Scheduling is the specific time phasing of the planned elements together with orders to proceed with the work, and follow-up and status reporting on job progress.

CMMS generally allows such planning and scheduling giving different possibilities. Some systems are more oriented towards the planning facilities, others towards history and others towards costs.

Time use can also be improved by tracking idle house or time spent in a wrong manner.

To locate how time is spent, a job method improvement study can be conducted. Such study must be made on some specific job. For example, replacement of a universal joint on a transmission. Specify and Record the following times and transform them into percentage:

TIME		
Travel Time	-	xx.xx
Tool and Equipment recovery	-	xx.xx
Spare parts acquisition	-	xx.xx
Idle Time	-	xx.xx
Obtaining instructions	-	xx.xx
Working Time (effective)	-	xx.xx%
T O T A L	=	100%

This will easily highlight the "Hot Point" of Organization.

The most difficult time to track is Idle Time because nobody wants to say *"I have nothing to do, I am Idle"*.

After this study you will be able to pin-point loss of time which can be minimized. Once it is identified, you can find the solution

Note that as soon as you talk about Time control, people think of "salary". Since this study must be based only on statistics, workers must realized that it has no relation with their wages, over-time hours, etc.

D. INVOLVEMENT OF THE BOARDROOM

All the benefits of a well designed maintenance system cannot be realized without the support of upper management.

Maintenance people are already experiencing pressure from and conflicts with other departments. With the complexity of managing maintenance activities personnel, the maintenance manager will not succeed in meeting maintenance objectives and if he will work as a "lone ranger".

The objectives of maintenance is productivity in the context of the whole plant operation. Therefore, it is proper for the Maintenance department to receive provisions for its activities.

Perhaps, the best way to involve Management Boardroom is to show to them the expected benefits and payback of the investments for every maintenance activity.

A well organized maintenance management system will surely result in substantial benefits towards the profitability of the Company.

1. Estimating Benefits and Payback

a) A plant engineering survey which attempted to clarify the benefits that can arise from a computer based Management System, indicate that:

- o Manpower utilisation and effectiveness: Improvement 10 to 15 %
- o Machine Utilisation and capacity: Reduction in Downtime 2 to 10%
- o Quality improvement in product: Reduction in Scrap/Waste 1 to 3%
- o Energy Cost: Reduction 1 to 5%
- o Deferred Capital Repla ent: Reduction 10 to 15%

This survey indicates the impact on unit costs that effective Maintenance Management can have.

b) The benefits expected from a computerized maintenance system can be summarized as follows in terms of Reduction in Unit Costs:

Short Term

- Increase labour utilisation and effectiveness.
- Control and reconciliation of job hours and clock hours.
- Setting Standard Target Times for jobs,
- Planning and scheduling jobs against known availability of equipment and resources.
- Reducing Time spent "off-the'job"
- Improving Trade performance.
- Reduce equipment hour cost, utility cost.
- Reduction of Down Time
- Reduction in direct and indirect production cost.

Long Term

- Reduction of Direct and Indirect Material Costs
- Positive stock Management.
- Appropriate purchasing system.
- Reduction in raw material cost (reduced waste).

c) Payback

After a good reorganization the Payback of a computerized system can be one year even less.

But the cost of an implementation depends essentially on the organization needed or the reorganization requirement. In fact we have 2 costs:

- o Organization or Reorganization cost which is very flexible. It can vary from 1 to 100 according to the type of industry and the level of actual organization.
- o Purchasing and implementation cost. This cost can be estimated with a rather good precision.

The first cost (organization cost) has nothing common with computerization. The cost of reorganization must not be presented to the boardroom as a necessity required by computerization because reorganization of a department can be useful either with or without computerization.

The second cost which is purchasing and implemention cost of the computerized maintenance management system is directly related to the computerization.

The payback of this cost can be easily calculated according to the estimation of expected benefits as we have seen above.

Involvement of the boardroom is the fesult of the ability of the maintenance manager to:

- o Highlight the expected benefits
- o Estimate the Payback of the investment.
- o Show how you are confident on the way to reach your goals.
- o Be persuasive.

E. RELATIONS WITH PRODUCTION

As pointed out earlier, maintenance can be and must be productive. Maintenance efforts must improve the "Total Plant Production."

Even if maintenance people do their best to maintain the plant in its best running condition, other departments still criticize the Maintenance department. The Accounting department for example always complain that maintenance is "too expensive" while the Production department are irritated by the interventions to repair which are too late and too long.

When an individual or a group finds its goal directed activities are being blocked by other individuals or groups, conflict occurs. Hence, the issues facing maintenance are not easy ones. There is a need to view the situation wholistically. This means, production must view maintenance activities as reinforcement to enhance availability of equipment.

1. Cost of Maintenance

Regarding the cost of maintenance, it should be noted that an excess of maintenance is as bad as lack of it.

The perfect level of maintenance is in fact difficult to find . A CMMS can be a good help in such a problem.

2. Conflicts

Conflicts between Production and Maintenance are common experience in industrial plants all over the world. This occurs most often when maintenance is not well organized.

If a maintenance department is not able to prove its efficiency, it is very difficult for it to positively react in case of conflicts.

The major causes of conflict between Production and Maintenance consist of equipment unavailability for maintenance purposes, especially for PM, delay to repair, duration of interventions, down time of equipment and many others. All these are nuissance to both departments. Experience shows that these conflicts occur generally during peak hours of production. Furthermore, even some of these are small and superficial, the cumulative effect makes it big and inflating.

If the pressure of conflicts increases, the "vessel" will eventually explode unless there is a safety valve. There are two points of attack to reduce such pressure, namely: upstream before the vessel or downstream using the safety valve. The best solution is to lower the pressure upstream to avoid over pressure in the vessel.

3. Resolving Conflicts

To resolve the conflicts the solution is not to run-away but rather a mutual understanding between the departments involved. To have mutual understanding, a good communication is necessary, and for a good communication, information is required.

Fortunately enough for companies having a well organized maintenance system, information is available. The maintenance manager will be able to justify the equipment availability requirement for maintenance scheduled plans, the actual availability of equipments, and the actual MTBF or MTTM and other ratios.

The maintenance manager will be able to plan with Production Manager and come to an agreement which is mutually beneficial. The maintenance manager must highlight the main reasons for delay and to show to other managers that delay is not always under the responsibility of maintenance.

Information and Dialogue are one of the best means for productivity improvement. Hence, maintenance and production should work in the same way in the same vessel. Both working for improved production.

This does not mean however, that Production and Maintenance must be in the same department. That is not the best solution. It is never good to have two different heads in a cap. One will invariably become predominant to the detriment of the other.

Maintenance and Production therefore, must have separate management and workforce but, must be at the same hierarchical level and must share information and work together for productivity.

The scheme will work better for some with computerized systems that can accept several and simultaneous users and entries. It is easier then to ask Production people to enter information such as other down times of equipments, and those that not are direcly due to maintenance. This can also be a way to involve Production people in maintenance system and thus motivate them to understand and solve maintenance problems.

F. ADVANTAGES AND LIMITATIONS OF A CMMS

Maintenance is very expensive for most industries. To some industries such as steel plants and petro-chemical plants, maintenance personnel represents roughly 20 to 40% of the population of the entire plant. Maintenance cost varies according to the type of industry but it is always a significant cost.

A survey in UK on 41 companies showed that the Annual Maintenance Cost amounts up to 5 to 26% of the Assets cost and 2 to 9% of the total Turnover and 4 to 16% of the Added Value.

In most of the industries therefore, the reduction of maintenance costs has become a necessity.

An important and powerful tool to reduce maintenance costs is the computerized maintenance management system (CMMS).

The computer is a very useful tool because it gives a lot of possibilities to reduce costs. Though we are thankful to information CMMS gives we have to realize that it has also its limitations (it does not make miracles). Further, there are also considerations of capital importance on the success of its implementation, namely: ORGANIZATION and STRICTNESS.

A computerized Management System is a complete computer-based system designed to manage the information necessary to improved control and productivity in maintenance organizations.

The system helps to:

- Minimize downtime through more consistent preventive maintenace
- Improve maintenance labor productivity through better scheduling
- Reduce the severity, frequency and cost of breakdowns
- Prolong equipment life
- Increase production efficiency and quality
- Control costs of repairs
- Improve management through better, more timely reporting

1. Limitations of CMMS

Perhaps, it is better to start with the limitations of CMMS before the benefits from implementing such a system is discussed in detail.

A computerized Maintenance Management System can change the operation from "crisis" to "managed" maintenance. And, when used in conjuction with a Parts and Storage System, even greater results will be obtained.

But the system can not help to:

- Deal with people;
- Find technical information not entered to it;
- Get accurate figures if data such as actual man-hours, rates, times, etc. are not properly entered;
- Train people technically;
- Take decisions in place of the maintenance manager. As everyone knows, a computer is not intelligent. It only makes researches and calculations, even very sophisticated calculations, very fast. It never takes decisions.

Maintenance managers still have to take decisions and it is better that way.

A computerized maintenance management system is only a tool. It does the work it is asked to do and like a car it needs a driver, roads and gasoline to be useful. Otherwise, it is absolutely useless.

If you have a car you can not use it to cross the sea. And a boat is not prepared to climb a mountain.

Do not expect more than the system can do.

2. Benefits from a CMMS

a) Minimize Downtime through More Consistent PM

- Better organization of PM. (better preparation). An inventory of the different tasks to be performed can be prepared. The system does not prepare it, maintenance personnel does it but it helps to keep the information, classify it and retrieve it easily.

- Better planning. It is easier and quicker to adapt or modify the tasks to be done because one can easily go back to a task or job description.

  But the system does not do the planning. Managers must prepare it. The system will help to efficiently prepare it.

- It will also help the craftsman to diagnose more quickly the reason of the breakdown. For that, he will be able to get technical information and equipment history more quickly. Remember that a study has shown that the time spent for diagnostics represents from 60 to 80% of the repairing time.

b) Improve Maintenance Labor Productivity through Better Scheduling

- Better scheduling means better preparation of intervention for PM

- Better intervention situation in accordance to other requirements

  Here, the system also helps to prepare the schedules and serves as a reminder. But, it will also not do the job.

c) Reduce the Severity, Frequency and Cost of Breakdowns.

- That is one of the first improvement a good PM can bring. If PM is well organized, planned and scheduled equipments are kept in better condition and breakdowns are less frequent.

- Data from Condition Monitoring, Oil analysis, Vibration control, Inspection, etc. can be combined with the data in the computerized system to centralize data. This will reduce frequency and cost of breakdowns since better planning will be made out of the centralized information.

- Note that the best CMMS will not suppress breakdowns or corrective Maintenance. Maintenance people will still find unexpected leaks which need urgent intervention or motor burnt out by a default of the power supply. However, the frequency of occurence will be minimized.

d) Prolong Equipment Life

- The combination of different PM technologies will obviously lengthen the equipment life.

  The computerized maintenance system is a help in the sense that it facilitates maintenance planning and scheduling and it records the history of each equipment. Maintenance Manager will be able to identify repetitive faults. Thus he can react quickly to prevent catastrophies.

e) Increase Production Efficiency and Quality

- This is the result of the above benifits.

- It should be realized that the system itself does not increase production. The system provides the means to improve it.

f) Control of Costs of Repairs

- Through reporting, the system can provide the cost of any job done, the cost of any equipment related to certain period or certain type of intervention or a combination of both.

- Most systems can split the costs into Manpower, Spare Parts and others. Cost can also be splited by Trade, Priority or other criteria

- It will also enable the maintenance manager to determine the most significant source of cost and analyze it.

  Of course the system requires structures and constant vigilance in recording time, spare parts and other costs.

g) Improve Management through Better and Timely Reporting

- Reporting is generally on request. Reports needed can be asked whenever the users specify them.

- Reporting can be obtained on screen or through a printer. Generally, long reports can not be obtained on screen only on printer.

- Several reports in different formats can be obtained from such systems.

- The requestor must be very precise when he formulates his report.

- Some systems allow special researches and interrogation of the database through specific report generators. This is a very good possibility but it requires some precaution to protect the database against wrong action corrupting them.

A Computerized Maintenance Management System must be considered as a good help, a very powerful help, but, such system requires a lot of attention strictness to be helpful. Secondly, it does not do maintenance job and it cannot take decision. CMMS should be used as a tool!

CHAPTER II

GUIDELINES AND STATEGIES IN ENCOURAGING AND IMPLEMENTING COMPUTER-AIDED MAINTENANCE SYSTEMS IN THE PHILIPPINE INDUSTRIES

INTRODUCTION

To advice on how to encourage the implementation of computer aided maintenance systems in the Philippine Industries, it would be interesting to have an idea of the present situation of the computerization of Maintenance departments.

A series of plant visits have been conducted and the conclusion of these visits can be the foundation of the guidelines. As a matter of fact, these visits gave a rough idea of the actual level of computerization in the Philippine industry maintenance. The small number of industries visited can not give a comprehensive view of industries, it gives only a limited aspect of the situation. Comments on these visits are given in annex.

The analysis of these visits shows a general willing to improve maintenance practices and efficiency but the means to reach this goal are often not clearly defined by Maintenance Management.

Generally, the services offered by a computerized system are not appraised and maintenance managers expect good results from a computerized system but do not have a precise idea on:

- how a system can help them
- what are the requirements to implement and to run a system

However, some maintenance managers have a very good approach and are implementing computerized systems in a very professional manner.

For a large part of industries, it is clear that tne first step of the strategy is to present the expected benefits to maintenance managers with its counterpart which is the requirement of a system, namely organization and strictness.

To encourage the use of computerized system it is like to sell a material or an idea, it needs marketing and elaboration of a strategy. This marketing can be done at the occassion of meeting industries, at the maintenance management level, but also at the top management level. Motivation of management is required to get hierarchical and financial support to the project. As it is an investment, management support is required.

STRATEGIES

Different aids and method can be proposed to motivate and encourage or justify the use of computerized maintenance systems. Suggestions are as follows:

A. Present A Successful Implementation

1. The best encouragement is motivation and this can be obtained by the demonstration of expected benefits and the presentation of successful realizations, either implementation of an external system, or an internally developed system.

2. - Audit different industries and found one or several using a computerized system with success.
   - Analyze the benefits they can realize or have realized through the use of this system.
   - Establish a case study
   - Present this practical example to other industries and comment the results of this implementation in terms of profits, but also in terms of intangible benefits namely help for breakdown diagnostic, immediate availability of figures for reports, etc.

B. Present A Demonstration System On A Computer

1. To propose the demonstration of a system could also be a source of motivation to present the different possibilities of a system and how a maintenance manager can get figures and analysis or technical information to improve his maintenance policy and efficiency.

2. Action Suggested

NEC has already a computerized system and the application of this software can be showed to industries.

- First step: This system can be presented as it is to industries to present the different possibilities of a comprehensive system and demonstrate advantages. At first a brochure can be showed to the industry but a demonstration on the computer itself is more advisable.

  Caution:

  When presenting a system, always remember that you are not presenting it to a computer specialist but to a Maintenance-man. He is not interested by database or programme; his interest is: report, technical data and data to be entered. Showing database structure would disturb him and let him think that the system is not easy to use. Show only the user side, the way he will use it.

- Second step: The system can be implemented in a pilot plant and this experience and its results can be presented to several industries.

  Warning: This must be done according to the license terms. The approval of the vendor can be requested.

C. Make An Audit of Maintenance Department

1. An audit of maintenance department can also be proposed and after the analysis of this audit it is possible to highlight the points where maintenance can be improved and which benefits can be expected from a computerized system. This audit must be conducted in such a manner to identify the particular sectors of maintenance where computerized systems can have positive impact.

   This audit can be conducted and analyzed by a specialist of maintenance.

2. Action Suggested

   - Contact an industry and propose to perform an audit (either a complete audit or a simplified one) to evaluate their needs and the present level of their maintenance.

   - Conduct the audit and analyze it highlighting the points where maintenance can be improved and how a computerized system can be helpful.

   - Propose to industry the conclusions of this audit and the solutions of their problems through computerization.

   - Focus the points where benefits are expected.

D. Proposed Supports

1. Matter to support presentation can be found in maintenance manuals developed during the present mission.

   - Guidelines on justifying computerization of maintenance systems.
   - Guidelines on preparing specifications and implementation plan of maintenance systems.
   - Guidelines on training maintenance personnel on computer-aided maintenance systems.
   - Audit of maintenance form.

2. Action Suggested

   Go through these documents to find argument to support your presentations.

CHAPTER III

GUIDELINES ON PREPARING SPECIFICATIONS AND IMPLEMENTATION PLAN OF COMPUTER-AIDED MAINTENANCE SYSTEMS

INTRODUCTION

Implementing a Maintenance System is an important investment in terms of money and manpower and it is the reason why an investigation must be conducted first and a detailed planning must be issued before starting.

To prepare this planning it is necessary to evaluate the situation of the present procedures. An audit will establish the present status of maintenance. The analysis of this audit will draw attention to the critical points and determine what is to be done before implementation.

Present procedure and policy will be revised or new procedures and policy will be drawn up according to conclusions of the analysis of the audit.

An estimation of the amout of manpower will be drawn out of this analysis and then a planning will be issued.

This implementation planning will take into consideration:

- new or revised procedures and policy
- new or revised functions
- new or revised administrative structure
- new or revised organization
- new or revised documentation required

The following guidelines have been established to present the different aspects of a Maintenance department and list the different actions to be taken to organize and computerize the department. And finally, the different phases of an implementation plan are proposed.

CHAPTER A: Maintenance Management Functions. Maintenance Management is the first and the most directly interested by computerization. It is thus normal that the maintenance management functions are clearly defined. This emphasizes the different priorities of these functions and determine the different responsibilities.

CHAPTER B: Administrative Structure. Before computerization, administrative structure of a maintenance department must be clearly defined. Thus, the different functions will be covered.

CHAPTER C: Organization of Maintenance Management System. To implement a system it is necessary to understand how it works and what are the major modules at the system to be able to evaluate the gap to be bridged between maintenance needs and the system requirements.

This chapter lists also the information a system can provide. But, it is essential to remember that a system works with the data entered and that is why an example of work-order procedure is given. All information required to run a work-order system are listed.

CHAPTER D: Documentation Requirements. As for the preceeding chapter, the system works with data entered by maintenance. It is very important, thus, to list all data required by a system and the documents from which these data can be retrieved.

CHAPTER E: Organization for Computerization. Without organization it is useless to think about computerization. This chapter gives a basic plan for organization of a maintenance department in view of computerization. The different steps of an organization are mentioned.

CHAPTER F: Implementation of a CMMS. Organization of the maintenance department is the preliminary phase of the implementation of a computerized system but the comprehensive planning must include all the phases from the first inquiry or audit to the post implementation evaluation. This chapter lists the different phases of an implementation.

It can be rather easy to determine the duration of some of the phases, but, most of them can have a variable duration. In fact, the duration of several phases are directly related to the present organization of the Maintenance department, e.g: issue of the equipment inventory can be very rapid (1 week) or longer (1 to 2 months) if the coding system has to be created. The number of equipments to be monitored by the system is also a determinant criteria. Creation or modification of procedures can also have an influence on the duration of the project.

It is only after the analysis of the audit of maintenance when a planning can be established.

A few examples are given in Annex.

A. MAINTENANCE MANAGEMENT FUNCTIONS

The main aim of Maintenance Management is to *"Keep the wheels of production turning"*. That is, to maintain the production tools and equipment at high level of efficiency. This means, to target high values of "Availability" and "Reliability".

To achieve the objectives of maintenance, the management has several functions with both short and long term view.

1. Functions of Management

a. Establish goals and objectives, Policies and Procedures or Guidelines.

b. Establish permissible variance from the formulated guidelines.

c. Measure performance by the established guidelines.

d. Compare performance measurement feedback information to guidelines.

e. Isolate and identify deviations beyond tolerance.

f. Determine Basic Cause for Deviations.

g. Determine corrective action.

h. Plan Method of implementing corrective action.

i. Schedule plan for implementing corrective action.

j. Implement corrective action.

k. Follow-up to ensure completion of corrective action.

l. Control the efficiency of the corrective action afterwards, by the feedback information.

The most important element in the maintenance management functions is the feedback of information. Without this element, improvements cannot be realized.

Stated briefly, the management must establish goals and objectives then design a performance measurement system to measure performance to these goals and objectives. The goals and objectives and the policies and procedures written to implement them may be a long and complex list of guidelines. Just writing the guidelines will not insure that they are implemented. They may not be implemented for one or all of the following or other reasons:

- o Employees don't understand the guidelines;
- o Employees don't like the guidelines;
- o So many procedures have been written that the employee doesn't have time to carry out all of them;
- o Employee thinks and likes his own way better;
- o Etc.

Managers must perform periodic audits of all guidelines and study feedback reports. Otherwise, employees will do what they want to do which may not be helpul in attaining maintenance objectives. A good time to audit prodecures is during major crisis, breakdown or accident, since violation of established guidelines is frequently the cause of such crisis.

2. Control Functions of Maintenance Management

Functions of maintenance management are cyclical in nature and are repeated over and over again, never ending, each time, improving the total performance of the organization.

A very important aspect of maintenance management is "control". Maintenance manager must control all the resources available to him.

The following are the control functions of maintenance management according to priority.

a. Priority 1 - Control on Competence of Maintenance Labor

The first priority of maintenance management is to insure the availability of technically competent mechanics who can repair almost anything that breaks down. This is most obvious to owners of a small plant who is about to hire his first maintenance men. There is no question in his mind that this is the first priority.

b. Priority 2 - Control Over the "Logic" of Work Assignments

This item can best be illustrated by giving a few examples of illogical work assignments that should be caught and stopped by the audit.

Construction Work: It is illogical to have maintenance men build a desk for $300, when a superior desk can be purchased for $200.

Janitorial Work: It is illogical to have an electrician clean offices when the work should be performed by a lower paid janitor.
Design Changes: It is illogical to make design changes or modifications by unqualified operation or maintenance personnel. Checks and balances must be instituted to insure that authorized and qualified personnel work on appropriate work.

Maintenance Work: It is illogical to perform maintenance work that can be eliminated by correcting a design error (replacing a fuse that is constantly blowing with one of a correct size).

It is illogical to perform maintenance work that can be eliminated by correcting an operational practice that causes damage to facilities (craneman damaging structural elements by collision).

It is illogical to perform repetitive maintenance tasks that can be eliminated by a revision to preventive maintenance procedures. It is important to realize that some repetitive maintenance procedures can become so ingrained over the course of many years that the illogicalness of the procedure is overlooked.

c. Priority 3 - Control of Production Loss Caused by Equipment Downtime

The cost of production loss caused by equipment downtime must be minimized by the optimization techniques available. This will be discussed in the paper on optimization of resources.

d. Priority 4 - Control Over Labor Productivity

Then, systems must be designed to obtain high labor productivity. This will also be described later in the topic on optimization.

e. Priority 5 - Management Information and Control Systems

Finally, management information and control systems must be installed to "fine tune" the maintenance function.

PROBLEMS IN AN EXISTING ORGANIZATION SHOULD BE CORRECTED IN THE ABOVE ORDER OF PRIORITY!

In summary, it must be emphasized that the management control cycle is a continuous, never ending optimization process, which requires constant surveillance on the part of the manager. In order for it to work, every department must establish goals, objectives, policies, procedures and a matching and well thought-out performance measurement system.

B. ADMINISTRATIVE STRUCTURE

Administrative structure of maintenance department must also be organized to be sure that all maintenance functions are covered and somebody will take care of it.

The administrative structure of a maintenance department can vary widely depending on the size of the company and the type of activities. For example, in a petrochemical plant, the organization will be different from that of a power plant or that of a transport company. The needs are different, the equipments are distinct and the way of maintaining them are varied.

The administrative tasks in a maintenance department constitute essentially of two basic functions, namely: personnel and operation.

1. Personnel Function

This function determines the staff requirements of the maintenance department and organizes them.

The following are some of the personnel function in the maintenance depatment:

- o Defining the functions and roles
- o Staffing and manning each function
- o Determining the hierarchy of the functions
- o Defining the relationship ofthe functions

It is very difficult to draw the perfect organigramme (organizational chart). It must be drawn in accordance to the needs and the size of the company, the type of industry and the local market.

The organigramme for a large or small factory, for a steel mill, a transport company, a Petro chemical plant, etc. may or may not be the same since process are different, maintenance policies are different, but the role of maintenance remains the same.

2. Operation Function

This function determines the tasks to be performed in a maintenance department. The following are the maintenance tasks, valid either for a manual or a computerized system.

- Management, in general term to maintain the maximum production at the lowest cost.
- Management of personnel
- Equipment inventory follow-up
- Technical information keeping
- Planning of maintenance works
- Scheduling
- Work order and request system
- Controls
- Inspection
- Safety
- Inspection and work reporting (Feed Back)
- Preventive Maintenance
- Corrective Maintenance
- Reporting and analysis on manpower utilization, costs and availability of equipments
- Purchasing - Parts and material
- Stock keeping and management
- Budget follow-up

3. Methods to Organize an Administrative Structure

The role of the maintenance manager is to organize his department in order to match the two functions, namely: Personnel and Operation.

The following are some of the tasks of the maintenance manger in organizing his department:

- o Classify the operations
- o Estimate the volume and priority of each task in the particular convert of his plant
- o Evaluate the personnel resources both in terms of quality and quantity
- o Estimate the gap, if any, between personnel and operations to be performed
- o Accomodate the appropriate resources
- o Assign the different task to the right personnel
- o Train personnel or delegate training to the applied skilled personnel

C. ORGANIZATION OF MAINTENANCE MANAGEMENT SYSTEM

1. Basic Functions in the Oraganization of Maintenance

The basic concept of a maintenance managament system is summarized in the following basic functions:

- o Resource Management
- o Equipment and spare parts inventory
- o Stock management and parts purchasing
- o Work-order procedure
- o Preventive maintenance system
- o Corrective maintenance
- o Recording and reporting

Resource Management

Maintenance resources to be managed first is the Personnel. An improvement in personnel resources can be obtained by:

- o better organization of jobs
- o better organization of time = Planning
- o better skill = Training

Equipment and Spare Parts Identifications

- o All equipment must be identified by a unique number. Its functional and geographical position must be registered and the related technical data must be easily accessible.
- o Each part must also be indentified by a unique number. Its relation to an equipment or several equipments must be clearly established.

The numbering procedure can vary according to company policy but it must be as clear and strict as possible. Some numbering procedure associated the relationship between parts and equipments.

Stock Management and Parts Purchasing

This is an essential key to success for a well organized maintenance system.

- Stock control allows a maximum availability of spare parts for the minimum investment.
- Purchasing optimization can reduce delays in supply and delivery.

Work-Order Procedure

This is the means to record, plan, track and report all maintenance works.

- A work-order can be a work request before its approval by maintenance if it is issued by any other department.
- Work-order procedure must be clearly defined to avoid failures in procedure.

Preventive Maintenance System

Preventive maintenance use WO. PM is a means to reduce the number and frequency of repairs on a crisis situation by organizing and planning the following:

- Inspections
- Routine jobs
- Periodical adjustment
- Replacement in advance of critical parts
- Condition monitoring
- Lubricant analysis
- Vibration analysis

Corrective Maintenance

Preventive maintenance cannot avoid and totally eliminate corrective maintenance. Otherwise, the cost of PM would be disproportionate compared to the cost of corrective maintenance.

Corrective maintenance is the way of fixing an equipment after a breakdown or when a necessary repair is not planned and programmed.

Recording and Reporting

All information concerning any intervention is recorded to be able to report on:

- o Maintenance history
- o Utilization of manpower
- o Work backlog
- o Material cost
- o Cost analysis
- o Maintenance statistics

All these basic functions are applicable to any industry and anyone can create a maintenance management system according to the needs and the organization of the plant.

These basic functions are valid for a manual system, but would be more useful if a computerized maintenance management system exists.

2. Better Organization Through Computerization

Although computers have been widely utilised in industry for many years for a variety of purposes, the maintenance function has made relatively little use of this powerful tool.

Even where the computer has been employed in maintenance, the approach has often been fragmentary and the information output has been in a form which made quick reference very difficult. Furthermore, the main requirements which is the speed of response and the ability to arrange and compare data in a number of different ways are not usually met.

In addition, any maintenance system depends on a two-way flow of information i.e., into as well as out of the system. Thus, it is most important to ensure that as far as possible the input of data is simple and rapid.

Therefore, there is a need for a system which:

1. coordinates all the main maintenance operations;

2. permits almost instant access to data;

3. facilitates the arrangement of data into different formats according to the needs of the moment for comparisons;

4. simplifies the collection and input of information;

5. can provide automatic warning of deviation from preset parameters; and

6. can advise actions which are scheduled in accordance with previously agreed programmes.

Such systems have been developed and are usually known as computerized maintenance management system or CMMS.

3. Computerized Maintenance Management System (CMMS)

A CMMS is designed to be used mainly by people close to the work. Procedures must be developed to reduce the routinary any work of the people involved. Offering therefore, immediate apparent and advantages will encourage their active co-operation. It must also be designed to be introduced with a minimum of change to existing procedures.

There are systems designed for different type and different size of industry. They of course run on different size of computer. From the PC size to Mini and Main Frame.

But the concern of a Maintenance Manager is not to know how the computer is working. His concern is to know how to use it, how to drive it and how it can help him. A driver's concern is to drive the car even if he does not know how gasoline is transformed into gas in the carburettor.

a. Information in a CMMS

To drive Maintenance, the Maintenance man has to store and retrieve informations.

Information is entered in the system either as permanent data (equipment inventory codes, job description, technical details, etc.) or as live data (work done, number of hours spent etc.).

Information can be called upon from the system (e.g. reports, analysis, technical details)

Information can be called up though the VDU screen by using a simple series of codes entered into the system via the VDU keyboard. An important feature of a CMMS is that it can be interactive, that is, engineer as manager is able to interrogate the system to obtain the information he needs. This avoids the output of routine reports which are often too voluminous to be properly used and which can seriously diminish the attraction of a computer-based system.

b. Information Storage

Remember this important thing: A system works with the information entered in the computer. It does not work by its own. "*Garbage in, Garbage out*" is the rule of the game. Good organization = good information in = good information out.

A CMMS uses a database which contains a number of logically connected information groups related to the maintenance function, as follows:

- o System Information;
- o Technical Data (Maintenance Information). All the fixed technical information on each individual item of equipment, Description, Location, Design, Data, Components;
- o Work elements, tool and manpower requirements, standard times;
- o Current Jobs. Details of work requests and their status;

- o Costs. All cost data on the basis of work order numbers. Provides for interrogation and print out of cost data in different formats, both as formal reports at fixed time intervals or in response to ad-hoc queries;

- o Preventive Maintenance. Holds details of preventive maintenance routine actions, including inspections;

- o Equipment History. Information on defects and repair actions taken on individual items of equipment;

Further data can be added, for example:

- o Major Turnaround Planning; and

- o Work Study - Standard times for repetitive work elements which are not included in the work specifications, e.g., welding, metal spraying, cutting, facing etc.

c. Accessing Stored Information

Information entered is stored in the Database through codes. One can retrieve it by means of lists, reports and analyses.

Codes used to retrieve information could be:

- o equipment number
- o specific sector or system code
- o analytical account or cost center
- o specific trade or craft
- o etc.

Reports and Analyses

According to the selected system one can obtain a wide diversity of reports.

- o Work reports
- o History reports
- o Economic reports
- o Contract reports
- o Availability reports
- o etc.

More specific reports could be obtained by means of some computer utilities such as Report Generators or Report Writers.

Reports can have the shape of:

- o list of Equipments jobs, technical descriptions.
- o tables: Figures for economic reports
- o Graphs: Manpower utilization, Economic Reports
- o etc.

4. The Work Order System

The work order system issues and tracks work-orders, the people, parts, and procedures necessary to complete maintenance works.

A Work-Order can be issued:

- o By the computer itself according to Planning and Scheduling for P.M.
- o By the computer itself according to instructions entered by the Foreman on the keyboard. In this case, the WO may ask for the approval of Maintenance Manager before it is issued.
- o In writing by the Foreman and approved by Maintenance Manager before entry in the computer.

A Work-Order can be issued:

- o Before the execution of the job for Preventive Maintenance and normal jobs.
- o Afterwards or during the job for Emergency jobs.

A Work-Order must mention details of maintenance job descriptions and other information needed It should be remembered that:

- o lack of information gives trouble to the worker who may not able to perform the job properly. He may have to ask for complementary informations.
- o an excess of information gives also trouble to the worker who may not be able to select the essential information.

5. Issuing the Work Order

Compulsory information to be entered:

- Work order Number and date of issue (it is sometimes given automatically by the computer)
- Equipment Number
- Work to be done
- Priority or Emergency
- Date of Start-requested
- Permits required

Complementary information to be entered:

- Cost Center
- Fault code
- Work specification
- Craft code
- Latest completion date
- Comments
- Job status which changes along the life of the Work Order. Generally, the system changes automatically this status after each updating of the Work Order.
- Delay cause
- Type of work
- Requestor's name

Information generally provided automatically by the system:

- Description of Equipment
- Relation with other equipments or associated Items
- Equipment class or Family.
- Work details according to work specification number.

Information to be entered during the life of the Work Order:

- Manpower used (Craft, Man hours and Team)
- Spare Parts used if the system is not directly interfaced with a Stock system.
- Status of the Work Order if the system do not do it. At least 3 status are there: Outstanding; Ongoing; and Completed. Some systems propose up to 9 status.
- Comments and Remarks on the Work done to limit the occupation of the memory of the computer, systems generally accept to store only a summarized report:

  * Date of start

  * Date of completion.

6. Work Order Life

For certain system, the Work Order is first named a work request before it is accepted and planned.

A Work Order can be issued for a Preventive Maintenance job but it must be issued for corrective maintenance also.

The Maintenance Manager or Supervisor receives a call for intervention. There are different ways of receiving the call and issuing the Work Order. The Maintenance Manager or the Supervisor issues the Work Order with the basic information.

- W.O. IS OUTSTANDING. If the intervention is too urgent he launches the work first.

  Work Order goes then to planning if necessary. It can also go for approval.

  Work Order is given to the Tradesman

- W.O. BECOMES ONGOING.

  Tradesman
  - Draw parts from store
  - Collects necessary material and tools.
  - Carries-out the work.
  - Reports to Supervisor.

  Supervisor
  - Controls work
  - Controls and completes the Report
  - Enters the Report in computer
  - Work summary
  - Date of completion (and start date if different than estimated)
  - Details on Manpower
  - Details on sparc parts used if necessary

- W.O. BECOMES COMPLETED

See Annex 1: Work-Order Life

D. DOCUMENTATION REQUIREMENTS

A Computerized Maintenance Management System, as pointed out earlier implies at first a good organization, then rigour and strictness.

The first approach of this organization is the collection of data. Data will be the foundation of the building. If the foundations are correct the system will have a chance to be reliable.

Data come from the Documentation.

What documentation is required? In fact, any reliable documentation can be useful for the system.

The documentation will not be stored in the system but it will be used as reference for technical information or as a basis to structure the equipment inventory.

For a new plant, it can be very easy to collect documentation especially if engineering is good. But for older plants, collection of documentation is much more difficult and some are impossible. Most construction documents are already lost, not updated or in bad condition.

History of equipments is also very difficult to establish in older plants where maintenance is often managed in a crisis condition.

1. Documentation Required

- Equipment Inventory

- Technical Documentation
  - Plans, schemes lists of components and spare parts
  - Equipment user manuals
  - Work and repair books
  - Maintenance manuals

- Equipment history
  - Information on life of equipments
  - Information on cost of equipments

2. More Details About This Documentation

- Equipment Inventory (+ Function and Position) This is a construction or engineering document which shows:

  - Comprehensive list of equipments with equipment number and description
  - Functional relations between equipments
  - Geographical position of equipments

  In Petro-chemical industries we can find all these information in the P and I D (Piping and Instrument Diagram). Other industries have other Process documents.

  Such a document is very important for the creation of the Database.

- Technical Documentation

  Either construction, or engineering documents or any other document useful for maintenance

  - Plans and schemes for mechanic, electrical or instrument purpose
  - List of components and spare parts of each equipment with reference to these parts
  - Equipments user manuals with details of the function, the way of using it, etc.
  - Work and repair books, workshop manuals for each equipment. Any document explaining how it can be repaired. Any note and also personal notes which can be useful for another repair.
  - Maintenance manuals

  Any document with details for preventive maintenance such as lubrication, controls, analysis and tests to be performed and the periodicity of these interventions. Such information given by the constructor is generally a "mean" periodicity, an average. Before using such information for PM, it is very important to review and update this and adapt it to local context.

  Periodicities can be lengthened or shortened.

- Equipment History

  • Any information concerning the life of equipments (Dates of installation, renewal and replacement, etc.)

  Major parts replaced and when; major problems faced during installation or maintenance, etc.

  • Any information concerning the cost of equipments:
  Previous major repairs

3. Why This Documentation

This documentation is required to:

- o Draw up the inventory of equipments with the related useful technical information. Information such as make, model, serial number, constructor, vendor, etc. which are useful for maintenance purposes.
- o Draw up a list of spare parts
- o Collect the maximum information to prepare PM
- o Know exactly where the craftsman can find information about specific repair technic.

4. How To Store This Documentation

- o A list of available documents must be drawn up and this list must be kept up-to-date.
- o Each document must have a Title and a number (internal number).
- o The list must mention where this document is. Documents are not always in the Maintenance department.
- o The references of the documents will be entered on the Technical Data screen of each concerned equipment.

When the technician prepares an intervention, he can ask the computer about the Technical Data of the equipment he wants to work on and he will have the list of related documentation with titles and location. The systems have not always enough memory space to store all informations, and therefore store only the reference. The technician can then consult the list.

E. ORGANIZATION FOR COMPUTERIZATION

Before thinking of computerization one has to think first of organization.

A computerized system is like a car. A car needs a driver, (the maintenance people are the driver) streets and roads. Otherwise the car stays in the garage. Even if engine is running, the car will not produce anything.

For the computerized system the roads and streets are the basic information entered in the computer. If roads are good, the trip is smooth. Otherwise, the driver will not be sure whether he can reach the harbour. Likewise, with the computerized system without the basic information, maintenance people will not be sure to get reliable reports and information.

The car also need gasoline. Otherwise, the car will stay in the garage or be stuck on the road. Also if wrong fuel is put in the car the driver will get very bad surprises. For a computerized system, the gasoline is the live information entered. For example, the work done, the number of hours spent, the cost of spare part, etc.

For a computerized system we can say "Garbage in Garbage out".

The information entered (either permanent data or live data) must be reliable if we want to have reliable output.

Even if a computerized system is very powerful and very convivial, if the information is not reliable it is useless.

Therefore, the first approach for computerization is the organization.

1. Inquiry on Maintenance

A maintenance audit and an inquiry must be performed.

The purpose of this inquiry is to check if maintenance department is ready for the implementation of a CMMS. Otherwise, the missing information and the procedures to be issued prior to implementation is to be secured first.

Bases For Inquiry

First Questions - Have we got enough information to answer: WHAT - BY WHOM - WITH WHAT - and HOW?

WHAT: Asset Register - Equipment Inventory

- Equipment list exists? with
  - Equipment number? Is there a numbering structure? existing?
  - Equipment description? Is it summarized?
  - Hierarchy of equipments according to process?
- Technical Data - Are they available and classified?

BY WHOM: Resources

- Personnel from Maintenance Department
  - Trades and categories?
  - Hourly rates?
- Personnel from Contractors
  - Trades and categories?
  - Hourly rates?
  - Contract follow up system?

WITH WHAT: Parts-Tools-Equipments

- Purchasing system?
- Stock control?
- Reservation system for parts?
- Tools and equipment follow-up system?
- Tools and equipment hiring facilities and procedures?

HOW: Job specifications, work-order procedure, planning, history, relation with other departments

- job specification for PM? Including
  - work description?
  - tools and equipments required?
  - spare parts necessary?
- work-order procedure and also time sheeting procedure
  - work request?
  - work order?
  - work report?
- planning and scheduling?
- history of equipments to help diagnostic?
- relation with other departments
  - Accounting with cost - centers or analytical accounts?
  - Personnel: Pay roll?

Other questions - What is expected from the system? Reports and analysis? History?

2. Organization For Computerization

- o Inquiry of Maintenance.
- o Analysis of this inquiry to determine what is acceptable for computerization and what is not or what is missing.
- o Selection and classification of problems to be solved.
- o Definition of procedure. Keeping always in mind that procedures are to be computerized.
  - Equipment numbering or tag numbering policy
  - Creation of codes: priority, type of intervention, trades, etc.
  - Work order procedure if not existing or requirements for the existing one.

- Decision to launch the preparation of the new organization asking: WHO - WHAT - WHERE - WHEN - HOW
  - Assign the required resources with a responsible.
  - Determine work to be done precisely: With guidelines for procedures, numbering, etc.
  - Find the right place to do it.
  - Determine a plan highlighting the main points and details.
  - Specify how the job must be performed and where information can be found.

- Launching of the preparation
  - By the new responsible and under the control of maintenance manager
  - Start the collection of information
  - Prepare procedures. But, this must be made according to the selected software
  - Prepare the list or inventory of equipments with structure, relations, etc.
  - Numbering of equipments and determine the different levels
  - Prepare Technical Data to be entered (Select necessary data)
  - Define the different codes to be used (codes and descriptions)

As soon as Data and Procedures are ready, the system can be implemented.

F. IMPLEMENTATION OF A CMMS

The implementation of an In-house system is completely different from that of a system which is purchased from the market. The process of implementing it depends essentially on the size of the company and the availability of resources. This paper presents only the implementation of a CMMS available in the market.

1. Major Phases of Implementation

a. Inquiry on Maintenance to define what have to be done before implementation and creation of implementing team.

b. Software tender preparation and issue.

c. Evaluation of co-tenders.

d. Organization for computerization.

e. Preparation of implementation plan.

f. Collection of information.

g. Placement of an order for the software.

h. Issue of the equipment inventory with tag numbers and hierarchical relations and creation of the pyramid.

i. Installation of software.

j. Customization.

k. Training of Data entry operator.

l. Entry of equipment pyramid.

m. Entry of codes, rates and other permanent data.

n. Entry of technical data.

o. Entry of previous history, if any.

p. Review of procedures.

q. Training of users.

r. Implementation of procedures.

s. Start up of entry of Live-Data (Work-Order.)

t. Normal use of system

u. System evaluation.

v. Improvement of procedures.

w. Control of reports.

x. System evaluation.

y. Running of the system.

2. Details on Implementation Phases

a Have we get enough information to answer WHAT, BY WHOM, WITH WHAT, and HOW.? (See 4.1: Organization for Computerization)

b. See Section 2.0 on How to select the system which is the best for the plant utilization.

c. Evaluate according to Section 2.0. The best one may be difficult to select. But a decision must be reached.

d. Organization (Section 4.0), the most important part of implementation-the key to success.

e. Elaboration of an implementation plan according to the work to be done and the resources. With Dates and Names.

f. Collection of information is the second important phase of implementation.

Technical information must be collected by Technicians. This makes information reliable aside from good involvement of technicians and make them confident of the system.

Codes have to be created as required by the system. Breakdown codes, priority, rates, hourly costs, etc.

g. Order Software. The managers's job. Be very careful on what is included in the order and what is not.

h. Issue of equipment inventory and pyramid.
- Tag numbering procedure

Use as much as possible the existing numbers but remove off gaps, hyphens, dots, slash, etc.

A pump P - 1234 or P 1234 can also be named P1234. It is easier to type and the user will not have to think what is the correct spelling.

The system will not accept any other spelling than this which have been entered.

- Create sectors or workshop - names, systems or area codes etc and link the related equipments

Then link the related components to equipments, etc.

i. Installation of software by supplier personnel with the assistance of computer people of the company.

j. Customization. According to what have been agreed with the supplier.

k. Training of Data entry operators by the supplier.

l. Entry of Data collected for the creation of the equipment pyramid.

m to o. Entry of Technical Data and codes collected.

p. Review of procedures to check if what have been issued correspond exactly to the system.

q. Train users on procedures and on the use of the system with the help of the supplier.

r. Implement procedures and use of work-orders.

s. Start up of the system.

Start entry of work orders and live data.

t. Normal use of the systems under the supervision of the implementing team.

u. System evaluation . After 2 to 3 months of normal use. To check if procedures use of the system are correct and if we can obtain the expected reports.

v. Improvement of procedures, if required.

w. Control of reports to be sure that it is what was expected

x. System evaluation after a normal use of 3 months.

y. Running of the system. Normal running.

3. Implementation Plan

It is not possible to draw a typical implementation planing, because it can vary from 1 month to 1 or 2 years depending on the organization of the company and at the level of this organization.

The length of phases 1 to 8 (inclusive) depends essentially to the organization to be programmed and on the quantity and quality of resources affected by the project.

Phases 10 to 15 depends also on the number and quality of data and on resources.

Other phases can go very quickly from 2 to 6 weeks.

When establishing a plan, the maintenance manager must be very careful to estimate the length of the work to be done.

CHAPTER IV

GUIDELINES ON TRAINING MAINTENANCE PERSONNEL ON COMPUTER-AIDED MAINTENANCE SYSTEMS

INTRODUCTION

Computer-aided systems are now reaching the maintenance departments. Most of maintenance personnel are not familiar with computers and strictness of procedures required by computer-aided systems.

To be reliable and fulfill its function it requires reliable data and that means strictness and consiousness of maintenance personnel.

The involvement of all maintenance personnel is required to assure the success of the implementation of a system and of its perennity. This involvement can only be obtained through the actual participation of all categories of workers or staff. Personnel will not participate positively in the implementatioin of a system without prior information. This information can only be achieved through training.

Training is one of the first key to the success of any development and implementation of a new procedure and especially a computerized procedure.

A. GENERAL APPROACH TO TRAINING MAINTENANCE PERSONNEL

Different types of training are possible, either internal or external training but both must have a theoretical and practical aspects. The training must be adapted to the level and the skill of the personnel.

All personnel involved in maintenance-related issues at the plant, therefore needs to undergo special training. Managers and supervisors of manufacturing plants, managers of maintenance divisions, engineers and technicians involved in maintenance management, planning, repair works, parts storage or purchasing, or any maintenance related function should be adequately trained. Such trainings should first be undertaken at the formal educational level and later-on during the course of their employment, i.e., in the form of in-service training.

Personnel involved in the design of maintenance systems and procedures and those involved in planning maintenance requirements including spare parts procurement are, in particular, in need of training. They should be capable of finding their own solutions to maintenance problems arising out of special circumstances such as local environment, corrosion problems, manpower utilization, lack of spare-parts, production priority, etc..

Training for trainers is another important aspect as trainers will be responsible for passing on knowledge, through internal training in the company itself as well as external training in seminars, etc. Otherwise the dissemination and up-grading of knowledge will not keep in step with the requirements of industry.

A wide range of personnel at different levels is engaged in maintenance-related activities and requires varying degrees of prior educational or vocational training. Therefore, training programmes must be comprehensive, diversified and adapted to the individual needs of the trainees. Separate training programmes should be developed for the various groups of personnel to broaden their knowledge and skills and, most importantly, stimulate creative knowledge.

Maintenance training from the equipment user's point of view is a very important aspect which should be included in all maintenance training programmes. As Production personnel are the users of equipments, the way they are using it is very important and has an influence on the number and severity of failures.

The main objective is to further creative knowledge and to enable trainees to develop maintenance systems commensurate with the particular conditions in their industry.

B. GENERAL TRAINING PROGRAMME ASPECTS

Therefore, training programmes must be sufficiently comprehensive to cover the various phases that a good maintenance system should comprise. Training programmes for personnel engaged in utilization, maintenance or improvement of equipments or machines and other capital goods, purchasing of such equipment from local or foreign sources and design of maintenance systems should include the following issues:

1) Theoretical considerations as the framework to facilitate better understanding of the operations of technical systems and the occurence of failures;

2) Objectives of maintenance in economic terms, including life cycle costs as well as possibilities for cost control;

3) Maintenance management including maintenance strategies.

4) Maintenance system including preventive and corrective maintenance, system structure (organization), and procedure techniques.

5) Knowledge of information systems and data processing to provide data for maintenance design and programming (data on failures, down-time, maintenance undertaken, cost, manpower utilization.

6) Integral logistic support to provide the knowledge required for managing inventories and stocks and purchasing materials.

7) Elements of optimization methods for the selection of the best solution of maintenance alternatives.

The practical implementation of such trainings requires elaboration of detailed planning for each application, based on the specific requirements and the basic level of the personnel to be trained.

C. SPECIFIC TRAINING. OPPORTUNITY TRAINING AT PLANT LEVEL

One very important training which should be a permanent worry is the training of maintenance personnel at plant level. Maintenance people should always improve their skills in maintaining specific equipment. Optimization as a never ending process, so as learning.

It is imperative therefore, that manager should design activities in the plant such that maintenance people are continually learning new and improved techniques. This scheme will motivate maintenance personnel to work and stick with the company ensuring "competence of labor" which is the priority in maintenance management.

As it is always said, "Experience is the best teacher". This is true especially in opportunity training. By opportunity training, we mean learning some things only when there are opportunities such as during start-up, emergency and moth-balling. These situations do not always as often occur. It is therefore, important that maintenance people be aware of these opportunities.

Preventive maintenance programs will not be successful if PM people are not properly trained. Maintenance people should know the value of what they are doing. They must realized that their activities are important for productivity improvement in the plant. Special instruments such as those for condition monitoring for computer-aided management maintenance are very valuable. But, if not properly used will not give accurate results, and thus, be a useless investment. Training therefore, need not be over-emphasized.

Opportunities of training are very frequent in an industrial plant and training must be a constant worry of management.

D. SPECIFIC TRAINING TO COMPUTER-AIDED MAINTENANCE SYSTEMS

Implementation of a Maintenance Management System is an important investment as of money and manpower and its success depends on the participation of everybody in Maintenance department, and also other departments or divisions of the plant.

A maintenance management system is a tool and as every tool it requires skilled users to fulfill its purpose. Personnel must be trained to use it properly to ensure correct entries and thus to guaranty the reliability of the output (reports and analyses).

1. Who must be trained

In fact all maintenance personnel must be trained, at different level and on different subjects about the system. Other plant personnel (management, administratitive, etc.) must also be trained or at least be informed and involved in the project.

- Maintenance Management

Manager and superintendent, are in charge of the reliability of the system and are the ones to monitor the analyses and figures given by the system to improve maintenance efficiency and productivity.

- Maintenance manager must know all details of the system to be able to control and monitor the use of the system. He must be trained in this direction. Particular attention must be drawn on the study of reports and analyses issued from the system.

- Superintendents must also be trained on all details of the system to be able to control the accuracy of data entry. They must also be trained on the way to use reports, analyses and technical data issued from the system.

- Executive Personnel: Foremen and workers are at the basement of the system and they fill in the system with live data (manhours, spare parts consumed and work done, etc.). From these data, depend the success or the failure of the system. Their training is very critical and must be precisely defined.

  - Foremen must be trained on how to record manhours and spare parts consumption. Other training must also make them able to get technical information and history of equipments from the system, using the keyboard.

  - Workers as well as Foremen must be trained on how to record data and also how they can get technical information from the system. Even if they are not using frequently these data, they are informed on the different possibilities of the system and they are more concerned by the system and more conscious of the importance of the reliability of the system.

- Production Personnel

  The main goal of a maintenance system is to reduce maintenance costs and increase equipments reliability and this means increase production.

  For this reason, production personnel must also be trained on the maintenance system. Their training will be on general purposes of the system.

  Maintenance will require the production cooperation and eventually the participation, especially during implementation of the system.

- Management and Administrative personnel must also be trained on the general purpose of the system to get their support.

  Full support of management is one of the keys of the success of an implementation.

- System Manager, generally a DP responsible must be trained on all the technical aspects of the programme and of the structure of the Database.

2. Training Duration and Planning

The duration and planning for training are subject to several factors (complexity of the system, type and size of industry, level of training and organization of the plant, etc.) and can not be determined without a prior study of the situation.

In any case training must be planned and done accordingly.

- Before implementation of the system to prepare organization and evaluate the personnel and management.

- During implementation to force the success of implementation and assure the accuracy of data entry. It is also very important for the motivation of personnel.

- After implementation of the procedure and of the system to confirm the good running of the system and correct the eventual errors.

3. Training Subjects

Subjects	Personnel to be trained
- Software Programme & Database structure and organization	DP Personnel
- Presentation of the system & of the purpose of the different modules. Main Menus & Sub menus	All Maintenance Personnel Production Mgnt. General Mgnt.
- Detailed training on procedures, e.g: work order procedure, data collection procedures, work-permit, etc.	All Maintenance Personnel
- Detailed training on the system use: • Use of the keyboard	All Maintenance Personnel
• Collecting live data e.g: man-hours, spare parts & material utilization, work done, etc.	All Maintenance Personnel
• How to get technical information e.g.: technical description of equipments, initial or current adjustments of instruments, data for condition monitoring, etc.	All Maintenance Personnel
• How to get equipment history e.g.: work done, last repairs done, etc.	All Maintenance Personnel
• How to issue reports & analyses from the system.	Maintenance Mgnt. (Manager and Superintendents)
• How to examine & interpret the figures given by report and analyses	Maintenance Mgnt. (Manager and Superintendents)
• How to prepare specific reports and analyses through a "Quiz" system or report generation.	Maintenance Mgnt. (Manager and Superintendents)

CHAPTER V

GUIDELINES ON MAINTENANCE SYSTEMS SOFTWARE ACQUISITION

INTRODUCTION

Computerization of a maintenance management system requires a computer or hardware and a programme or software. The hardware definition will be done according to the software capacity requirements and to the availability on the local market. Most of the programmes are presently designed to be used on PC's; 80% of the available programmes run on PC's and only 20% on Microcomputers or Main frame.

The general hardware requirements for a single user are the given in paragraph 3.1.1. For a multi-user system, a local network can be implemented to suit the endless need of improvement. For the implementation of a network it is important to take the required precautions to avoid the destruction of the integrity of information. For the selection of the software, the problem is different because the number of possibilities is very wide. A lot of ready made softwares are available from the market and there is also the possibility of an in-house development.

The first choice will be to decide if the system will be developed in-house by a company's programmer or bought from an outside vendor. Chapter 1 of this guidelines shows the advantages and the disadvantages of one and the other solution.

If the In-house development solution is selected, major conditions are required:

- Precise definition of requirements (reporting)
- Precise definition of organization and procedures (work-order, availability of information, spare parts management, purchasing, etc.)
- Investment of resources and more precisely, human resources.

A full-time implementation leader must be affected to the project, and must have a good experience in maintenance functions.

- Define an implementation planning showing the different phases of the pre-implementation and the implementation itself.

If the solution of the outside vendor is selected, the selection of the system which suits most of the requirements of maintenance is necessary.

How to select this software? The different selection criteria are given in the following pages, but prior to this selection it is necessary to follow different steps:

- Conduct an audit of maintenance to evaluate the present situation and determine the needs and requirements.
- Consult books and periodicals (see annex) to have a list of available softwares.
- Ask vendors for information on their software and when it is possible ask for demonstration diskette. As soon as you receive the documentation and diskette from vendors, you can start the selection of the most suitable software.

The goal of this comparison analysis is to select the most reliable software and the most compatible with your present organization. In any case, you will have to adapt your procedures to the software which needs the least modification in your organization.

To reach this goal analyze the softwares according to the following criteria (see chapter 2) and then ask the vendor a demonstration or organize a visit to a user of this software or softwares.

A. SOFTWARE SELECTION

1. External Purchase or Internal Development

   a. In-house Programme (Internal development and programming)

      Once a manual system is established and is working it is possible to ask a programmer to computerize it. It can be done. Some programmers do very good job.

      But in such creation, problems often occurs and the initial estimated cost is always (at least for all the experiences the author knows) multiplied by 2, 3 and even more.

      To be produced, the system will consume a lot of efforts and take a long time. Up to 2 or 3 years to be achieved and be reliable and powerful enough.

      After development and implementation, question arise such as who will take care of maintenance and upgrading the system.

      Computer people are frequently moving. After a few years of use, an update or upgrading is needed, it will be very difficult for a new programmer to study the system and improve it.

      This alternative is a good one because it is just what was specified assuming that the primarily needs are already determined. But, it is risky and always more expensive than expected and it also takes more time than expected.

b. System Available On The Market (External Purchase)

In the opinion of the author, the best alternative in acquiring a CMMS is to buy one which is available in the market even if the cost seems to be higher than an In-house solution at the first approach.

Experience shows that generally this second solution is in fact less expensive because it can be implemented quickly and the payback is also quicker.

But first of all, the selection of the appropriate software is very important.

c. Advantages And Disadvantages Of Each Solution

INTERNAL DEVELOPMENT AND PROGRAMMING

Advantages	Disadvantages
Necessitate no important change in your organization.	Necessitate an important involvement maintenance personnel to determine the requirements and procedures.
Suits exactly your requirements.	Is always more expensive than expected especially if requirements have not been well defined at the start-up of the development.
Can be adapted during the implementation.	Requires generally more time than planned.
Is flexible and can be modified at any time.	Debugging very long because you are the first and the only user.
	Maintenance of software difficult if the programmer is no more available.

EXTERNAL PURCHASE

Advantages	Disadvantages
Structured and Tested System. Fixed cost. Fixed implementation planning Guaranty from vendor. Maintenance of software assured by manufacturer. No debugging because already tested and implemented in several companies.	Not or slightly flexible. Necessitate an adaptation of organization and procedures. Selection of the good software is not always very easy.

2. How To Select A Maintenance Software

A maintenance software must suit the maintenance organization if it is expected to yield the best results. Otherwise, a software which suits most of the manager's wishes should be chosen. It will, of course, be a compromise.

The best solution is to call a tender. A first selection must be made from specialized periodicals as "Maintenance" published by the European Federation of National Maintenance Societies (EFNMS). (Refer to Annex).

3. List of Criteria To Select A Maintenance Software

a. Importance of the computer company
- Capital and Turnover
- Number of employees in general
- Number of employees for this software

To evaluate the reliability of the company and check what is the importance of the maintenance software for this company. A medium company is suitable because of its capability and its flexibility.

b. List of users of this software
- Name and location (country)
- Type of industry
- Date of implementation of this software

To be sure that the software has been experienced in various companies for a long period and perfectly debugged. Check also in the list if users are working in the same type of industry as you.

Try to contact some industries to get their opinion, as users, on the system.

c. List of modules of this software package
- Maintenance (Preventive Maintenance and Corrective Maintenance)
- Planning and scheduling
- History Reporting
- Economic Reporting
- Purchasing Spare Parts
- Stock Management
- Stock Interrogation
- Reservation of spare parts
- etc.

To be sure that the system covers most of your requirements. If the document is not enough precise and gives only the title of the module do not hesitate to ask more information to the vendor, e.g.: a planning module can be designed in different manner. One can suit your organization and the other can be difficult to adapt.

d. Work Order Follow-up or Monitoring System
- Automatic issue from the computer
- Number of possible status
- Entry of live data: Work done, manhours, etc.
- Which data must be and can be entered in a work-order

This module must be carefully examined to confirm that it can be used without big changes in your organization and procedures. Do not try to find the perfect one, but select the system which necessitate the least change in your procedure.

e. Planning and Scheduling Facilities
- Only list of jobs planned for a determined equipment
- Full planning and scheduling system

Same as work-order system, the planning and scheduling module must be carefully studied and in this case also the selection will be the result of a compromise.

f. Reporting Facilities
- Do reports are ready-made or have to be customized
- Equipment lists
- History report
- Work report
- Economic report and analysis
- Availability report
- Do the use of a "Report generator" or similar, is possible?

The possibilities are very large. Preference will be given to a system offering some formal reports which can be used at the beginning of the use of the system. Customizable reports are also appreciated.

The system must offer the possibility to use a "report generator" or similar facility to give the possibility to create more specific reports if required.

g. Conviviality of the system (very important for the success of implementation)
- Accessibility of Menu (Chained Menus or direct access)
- Easiness of entries (Use of codes, access menus)
- Avoid double entries
- Accessibility of reports (selection menu)
- Easy interpretation of reports
- Response time for reports on screen and on printer
- Help facilities to ease the new comer
- Language and vocabulary of screens (easy to change or to modify). Customization.

A system must be easy to use and be accessible to a non-computer specialist. The conviviality of a system is difficult to evaluate without a demonstration diskette or an actual presentation. Visit of plant where this system is used is recommended.

h. Interface With Other Systems
- Built-in or to be developed for interface with a Purchasing-Stock System
- Possible interface with other existing systems
    - Accounting (for costs)
    - Payroll (for manhours and costs)
    - Process (for downtime)

Even if the system is used separately at the beginning, an evolution has to be foreseen. That is the reason why interfaces with other systems must be possible. The first interface to be planned is this with the stock and purchase system, if it is not included in the present software.

i. Do the system requires a dedicated computer? Experience shows that this is the best solution. But, interfaces must be possible.

A dedicated computer is generally required.

j. Hardware requirements

A medium hardware model is given here under, it can suit the requirements of a medium company. If a system requires less than the following figure, the question must be: "is the capacity of this system big enough for my company?"

- Mini or Micro (statistics shows that 18% are on Minis or mainframe and 82% on Micros)
- A computer (IBM PC or compatible) with Memory capacity RAM and Hard Disk (e.g. 640 Kb of RAM 20 to 40 Mb hard disk)
- A color monitor
- Printer 132 lines (for example)
- Requirements for Multi user (Network)

k. System Cost

The cost of a system is only one of the elements of an implementation, it is only a part of the investment, and sometimes a small part of the total cost. That is the reason why the "purchase cost" is not one of the most significant criteria. A less expensive software can cost a lot more if it requires big changes in your organization and procedures.

- Purchasing cost ranking form 4 to 20,000 US $ (which modules are included?)
- Interfaces development with parts system and other systems if required
- Implementation and training
    - Volume and limitation of training included in purchase cost
    - Complementary training to be foreseen and cost
    - Is it locally or in supplier office?
- Customization
    - What is included in Purchase cost
    - What is to be added. (Report format, adaptation to special requirements)
- Maintenance of the software
    - Cost of this maintenance (10 to 15%/year of purchase cost is an average).
- Cost of new releases included in maintenance contract?

l. Maintenance of the Software and Guarantee

A computerized system as well as an organization, is subject to updates and adaptations. A system is "alive", and need maintenance.

The vendor must assure:
- assitance, maintenance and guaranty
- to maintain the system running at least for 5 to 10 years.

- Assistance especially at the startup of the system and later on
- How? (By hours: Working hours?)
- By local dealer?
- Implementation of new releases by means of diskette or other
- What are the conditions of guarantee?

m. Source Programme

Source programme give a programmer the possibility to modify the basic programme but that requires a lot of precautions and a good knowledge of the structure of the system.

- Do they deliver the source progrmmer (this is not frequent at all)
- If they deliver it what are the conditions of guarantee and maintenance?

As soon as maintenance manager answers to most of these questions, he has the maximum references to compare the different offers. Manager may not have answer to all the questions. But, even with a part of it he will be able to select the better system. A decision must be reached.

Remember one thing: The Purchasing cost is only the emergent part of the iceberg. It is only a part of the global cost. Organization cost and training cost represent a large amount of the total cost.

CHAPTER VI

MAINTENANCE AUDIT FOR COMPUTERIZATION

TABLE OF CONTENTS

INTRODUCTION

Maintenance Management of a plant can be improved by the use of a computer to record Maintenance Data and analyze it to have a help in making decision. The final goal of the computerization is to reduce maintenance costs and increase the plant reliability. Computer-aided Maintenance Management systems are available, ready made, on the market but can also be developed internally under the control of Maintenance Management.

In any case the implementation of a computer aided system is an important and critical step in the development of the maintenance strategy of a company. It is always an important investment as well as for material or software purchase and for personnel investment.

To maintain the payback of this investment at a correct level, it is necessary to prepare this investment in details. A badly prepared implementation can be a real catastrophy and a big waste of money and the waste of confidence of the personnel in computerization.

The first step of an implementation is to examine in detail the present status of maintenance department focusing especially on

- Maintenance Organization
- Maintenance Procedures
- Parts and Material Management and Purchasing Procedures
- Maintenance "Turnover" or volume

To examine the situation of a Maintenance department it is necessary to follow some basic rules and the best solution is to conduct an Audit on Maintenance with the final view of computerization.

The second step will be to analyze this audit and thus to determine the most suitable software for the company.

The third step will be organization of the Maintenance department and implementation of the software or development of a tailored software.

The fourth step will be the post implementation analysis to evaluate the performance of the system.

The main goal of this audit is to:

- Evaluate the situation of Maintenance department.
- Evaluate the volume of information to be managed.
- Appreciate the different procedures and check if they are easily computerizable.
- Evaluate the required changes in the present organization.
- Evaluate the amount of work to be done for a computerization.
    - Data collection
    - Organization
    - Adaptation or creation of procedures
- Establish an implementation planning
- Evaluate the cost of this implementation

MAINTENANCE AUDIT FOR COMPUTERIZATION

1. COMPANY OVERVIEW

1.1 PLANT GENERAL

1.1.1 General Information

- Company: _____
- Address of the Plant: _____
- Telephone: _____ Telex: _____ Fax: _____
- Nature of Business of the Company:

  _____
- Name of the contact person:

  _____
- Function: _____

1.1.2 Plant and Maintenance Figures

- Actual Turnover of the Plant _____
- Actual Turnover of Maintenance (Parts, Material & Personnel Expenses_____
  - Part of the plant _____%
  - Part contracted _____%
  - Part of the group or (central maintenance department _____%
- Total Energy Consumption of the Plant _____ kW
- Total Electric Power Installed _____ HP

1.2 HUMAN RESOURCES

1.2.1 Organization of Maintenance Department

Please draw a schematic organization chart showing the different functions of Maintenance and the number of persons affected to each function: eg.

- Maintenance Management and staff
- Maintenance Planning and Scheduling
- Maintenance Work Supervision
- Maintenance Work Execution
- Maintenance Workshop
- Inspection and Control
- Stores Management
- Purchasing
- Other Maintenance Function

Organization Chart

1.2.2 Costs and Statistics on Plant Human Resources

	This year	Next year Budget or Estimate
Total No. of personnel of the plant	_____	_____
- Production	_____	_____
- Maintenance	_____	_____
- Others	_____	_____
No. of Tradesman in maintenance	_____	_____
No. of Maintenance Supervisors	_____	_____
Estimated annual maintenance cost total:	_____	_____
- manpower: (labour)	_____	_____
- materials:	_____	_____
- contracted:	_____	_____
Hourly rate of tradesman (on average)	_____	_____

1.2.3 Organization of Maintenance Jobs

- Are your personnel organized by team? Y/N
- Are these teams organized by trade? Y/N
- Are these teams regrouping several trades? Y/N
- Are your teams working on shift? Y/N

2. MAINTENANCE MANAGEMENT ORGANIZATION AND POLICIES

2.1 MAINTENANCE MANAGEMENT ORGANIZATION

2.1.1 How is your maintenance organized?

- The group (if any) or a central maintenance department manage all maintenance Y/N
- The group (if any) manage only major overhauls Y/N
- Is maintenance organized at the plant level? Y/N
- Are you contracting most of your maintenance works? Y/N
- Are you contracting maintenance only occasionally? Y/N

2.1.2 If maintenance managed at the plant level, which part is contracted, which part is managed by the group or a central maintenance department. What is the limit of their responsibilities:

	Group or central maintenance	Plant level	Contracted
• Preventive Maintenance			
• Predictive Maintenance			
• Corrective Maintenance			
• Major overhauls or shutdown			
• Material stock management			
• Spare parts and material purchasing			
• Planning and scheduling of normal maintenance			
• Planning and scheduling of major overhauls or shutdowns			
• Determining of personnel policies			
• Equipment cost management and analysis			
• Involvement in Equipments replacement (and selection for).			

2.1.3 Contracting

Which type of contract is generally used with contractors

- Lump-sum Y/N
- Unit basis Y/N
- Hiring of Personnel Y/N
- Others (specify) _____

2.1.4 How many contractors are you currently using? _____

2.1.5 How many contracts are you recording per year? _____

2.2 MAINTENANCE MANAGEMENT POLICIES

2.2.1 How many production hours have been lost last year due to breakdown (unplanned maintenance)? _____

2.2.2 How many "units" have been lost last year for the same reason? (unit: _____) No. ____

2.2.3 What do you think about these losses?

- Is it a normal loss which cannot be avoided? Y/N
- Is it a reasonable loss which can be reduced? Y/N
- Is it an excessive loss? Action must be taken to reduce it. Y/N

2.2.4 In your maintenance policy what do you consider as the most important factor?

	1st Prio.	Impor-tant	2nd Prio.	No Impt.
• Production loss cost				
• Repair cost				
• Non productive hours cost				
• Company's image				

• Other (specify) _____

2.3 Maintenance Management Practices

2.3.1 In which of the following categories do you place:

	Correct. Maint.	Prev. Maint.	Pred. Maint.	Cond. Based Maint.
• Breakdown or failure				
• Condition monitoring				
• Vibration analysis				
• Lubrication				
• Oil analysis				
• Corrosion Control				
• Major over-hauls.				
• Modifi-cation				
• Other (Specify) _____				

	Correct. Maint.	Prev. Maint.	Pred. Maint.	Cond. Based Maint.
2.3.2 Which type of maintenance do you use in your plant? Tick in the adequate column.				
2.3.3 What percentage of each category are you generally using in your plant?	_____ %	_____ %	_____ %	_____ %
2.3.4 What percentage of each category is generally contracted?	_____ %	_____ %	_____ %	_____ %

2.4 MAINTENANCE MANAGEMENT TOOLS

What "tools" do you use to:

2.4.1 Manage, analyze and improve your maintenance

	Do this material belongs to		Is contracted	
	The group or central maint.	The plant	On a permanent basis	When required
• Computer for maintenance mgnt. and parts mgt Model and capacity				
• Software for maintenance mgnt: External purchase				
Internal devpt.				
• Vibration Analysis Equipment				
• Thermo Vision Control				
• Oil analysis				
• Corrosion control				
• Others (specify) _____ _____ _____				

2.4.2 How do you analyze maintenance data to improve the "Productivty" of your Maintenance? (specify)

_____

_____

_____

2.4.3 How do you try to improve your Maintenance Policy?

What are your general sources of information?:

- Technical periodicals Y/N
- Technical books Y/N
- Seminars on Maintenance Y/N
- Exiditions or Fairs Y/N
- Other (specify) _____

2.4.4 What are your conclusions on your maintenance management analysis:

- Production tool (equipments) must be improved Y/N

- Production must be reduced to avoid major trouble Y/N

- Production personnel must be trained to improve the use of equipments Y/N

- Maintenance management must be more involved in production decisions Y/N

- Maintenance department must be reorganized Y/N

- Maintenance policies must be revised in terms of:
  - Corrective maintenance Y/N
  - Preventive maintenance Y/N
  - Predictive maintenance Y/N
  - Others (specify) _____

- Maintenance procedures must be revised in terms of:
  - Corrective maintenance Y/N
  - Preventive maintenance Y/N
  - Predictive maintenance Y/N
  - Others (specify) _____

2.5 MAINTENANCE FORECAST

2.5.1 What are your expectations to reduce your maintenance cost?

- Coordinate with production to improve the maintenance tool utilization Y/N

- Use computer aided management system for
  - Maintenance cost analysis Y/N
  - Maintenance planning and scheduling Y/N
  - Maintenance personnel management Y/N
  - Maintenance history Y/N
  - Maintenance technical data storage Y/N
  - Maintenance work specification storage Y/N
  - Corrective maintenance works Y/N
  - PM works Y/N
  - Other Maintenance (specify)

    _____

  - Spare parts Management Y/N
  - Spare parts Inventory Y/N
  - Spare parts and Material Purchasing Y/N

- Do you expect to manage maintenance and parts with a unique system? Y/N

- If you foresee 2 separate systems do you expect to interface them? Y/N

- Do you expect to buy an already developed system from the market? Y/N

- Do you expect to develop it internally? Y/N

- Do you expect to hire the services of a specialized company to develop it? Y/N

- Do you intend to ask for the help of an engineering company for advice on organization? Y/N

- Buy or rent vibration analysis system Y/N

- Buy or rent thermovision system Y/N
- Use an oil analysis system Y/N
- Use a corrosion control system Y/N
- Use or buy other system (specify)

  _____

- Do you have any other suggestions to improve your maintenance management? Y/N
- If yes, specify: _____

2.5.2 Timing

- What are your expectations in terms of time for the purchase or the development of the above mentioned system? (Tick the good answer). - 1 month; - 3 months; - 6 months; - 1 year; - None
- Details or Remarks: _____

  _____

2.5.3 Finance

- What is your expected paybacks for the investment? _____
- Who can propose such investment? (Title)

  _____

- Who takes the decision? (Title)

  _____

2.6 MAINTENANCE STRATEGY

2.6.1 Any difficulties in keeping to current maintenance schedules? Y/N

2.6.2 Any dificit in information necessary to make decisions? Y/N

If yes, specify _____

2.6.3 Does amount of paperwork necessary to keep maintenance going cause you problems? Y/N

2.6.4 Problems concerning technical data Y/N
filing it Y/N
keeping it up-to-date Y/N

If yes, specify _____

2.6.5 Co-ordination of jobs
- can you get into a situation where work is scheduled and resources not available? Y/N

2.6.6 Any other problem in your maintenance strategy? Y/N

If yes, specify _____

3. MAINTENANCE PROCEDURES

3.1 EQUIPMENT INVENTORY

3.1.1 Is the equipment inventory organized by

- Equipments hierarchy? Y/N
- Alpha Numeric listing? Y/N
- Other (specify) _____

3.1.2 How many items of maintainable equipment you have? _____

3.1.3 How many critical equipments you have? _____

3.1.4 How do you store information on equipment that is maintained?

- Equipment card? Y/N
- History card Y/N
- Other (specify) _____

3.1.5 What information do you actually store?

- Manhours Y/N
- Costs manpower Y/N
- Costs spare parts Y/N
- History of interventions Y/N
- Others (specify) _____

3.1.6 What is the use of this information?

- Maintenance costs management: Y/N
- Planning purpose: Y/N
- Others (specify) _____

3.1.7 Do you record
- Dates of failures? Y/N
- Reasons or causes of failure? Y/N
- Time spent to repair? Y/N
- Shutdown time of equipment? Y/N

3.1.8 Do you have equipment identification code? Y/N

3.1.9 How many caracters (digits) compose the equipment code? _____

3.1.10 Are you using a hierarchical relation between equipments and areas using a functional and geographical relation? Y/N

3.1.11 Are you using only a list of equipments without relation between them? Y/N

3.1.12 Are you using spare equipments (One is running and the spare one is in "stand-by") Y/N

3.1.13 Do your equipments have a unique number? Y/N
or several equipments can have the same No.? Y/N

3.1.14 Are equipment technical data available? Y/N

3.1.15 Are these equipment data recorded on a "Technical Card" or similar? Y/N

3.1.16 Are Inspection Data available?

- Initial Data? Y/N
- Actual Data? Y/N

3.2 WORK ORDER PROCEDURES

3.2.1 Who can request maintenance work?

- Maintenance people? Y/N
- Production Y/N
- Other (specify) _____

3.2.2 Are Work Requests accepted before changing it into Work Order? Y/N
By whom? (specify) _____

3.2.3 Who is responsible for the maintenance budget? (Title) _____

3.2.4 Do you have a formal maintenance work request form? Y/N

3.2.5 Do you have a separate work order form? Y/N

3.2.6 Do you use a "Minor, Blanket or Open Work Order" for small jobs? Y/N

3.2.7 Do you have a separate Work Report form? Y/N

3.2.8 Do requests cover more than one equipment item? Y/N

3.2.9 At what hierarchical level are your requests issued
- Plant Y/N
- Area Y/N
- Equipment Y/N
- Both Y/N
- Other (specify) _____

3.2.10 Do you have a priority system? Y/N

3.2.11 How many classifications are in your priority system? _____

3.2.12 What is your percentage of emergency work? _____%

3.2.13 What is your percentage of urgent work? _____%

3.2.14 What is your percentage of normal work? _____%

3.2.15 What is the percentage of man hours charged to work orders? _____%

3.2.16 What is the percentage of man hours charged to general accounts or cost centers? _____%

3.2.17 How do you record actual manhours?
- Time sheeting Y/N
- From logbook Y/N
- Other (specify) _____

3.2.18 Do you charge manhours to work order numbers? Y/N

3.2.19 Do you charge material costs to work order numbers? Y/N

3.2.20 Do you charge any other costs to work order numbers? (Direct purchase, etc.) Y/N

3.2.21 Do you use a "cause" code on all work orders to facilitate failure analysis (normal wear, faulty parts, outside cause, lubrication failure, overloading, operator abuse, etc.?) Y/N

3.2.22 Do you use a "Delay code" (eg. awaiting for spare parts, awaiting manpower)? Y/N

3.2.23 Do you use a "Job code" for repetitive works? Y/N

3.2.24 Do you use a "Family code" (Pump, Boiler, Motor, etc.) Y/N

3.2.25 Do you use a procedure to monitor the contracts and contractors? Y/N

3.2.26 How many work orders do you process per week? _____

3.2.27 Are you satisfied with your present work order system? Y/N

If no, do you want to make some suggestions? _____

3.3. ESTIMATING

3.3.1 Are your work-orders estimated? Y/N

3.3.2 What is estimated?
- Manhours Y/N
- Manpower cost Y/N
- Material cost Y/N
- Other (specify) _____

3.3.3 Who estimates most work orders? (Title)
_____

3.3.4 What percentage of the work orders is estimated? _____%

3.3.5 How do you estimate maintenance work?
- Foreman's estimate from experience? Y/N
- Statistical standard (tabulated historical data)? Y/N
- UMS (Universal Maintenance Standards)? Y/N
- Others (specify) _____

3.3.6 Do you routinely report on the backlog of work? Y/N

3.3.7 How do you measure your work order backlog?
- By number of work orders? Y/N
- By total man-hours? Y/N
- By man-hours for each trade? Y/N
- By weeks of work, i.e. manhours by trade divided by weekly net capacity available? Y/N

3.3.8 What is your present backlog of work? (tick the correct answer)
- 0-2 weeks _____
- 2-4 weeks _____
- 4-8 weeks _____
- 8-16 weeks _____
- 16-26 weeks _____
- 27-52 weeks _____
- over one year _____
- do not know _____

3.3.9 Do you use backlog trend data for increasing or decreasing overtime on your work force? Y/N

3.3.10 Do you use backlog trend data for subcontracting? Y/N

3.3.11 Do you use short interval scheduling and control? Y/N

3.4 PLANNING AND SCHEDULING

3.4.1 Do planners have frequent contacts with maintenance executives? Y/N

3.4.2 Do planners identify materials and stores requirements before work orders are released? Y/N

3.4.3 Do they check availability of material and parts before work orders are released? Y/N

3.4.4 Do they reserve spare parts for major jobs? Y/N

3.4.5 Do planners write purchase requisitions? Y/N

3.4.6 If not, who does? _____

3.4.7 Do planners follow up with vendors? Y/N

3.4.8 Do you keep a completed work-order file by equipment number? Y/N

3.4.9 Do you keep a list of all jobs in active backlog, i.e. jobs ready for scheduling (all material available)? Y/N

3.4.10 Are planned jobs scheduled on a routine basis? Y/N

3.4.11 What do you need to know about a job before you schedule it?

- costs: Y/N
- labor requirements: Y/N
- materials from stores: Y/N
- materials purchased direct: Y/N
- special tools: Y/N
- contractors: Y/N

3.4.12 How do you schedule jobs? _____

3.4.13 Over what period do you schedule jobs?

_____

3.4.14 Who schedule the jobs? _____

3.4.15 What information is available to the scheduler to enable the schedule to be drawn up? _____

3.4.16 Could any further information be usefully made available? _____

3.4.17 How many jobs are scheduled at a time?

_____

3.4.18 From how many jobs is selection made? _____

3.4.19 How do you decide whether all labour resources have been allocated?

_____

3.4.20 What constraints are there on scheduling a job? _____

3.4.21 How do you coordinate maintenance and production schedules?

_____

3.4.22 Do you report on jobs falling behind schedule? Y/N

3.4.23 Do you use PERT or Critical Path Scheduling for overhauls and major maintenance work? Y/N

3.4.24 Do you use PERT or CPM for new construction? Y/N

3.4.25 Are you satisfied with your planning and scheduling system? Y/N

If no, do you want to make some suggestions? _____

3.5 CORRECTIVE MAINTENANCE

3.5.1 Are you using work specification for corrective maintenance? Y/N

3.5.2 Are these specifications coded? Y/N

3.5.3 Are you using Work-Order Procedure for corrective maintenance? Y/N

3.5.4 Do you have a follow-up of the status of corrective maintenance (outstanding, ongoing, etc.) Y/N

3.5.5 How do you report the job done?

_____

3.5.6 How do you report the time spent and the use of the spare parts?

_____

3.6 PREVENTIVE MAINTENANCE - PREDICTIVE MAINTENANCE

3.6.1 Is lubrication under the responsibility of
- Maintenance Y/N
- Production Y/N
- General management Y/N
- Others (specify) _____ _____

3.6.2 Do you differentiate Preventive and Predictive Maintenance? Y/N

3.6.3 Is your Preventive Maintenance
- Condition based? Y/N
- Time based? Y/N
- Unit based? Y/N

3.6.4 What techniques are regrouped in your predictive maintenance?

_____

3.6.5 Are you using work specifications? (Standard defined jobs) Y/N

3.6.6 Are these specifications coded? Y/N

3.6.7 Have you identified all "critical" equipment? Y/N

3.6.8 Do you have standard inspections for critical equipment indicating what to inspect, i.e. critical dimensions, temperature, pressures, torque, etc.? Y/N

3.6.9 Are you using work order procedure for Preventive Maintenance? Y/N

3.6.10 Do you record frequencies of inspections and control? Y/N

3.6.11 Do you record frequencies of Preventive Maintenance (regular services) Y/N

3.6.12 Do you have automatic generation of PM and inspection orders? Y/N

3.6.13 How is this done?
- By computer Y/N
- By tickler file Y/N
- By card system Y/N
- By wall chart Y/N
- Others (explain) _____

3.6.14 Do you have effective follow up of inspections Y/N

3.6.15 How is follow up made? _____

3.6.16 Do you report on overdue PM and inspection jobs? Y/N

3.6.17 Are inspection routes established? Y/N

3.6.18 Do you have specific PM and repairs budgets for all major pieces of equipment of facilities? Y/N

3.6.19 How often done are major overhauls: _____

shutdowns: _____

turnarounds: _____

3.6.20 Are they monitored by the same procedure as this used for normal maintenance? Y/N

3.6.21 Are you satisfied with your present preventive/predictive maintenance program? Y/N

If no, do you want to make some suggestions?

_____

3.7 COMPLETION OF JOB

3.7.1 Are you using the same procedure to complete Corrective and Preventive Maintenance jobs? Y/N

3.7.2 If not, what is the difference?

_____

3.7.3 What information do you collect when you finish a job?

- Dates (completion, start-up, etc.) Y/N
- Job description (work done) Y/N
- Summarized description of the job Y/N
- Technical information (actual values of inspection, etc.) Y/N
- Other: Specify _____

3.7.4 Whose responsibility is it to complete the information?

_____

3.7.5 Do you collect failure details at
- Component level? Y/N
- Area level? Y/N
- Equipment level? Y/N
- Other (specify) _____

3.7.6 Do you collect material cost at
- Component level? Y/N
- Area level? Y/N
- Equipment level? Y/N
- Other (specify) _____

3.7.7 Is material cost immediately available? Y/N

3.7.8 Do you collect labour hours at
- Components level? Y/N
- Area level? Y/N
- Equipment level? Y/N
- Other level (specify) _____

3.7.9 Do you compare estimates against actuals? Y/N

3.7.10 Do you wish to analyze costs?
- per job Y/N
- per area Y/N
- per period Y/N
- per equipment Y/N
- per code (delay, cause, family, etc.) Y/N
- cost center Y/N
- other (specify) _____

4. PARTS AND MATERIAL MANAGEMENT

4.1 STORES AND SERVICES ORGANIZATION

4.1.1 Who is in charge of Stock Management
- Maintenance Y/N
- Operations Y/N
- Others (specify) _____

4.1.2 Who is in charge of Purchasing parts and materials
- Maintenance Y/N
- Operations Y/N
- Others (specify) _____

4.1.3 Who supervises maintenance stores?
- Maintenance Y/N
- Operations Y/N
- Others (specify) _____

4.1.4 Are spare parts codes used? (Internal coding system) Y/N

4.1.5 How many characters (digits) compose the parts No. _____

4.1.6 Is spare parts code including the equipment code? Y/N

4.1.7 Are spare parts identified according to a related equipment? Y/N

4.1.8 Is Interchangeability of parts recorded? Y/N

4.1.9 What is the estimated value of parts and materials stored outside the regular maintenance store, i.e. bootleg stores, foreman stores, charged out material, etc.?

_____

4.1.10 Who determines "when-to-order", i.e. order point, re-order point, or minimum quantity? (Title) _____

4.2 Stores and Services Procedures

4.2.1 How is order point calculated?

_____

4.2.2 Who determines order quantity, i.e. how much to order? _____

4.2.3 Do you have frequent stock outs?

Daily	Y/N
Weekly	Y/N
Monthly	Y/N

4.2.4 Do you record stock outs? Y/N

4.2.5 Are maintenance spares stored separately from production stock? Y/N

4.2.6 Number of maintenance spares store locations? _____

4.2.7 Number of spare part types (i.e different line items)? _____

4.2.8 Approximate value of spares inventory _____

4.2.9 Any problems with availability of spares? Y/N

If any, specify _____

4.2.10 Are spares re-order procedures defined? Y/N

4.2.11 Who is responsible for ordering direct materials (those which are not ever held in stock)? _____

4.2.12 What is the percent of the Directly Ordered materials/Store items? _____%

4.2.13 Can maintenance staff inquire as to availability of stock before deciding whether jobs should be scheduled or not? Y/N

4.2.14 Are spare parts "Reserved" at planning stage? Y/N

4.2.15 How do parts receipts on which a job depends get reported to maintenance department? _____

4.2.16 How do you assess whether parts not previously available are now available to do a job?_____

4.2.17 Do you have a parts catalogue showing all stores items with description and location? Y/N

4.2.18 Do you constitute "Kits" for programmed repairs? Y/N

4.2.19 Do you have a document showing availability, order point, order quantity and other information? Y/N

4.2.20 Do you keep a history of parts consumption? Y/N

4.2.21 Do you tie the parts requisition to the work-order? Y/N

4.2.22 Do you delete obsolete inventory items on a regular basis? Y/N

4.2.23 Do you keep an up to date list of suppliers? Y/N

4.2.24 Do you record the "efficiency" of your suppliers? Y/N

4.2.25 Are you satisfied with the present system used by maintenance stores? Y/N

If no, do you want to make some suggestions? _____

5. RELATIONS WITH OPERATIONS

5.1 Is communication with the operations side good, as far as:

Requesting jobs? Y/N

Informing them jobs are to be done? Y/N

Obtaining availability of equipments? Y/N

Issuing work permits? Y/N

5.2 If communication is not good do you think a better communication system could improve it? Y/N

Your Suggestions _____

_____

6. COMPUTER USAGE

6.1 What applications have been implemented?

		on what Hardware?
Accounting	: _____	_____
Stock Control	: _____	_____
Purchasing	: _____	_____
Personnel	: _____	_____
Others	: _____	_____

6.2 Who uses the systems? _____

6.3 Are these systems interfaced? Y/N

6.4 Do you have a computerized maintenance management system? Y/N

- If yes, are you satisfied with its performances? Y/N
- If no, do you plan to implement one? Y/N
  - immediately Y/N
  - within the next year Y/N
  - within the next 3 years Y/N
  - no intention Y/N

6.5 Who will define any new system? _____

6.6 Do you intend to develop it internally? Y/N

6.7 Is the proposed maintenance system required to interface with any existing or future systems? _____

6.8 What are your maintenance objectives,

- Better plant performance Y/N
- Improved spare parts utilization and control Y/N
- Increased labour efficiency/utilization Y/N
- Better equipment monitoring Y/N
- Improved equipment availability Y/N
- Other objectives - please specify:

_____

7. MAINTENANCE DOCUMENTS

7.1 It would be helpful if examples of the following documents could be provided.

- Technical information/data held for each equipment or item.
- Format of work request/work-order/work-report.
- Details of any data held for work specifications/services.
- Work permits.
- Printed instructions to work force on job ticket/work order/job execution/time sheet.
- Information collected when job completed.
- Stores requisitions as used by maintenance.
- Purchase requisitions.
- Any computer-produced reports?
- Any manually produced reports?
- Samples of Equipment coding.
- Samples of Parts coding.

CHAPTER VII

GUIDELINES FOR MAINTENANCE AUDIT ANALYSIS

1. COMPANY OVERVIEW

The purpose of this chapter is to evaluate:

- The maintenance potential of the company in terms of budget and personnel.
- The part of maintenance department in the company budget or turnover.

2. MAINTENANCE ORGANIZATION AND POLICIES

This chapter gives to the Auditor all details on organization of maintenance department. The final goal is to determine if the department has an organization easily computerizable or if does a complete or partial reorganization must be foreseen.

With this chapter the auditor must be able to answer these questions:

2.1 Maintenance Management Organization

- Do a Preventive Maintenance Module is required?
- Do a Corrective Maintenance Module is required?
- Do a Contract Module is required?
- Which kind of Module is required for the above?
- Is it necessary to have a module or a sub-module to separate the costs for the plant level and the "group" level?

2.2 Maintenance Management Policies

What is the first requirement of Maintenance department and what are the expected analyses?

This is to prepare and analyze the reporting facilities of the software.

2.3 Maintenance Management Practices

How do the different modules of the software must be organized according to the importance of the different types of maintenance.

2.4 Maintenance Management Tools

- What is the stage of computerization?
- Is the available hardware powerful enough to suit the required developments?
- Are the present softwares compatible with the developments forecast?
- What is the level of computerization of the company?

2.5 Maintenance Forecast

- What are the major expectation of Maintenance department?
- Is a computer-aided maintenance management system able to cover all these requirements?
- Do they expect to buy a system or to develop it internally?

3. MAINTENANCE PROCEDURES

Before implementation of a computerized system, manual procedures must be clearly defined and also be computerizable.

Procedures must be as simple as possible and the goal of this section is to evaluate the suitability of the different procedures.

3.1 Equipment Inventory

- Does a coding system exist and is strict and clear enough to be computerized?
- What is the structure of equipment inventory? Pyramid structure? or equipment list?

3.2 Work-Order Procedure

- Is this procedure computerizable?
- What can be simplified?
- What is missing?
- Is it possible to use a unique models of work-order?

3.3 Estimating

- Is it necessary to include the estimation possibility and the possibility of actualization of estimation?

3.4 Planning and Scheduling

- Is the present planning and scheduling system easily computerizable?
- Is it necessary to include the availability of parts and material?
- Is personnel management included in planning?
- What information must be included in the planning module?

3.5 Corrective Maintenance

- How corrective maintenance is organized?
- Are Work-Orders used?
- How data are recorded?
- Are C.M. works planned?

3.6 Preventive/Predictive Maintenance

- Which kind of planning and scheduling is used for PM.?
- What is included in PM?
- Are the procedures similar?
- Is PM computerizable as it is?
- Are work-orders used for PM?

3.7 Completion of Job

- Do a specific procedure is used for completion of jobs?
- Which information is collected and stored?

4. PARTS AND MATERIAL MANAGEMENT

This section must show if a computer-aided system is already existing, if it is reliable and easily interfacable with a maintenance system.

If no computer-aided system system exists, is it easy to computerize the manual system?

4.1 Stores and Services Organization

- Is a coding system existing and is it reliable?
- Is it necessary to develop a new coding system?

4.2 Stores and Services Procedures

- How stores are managed?
- Is an inventory available for data entry? Is it reliable?
- Are parts requisition used to issue parts?
- Is it necessary to revise or replace the actual procedure?
- Do an interface between parts and maintenance systems is required?

5. MAINTENANCE STRATEGY

This section gives a rough idea of maintenance volume and of the difficulties, maintenance department encounters.

6. RELATIONS WITH OPERATION

This section must enable the auditor to evaluate the possibility to share information with operations department.

7. COMPUTER USAGE

With this section the auditor must be able to determine the level of computerization of the company and to estimate:

- Hardware requirements
- The future developments
- The expected interfaces

8. MAINTENANCE DOCUMENTS

With the documents given by the company it is easier to evaluate

- the level of organization of the company
- the existing procedures
- the requirements of the company in terms of reporting facility.

CHAPTER VIII

SIMPLIFIED MAINTENANCE AUDIT FOR COMPUTERIZATION

TABLE OF CONTENTS

INTRODUCTION

Maintenance Management of a plant can be improved by the use of a computer to record Maintenance Data and analyze it to have a help in making decision. The final goal of the computerization is to reduce maintenance costs and increase the plant reliability. Computer-aided Maintenance Management systems are available, ready made, on the market but can also be developed internally under the control of Maintenance Management.

In any case the implementation of a computer aided system is an important and critical step in the development of the maintenance strategy of a company. It is always an important investment as well as for material or software purchase and for personnel investment.

To maintain the payback of this investment at a correct level, it is necessary to prepare this investment in details. A badly prepared implementation can be a real catastrophy and a big waste of money and the waste of confidence of the personnel in computerization.

The first step of an implementation is to examine in detail the present status of maintenance department focusing especially on

- Maintenance Organization
- Maintenance Procedures
- Parts and Material Management and Purchasing Procedures
- Maintenance "Turnover" or volume

To examine the situation of a Maintenance department it is necessary to follow some basic rules and the best solution is to conduct an Audit on Maintenance with the final view of computerization.

The second step will be to analyze this audit and thus to determine the most suitable software for the company.

The third step will be organization of the Maintenance department and implementation of the software or development of a tailored software.

The fourth step will be the post implementation analysis to evaluate the performance of the system.

The main goal of this audit is to:

- Evaluate the situation of Maintenance department.
- Evaluate the volume of information to be managed.
- Appreciate the different procedures and check if they are easily computerizable.
- Evaluate the required changes in the present organization.
- Evaluate the amount of work to be done for a computerization.
    - Data collection
    - Organization
    - Adaptation or creation of procedures
- Establish an implementation planning
- Evaluate the cost of this implementation

MAINTENANCE AUDIT FOR COMPUTERIZATION

1. COMPANY OVERVIEW

1.1 PLANT GENERAL

1.1.1 General Information

- Company: _____
- Address of the Plant: _____
- Telephone: _____ Telex: _____ Fax: ____
- Nature of Business of the Company:

  _____
- Name of the contact person:

  _____
- Function: _____

1.1.2 Plant and Maintenance Figures

- Actual Turnover of the Plant _____
- Actual Turnover of Maintenance (Parts, Material & Personnel Expenses_____
  - Part of the plant _____%
  - Part contracted _____%
  - Part of the group or (central maintenance department _____%
- Total Energy Consumption of the Plant _____kW
- Total Electric Power Installed _____HP

1.2 HUMAN RESOURCES

1.2.1 Organization of Maintenance Department

Please draw a schematic organization chart showing the different functions of Maintenance and the number of persons affected to each function: eg.

- Maintenance Management and staff
- Maintenance Planning and Scheduling
- Maintenance Work Supervision
- Maintenance Work Execution
- Maintenance Workshop
- Inspection and Control
- Stores Management
- Purchasing
- Other Maintenance Function

Organization Chart

1.2.2 Costs and Statistics on Plant Human Resources

	This year	Next year Budget or Estimate
Total No. of personnel of the plant	_____	_____
- Production	_____	_____
- Maintenance	_____	_____
- Others	_____	_____
No. of Tradesman in maintenance	_____	_____
No. of Maintenance Supervisors	_____	_____
Estimated annual maintenance cost total:	_____	_____
- manpower: (labour)	_____	_____
- materials:	_____	_____
- contracted:	_____	_____
Hourly rate of tradesman (on average)	_____	_____

1.2.3 Organization of Maintenance Jobs

- Are your personnel organized by team? Y/N
- Are these teams organized by trade? Y/N
- Are these teams regrouping several trades? Y/N
- Are your teams working on shift? Y/N

2. MAINTENANCE MANAGEMENT ORGANIZATION AND POLICIES

2.1 MAINTENANCE MANAGEMENT POLICIES

2.1.1 How many production hours have been lost last year due to breakdown (unplanned maintenance)? _____

2.1.2 How many "units" have been lost last year for the same reason? (unit: _____) No. _____

2.1.3 What do you think about these losses?

- Is it a normal loss which cannot be avoided? Y/N
- Is it a reasonable loss which can be reduced? Y/N
- Is it an excessive loss? Action must be taken to reduce it. Y/N

2.2 Maintenance Management Practices

2.2.1 In which of the following categories do you place:

	Correct. Maint.	Prev. Maint.	Pred. Maint.	Cond. Based Maint.
• Breakdown or failure				
• Condition monitoring				
• Vibration analysis				
• Lubrication				
• Oil analysis				
• Corrosion Control				
• Major overhauls.				
• Modification				
• Other (Specify) _____				

2.2.2 Which type of maintenance do you use in your plant? Tick in the adequate column.

	Correct. Maint.	Prev. Maint.	Pred. Maint.	Cond. Based Maint.
2.2.3 What percentage of each category are you generally using in your plant?	_____ %	_____ %	_____ %	_____ %
2.2.4 What percentage of each category is generally contracted?	_____ %	_____ %	_____ %	_____ %

2.3 MAINTENANCE MANAGEMENT TOOLS

2.3.1 How do you analyze maintenance data to improve the "Productivty" of your Maintenance? (specify)

_____

_____

_____

2.3.2 What are your conclusions on your maintenance management analysis:

- Production tool (equipments) must be improved Y/N

- Production must be reduced to avoid major trouble Y/N

- Production personnel must be trained to improve the use of equipments Y/N

- Maintenance management must be more involved in production decisions Y/N

- Maintenance department must be reorganized Y/N

- Maintenance policies must be revised in terms of:
  - Corrective maintenance Y/N
  - Preventive maintenance Y/N
  - Predictive maintenance Y/N
  - Others (specify) _____

- Maintenance procedures must be revised in terms of:
  - Corrective maintenance Y/N
  - Preventive maintenance Y/N
  - Predictive maintenance Y/N
  - Others (specify) _____

2.4 MAINTENANCE FORECAST

2.4.1 What are your expectations to reduce your maintenance cost?

- Coordinate with production to improve the maintenance tool utilization Y/N

- Use computer aided management system for
  - Maintenance cost analysis Y/N
  - Maintenance planning and scheduling Y/N
  - Maintenance personnel management Y/N
  - Maintenance history Y/N
  - Maintenance technical data storage Y/N
  - Maintenance work specification storage Y/N
  - Corrective maintenance works Y/N
  - PM works Y/N
  - Other Maintenance (specify)

    _____

  - Spare parts Management Y/N
  - Spare parts Inventory Y/N
  - Spare parts and Material Purchasing Y/N

- Do you expect to buy an already developed system from the market? Y/N

- Do you expect to develop it internally? Y/N

2.4.2 Timing

- What are your expectations in terms of time for the purchase or the development of the above mentioned system? (Tick the good answer). - 1 month; - 3 months; - 6 months; - 1 year; - None

- Details or Remarks: _____
  _____

2.4.3 Finance

- What is your expected paybacks for the investment? _____

- Who can propose such investment? (Title)
  _____

- Who takes the decision? (Title)
  _____

3. MAINTENANCE PROCEDURES

3.1 EQUIPMENT INVENTORY

3.1.1 Is the equipment inventory organized by

- Equipments hierarchy? Y/N
- Alpha Numeric listing? Y/N
- Other (specify) _____

3.1.2 How many items of maintainable equipment you have? _____

3.1.3 How many critical equipments you have? _____

3.1.4 Do you have equipment identification code? Y/N

3.1.5 How many caracters (digits) compose the equipment code? _____

3.1.6 Do your equipments have a unique number? Y/N
or several equipments can have the same No.? Y/N

3.2 WORK ORDER PROCEDURES

3.2.1 Do you have a formal maintenance work request form? Y/N

3.2.2 Do you have a separate work order form? Y/N

3.2.3 Do you use a "Minor, Blanket or Open Work Order" for small jobs? Y/N

3.2.4 Do you have a separate Work Report form? Y/N

3.2.5 Do you have a priority system? Y/N

3.2.6 How do you record actual manhours?
- Time sheeting Y/N
- From logbook Y/N
- Other (specify) _____

3.2.7 Do you charge manhours to work order numbers? Y/N

3.2.8 Do you charge material costs to work order numbers? Y/N

3.2.9 Do you charge any other costs to work order numbers? (Direct purchase, etc.) Y/N

3.3. ESTIMATING

3.3.1 Are your work-orders estimated? Y/N

3.3.2 What is estimated?
- Manhours Y/N
- Manpower cost Y/N
- Material cost Y/N
- Other (specify) _____

3.3.3 Do you routinely report on the backlog of work? Y/N

3.4 PLANNING AND SCHEDULING

3.4.1 Do planners identify materials and stores requirements before work orders are released? Y/N

3.4.2 Do they check availability of material and parts before work orders are released? Y/N

3.4.3 Do they reserve spare parts for major jobs? Y/N

3.4.4 How do you schedule jobs? _____

3.4.5 What constraints are there on scheduling a job? _____

3.4.6 How do you coordinate maintenance and production schedules?

_____

3.4.7 Do you report on jobs falling behind schedule? Y/N

3.4.8 Do you use PERT or Critical Path Scheduling for overhauls and major maintenance work? Y/N

3.5 CORRECTIVE MAINTENANCE

3.5.1 Are you using Work-Order Procedure for corrective maintenance? Y/N

3.5.2 How do you report the job done?

_____

3.5.3 How do you report the time spent and the use of the spare parts?

_____

3.6 PREVENTIVE MAINTENANCE - PREDICTIVE MAINTENANCE

3.6.1 Is lubrication under the responsibility of
- Maintenance Y/N
- Production Y/N
- General management Y/N
- Others (specify) _____

3.6.2 Is your Preventive Maintenance
- Condition based? Y/N
- Time based? Y/N
- Unit based? Y/N

3.6.3 Are you using work specifications? (Standard defined jobs) Y/N

3.6.4 Are these specifications coded? Y/N

3.6.5 Have you identified all "critical" equipment? Y/N

3.6.6 Are you using work order procedure for Preventive Maintenance? Y/N

3.6.7 How is this done?

- By computer Y/N
- By tickler file Y/N
- By card system Y/N
- By wall chart Y/N
- Others (explain) _____

3.6.8 Do you report on overdue PM and inspection jobs? Y/N

3.6.9 Are you satisfied with your present preventive/predictive maintenance program? Y/N

If no, do you want to make some suggestions?

_____

3.7 COMPLETION OF JOB

3.7.1 Are you using the same procedure to complete Corrective and Preventive Maintenance jobs? Y/N

3.7.2 If not, what is the difference?

_____

3.7.3 Do you compare estimates against actuals? Y/N

3.7.4 Do you wish to analyze costs?

- per job Y/N
- per area Y/N
- per period Y/N
- per equipment Y/N
- per code (delay, cause, family, etc.) Y/N
- cost center Y/N
- other (specify)

_____

4. PARTS AND MATERIAL MANAGEMENT

4.1 STORES AND SERVICES ORGANIZATION

4.1.1 Who is in charge of Stock Management
- Maintenance Y/N
- Operations Y/N
- Others (specify) _____

4.1.2 Who is in charge of Purchasing parts and materials
- Maintenance Y/N
- Operations Y/N
- Others (specify) _____

4.1.3 Are spare parts codes used? (Internal coding system) Y/N

4.1.4 How many characters (digits) compose the parts No. _____

4.1 5 Is spare parts code including the equipment code? Y/N

4.1.6 Are spare parts identified according to a related equipment? Y/N

4.1.7 Is Interchangeability of parts recorded? Y/N

4.1.8 Do you have frequent stock outs?
Daily Y/N
Weekly Y/N
Monthly Y/N

4.1.9 Do you record stock outs? Y/N

4.1.10 Number of spare part types (i.e different line items)? _____

4.1.11 Are spare parts "Reserved" at planning stage? Y/N

4.1.12 Do you have a document showing availability, order point, order quantity and other information? Y/N

4.1.13 Are you satisfied with the present system used by maintenance stores? Y/N

If no, do you want to make some suggestions? _____

5. RELATIONS WITH OPERATIONS

5.1 Is communication with the operations side good, as far as:

Requesting jobs? Y/N

Informing them jobs are to be done? Y/N

Obtaining availability of equipments? Y/N

Issuing work permits? Y/N

5.2 If communication is not good do you think a better communication system could improve it? Y/N

Your Suggestions _____

_____

6. COMPUTER USAGE

6.1 What applications have been implemented? | on what Hardware?

Accounting	: _____	_____
Stock Control	: _____	_____
Purchasing	: _____	_____
Personnel	: _____	_____
Others	: _____	_____

6.2 Who uses the systems? _____

6.3 Are these systems interfaced? Y/N

6.4 Do you have a computerized maintenance management system? Y/N

- If yes, are you satisfied with its performances? Y/N
- If no, do you plan to implement one? Y/N
  - immediately Y/N
  - within the next year Y/N
  - within the next 3 years Y/N
  - no intention Y/N

6.5 Who will define any new system? _____

6.6 Do you intend to develop it internally? Y/N

6.7 Is the proposed maintenance system required to interface with any existing or future systems? _____

7. MAINTENANCE DOCUMENTS

7.1 It would be helpful if examples of the following documents could be provided.

- Technical information/data held for each equipment or item.
- Format of work request/work-order/work-report.
- Details of any data held for work specifications/services.
- Work permits.
- Printed instructions to work force on job ticket/work order/job execution/time sheet.
- Information collected when job completed.
- Stores requisitions as used by maintenance.
- Purchase requisitions.
- Any computer-produced reports?
- Any manually produced reports?
- Samples of Equipment coding.
- Samples of Parts coding.

ANNEX IV

I Periodicals

DUN'S REVIEW
Monthly Business trends, developments and problems of industry including management of maintenance systems. Also available on microfiche.

Publ. Dun and Brandstreet Publications Corporation
666 Fifth Avenue
New York, New York 10019, United States of America

ENGINEER
Weekly. General technical papers, news, and regular coverage of maintenance problems.

Publ. Morgan-Grampian Ltd.
Morgan-Grampian House
30 Calderwood Street
London SE18 6Q11, England

ENGINEERING
Monthly. Deals regularly with general maintenance and repair management topics. Also available in microfilm.

Publ. Design Council
28 Llaymarket Street
London SW1Y 4SU, England

ENGINEERING NEWS OF INDIA
Monthly.

Publ. Engineering Association of India
India Exchange Place, 7th. Floor
Calcutta 700 001, India

FACTORY
(Formerly Modern Manufacturing).
Monthly. Covers all topics of production management including maintenance.

Publ. Buttenheim Publishing Corporation
16 West, 61st. Street
New York, New York 10016, United States of America.

FACTORY MANAGEMENT
Quarterly.

Publ. Trade Publications Ltd.
1 Emily Place
Auckland, New Zealand

FACTORY MANAGEMENT MAINTENANCE AND ENGINEERING
Monthly. Gives all aspects of maintenance practice.

Publ. Trade Publications Ltd.

INDUSTRIAL ENGINEERING
Monthly. Covers also maintenance management. Also available in microfilm.

Publ. American Institute of Industrial Engineers
25 Technology Park
Atlanta Norcross, Georgia 30071, United States of America

INDUSTRY WEEK

Weekly. Covers managerial problems including maintenance. Free to qualified personnel.

Publ. Penton Publishing Company
Penton Plaza
Cleveland, Ohio 44114, United States of America

MAINTENANCE ENGINEERING
(Formerly Maintenance)
Monthly. Modern maintenance methods of plants, buildings, production machines, equipment and systems.

Publ. Cleworth Publishing Company
One River Road
COS COB, Connecticut 06807, United States of America

MAINTENANCE ENGINEERING
Monthly. Engineering methods and techniques of maintenance and repair in manufacturing industries, transport, building, construction, etc.

Publ. Mercury House Publications Ltd.
Product Information Division
Mercury House, Waterloo Road
London SE1 8UL, England

MAINTENANCE MANAGEMENT AND ENGINEERING
Quarterly. In English

Publ. National Productivity Council
Lodi Road
New Delhi 110 003, India

MANUFACTURING ENGINEERING AND MANAGEMENT
Monthly. Also available in microform.

Publ. Society of Manufacturing Engineers
20501 Ford Road
Dearborn, Michigan 48128, United States of America

MODERN PLANT OPERATION AND MAINTENANCE
Quarterly. Covers plant operation and maintenance practice, procedures and equipment.

Publ. United States Industrial Publications
209 Dunn Avenue
Stamford, Connecticut 06905, United States of America

PLANT ENGINEERING
Fortnightly. Covers plant equipment, its maintenance and improvement, its organizational aspects and supervision. Controlled circulation.

Publ. Technical Publishing Company
1301 South Grove Avenue
Barrington, Illinois 60010, United States of America

PLANT MAINTENANCE
Quarterly.

Publ. Fat Technical Society
Udyogawandal, Kerala, India

PLANT MANAGEMENT AND ENGINEERING
(Formerly Plant Administration and Engineering)
Monthly. Covers industrial management methods including maintenance.

Publ. Maclean-Hunter Ltd.
481 University Avenue
Toronto, Ontario M5W 1A7, Canada

P/PM TECHNOLOGY (ISSSSN 0747-2722)
Bimonthly.

Publ. P/PM Technology
P. O. Box 8096
Incline Village
NV 89450, United States of America
Tel.: (702) 831-6226

II. PUBLICATIONS

CHRISTER A. H. and WHITELAW

An operational Research Approach to Breakdown Maintenance: Problem Recognition.
J. Opl. Res. Sx. Vol. 42 No. 11 pp 1041-1052, Operational Research Society Ltd. London 1983.

FREEMAN R.

The use of computers for real time maintenance managements.
11th. National Maintenance Engineering Conference.
Conference communication. Farnham, 1986.

REYNOLDS R. P.

Use of computer to control economical aspects of maintenance.
8th. European Maintenance Congress. EFNMS - Barcelona, 1986.

TAKAO, MASAYOSHI, SHIGERU, SHUJI, HIDEO, MINORU, HIDEAKI, HIDEAKI.

Development of a Predictive Maintenance System at Sakai Works.
Nippon Steel Technical Report No. 19. June 1982.

WILSON, Dr. A.

Selection of the best computer system by users.
8th. European Maintenance Congress. EFNMS - Barcelona, 1986.

III. ASSOCIATIONS

FRANCE

MA. OGUS
AFICE: Association Francaise des Ingenieurs et Chefs d;Entretien
13, rue de Liege
75009 Paris (Tel.: (1) 280 64 00

GREAT BRITAIN

(Interim) E. J. Searle
BCMA
c/o Instron Ltd. MEJ Searle
Coronation Road
High Wycombe, Bucks
Tel.: 0494 33333

INDIA

M. N. Ghua
Indian Institute of Plant
Engineers
3 Lee Court, 36 Elgin Road
Calcutta 700 020

JAPAN M. SEHCHI NAKAJIMA

JIPE
Kyontsu Bldg. 3-1-22 Shiba Park
Minato-ku
Tokyo
Tel.: 434 6211

MAINTENANCE ASSOCIATION OF THE PHILIPPINES

4F Lower DAP Bldg. San Miguel Ave.
Metro Manila 1600
Tel.: 673 5215 to 17