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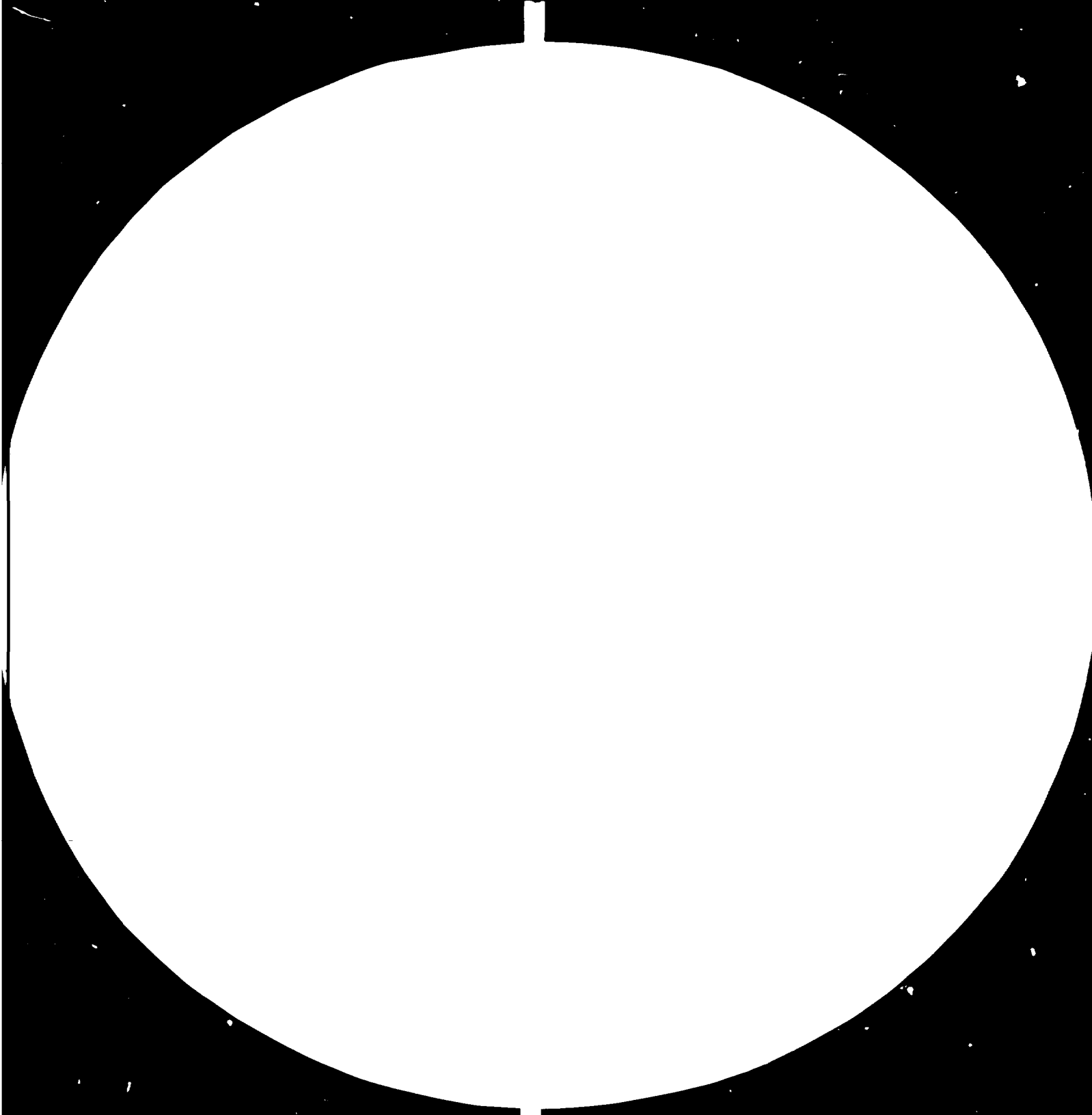

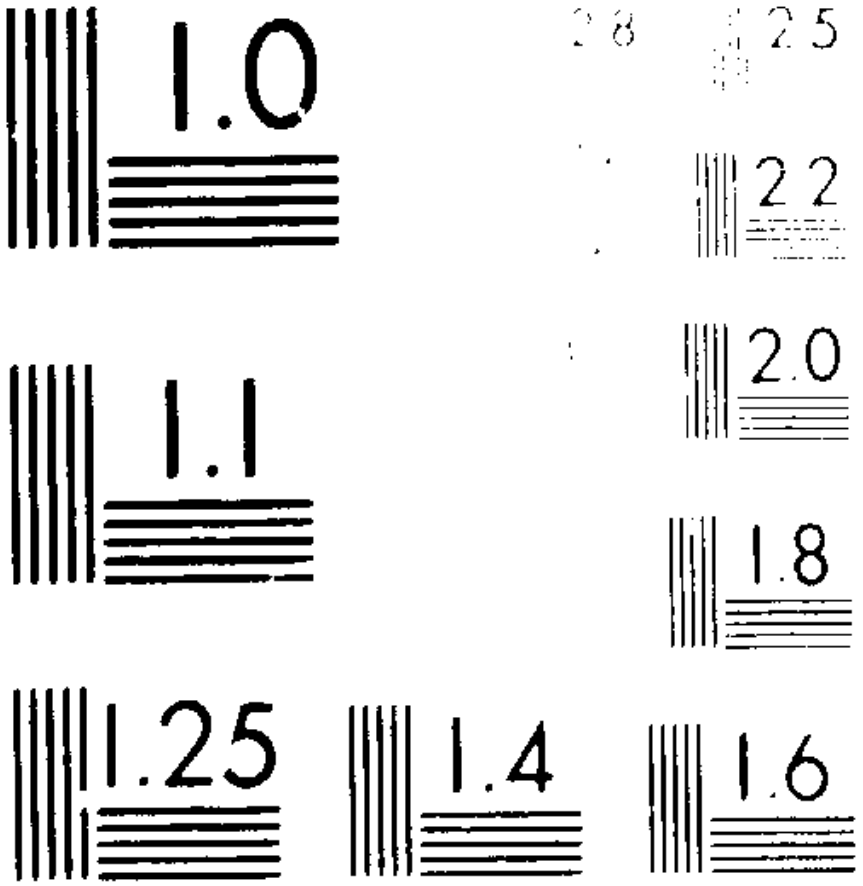
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8 January 1980
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ASSISTANCE IN THE DESIGN OF PREVENTIVE MAINTENANCE PRACTICE FOR FEDERAL CHEMICAL AND CERAMICS CORPORATION LIMITED

SI/PAK/79/803

PAKISTAN

Technical report: Design of a preventive maintenance scheme

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

Based on the work of Nabil N. Roshdi, expert on
safety, repair and maintenance

United Nations Industrial Development Organization
Vienna

80-30485

Explanatory notes

References to dollars ($) are to United States dollars.

The monetary unit in Pakistan is the rupee (PRs). During the period covered by this report, the value of the rupee in relation to the dollar was $1 = PRs 9.90.

One mil is one thousandth of an inch (1 in = 2.54 cm).

The following forms have been used in tables:

Three dots (...) indicate that data are not available

A dash (-) indicates that the amount is nil or negligible

Besides the common abbreviations, symbols and terms, the following have been used in this report:

BD	breakdown
BHC	benzene hexachloride
dB	decibel
DDT	dichlorodiphenyltrichloroethane
DSA	dimensionally stable anodes
DT	downtime
FCCCL	Federal Chemical and Ceramics Corporation Ltd
GMT	general manager technical
MCB	monochlorobenzene
PM	preventive maintenance
PVC	polyvinyl chloride
UNICEF	United Nations Childrens' Fund
WAPDA	Water and Power Development Authority
WHO	World Health Organization

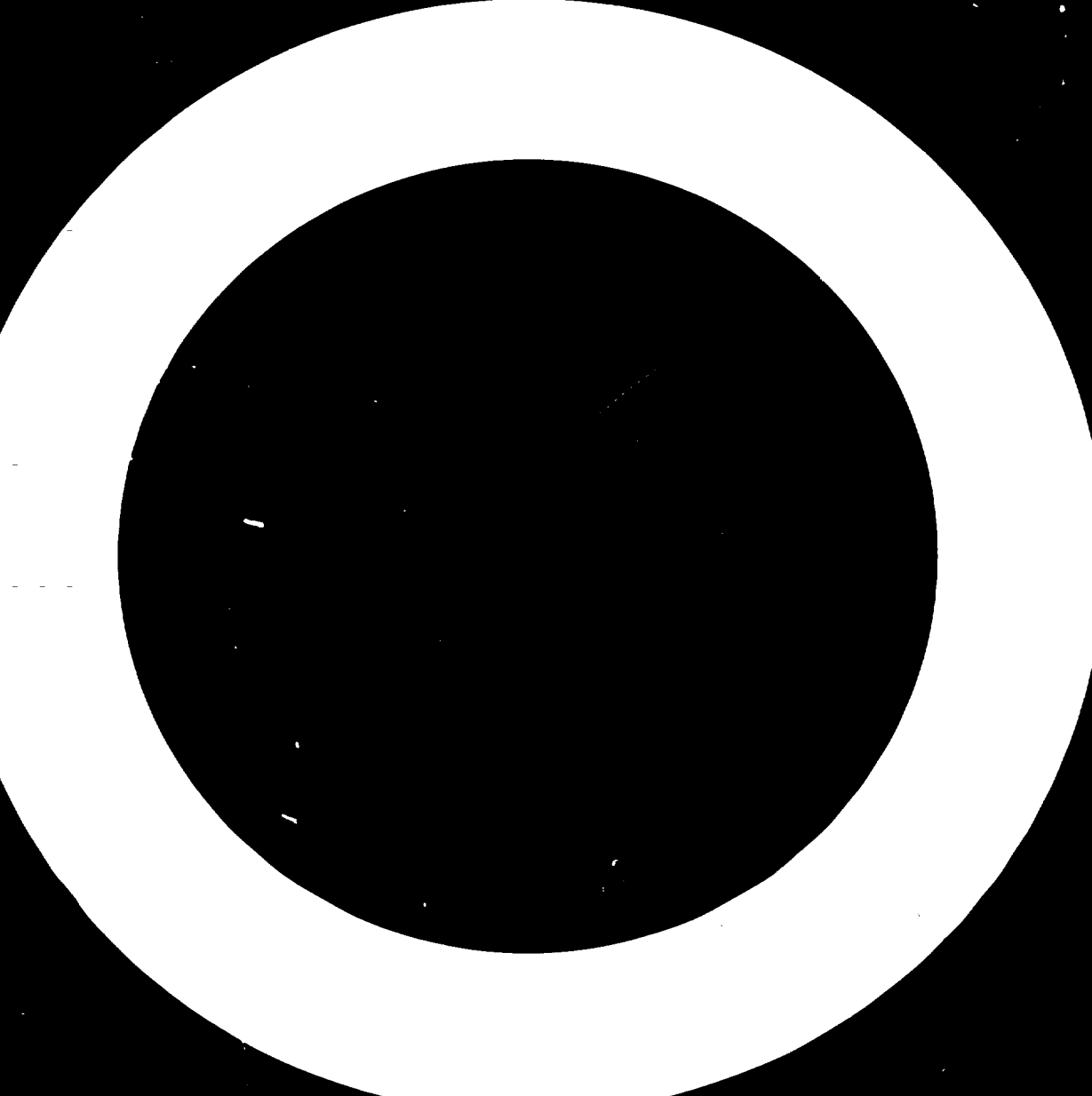
Mention of firm names and commercial products does not imply the endorsement of the United Nations Industrial Development Organization (UNIDO).

ABSTRACT

Following a mission by the United Nations Industrial Development Organization (UNIDO) in 1975 to survey the maintenance problems and needs of the Federal Chemical and Ceramics Corporation Limited (FCCCL), the Government of Pakistan submitted a request for technical assistance to be extended to the 12 factories belonging to the FCCCL group. The project "Assistance in the design of preventive maintenance practice for Federal Chemical and Ceramics Corporation Limited" (SI/PAK/78/803) was approved on 30 June 1978 and the expert on safety, repair and maintenance took up his assignment of six months on 8 April 1979.

The objectives of the mission were to design a preventive maintenance scheme which would be implemented in phase II of the project, to prepare the project document for phase II and to advise the engineers of FCCCL on repairs, safety and maintenance problems as might be needed.

Based on data collected from all units of FCCCL by means of a questionnaire, the expert developed a comprehensive preventive maintenance system and a procedure for its implementation consisting of the following parts: preventive maintenance planning, lubrication planning, inspection planning, spare parts control, safety rules and maintenance cost budgeting. He trained 12 engineers in preventive maintenance and emphasizes in his recommendations the need to establish a training centre and to make the training of engineers a continuous process in order to overcome the turnover of qualified personnel, which is exceptionally high at all FCCCL units. Other recommendations pertaining to maintenance management aim at increasing the engineering guidance to FCCCL units, at augmenting the possibilities of the management to enforce the application of safety rules and at improving maintenance performance at all levels. The expert, who also visited all FCCCL factories, gave advice on specific repair problems and prepared the draft project document for phase II.



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INTRODUCTION

A. Project background

In its development plans, the Government of Pakistan has placed emphasis on the development of the chemical industry. The need has therefore become evident for the development of the chemical industry controlled by the Federal Chemical and Ceramics Corporation Ltd. (FCCCL) established through the Ministry of Production under the Economic Reforms Order 1972.

FCCCL which owns 14 units working in a variety of products ranging from general chemicals through pharmaceuticals, plastics and ceramics to man-made fibres, was anything but healthy at the time of takeover. However, since 1972 the productivity of most of the former individual companies as well as the productivity of the Corporation decreased steadily.

In 1974 FCCCL decided that, with a view to maximize its productivity, better maintenance management as well as improved preventive maintenance systems were required. UNIDO sent a mission in November 1975 under project TS/PAK/75/039 to survey the needs of FCCCL. The conclusions of the mission were as follows:

(a) Lack of proper preventive maintenance practice at the plant level;

(b) Shortage of qualified maintenance engineers and supervisors;

(c) Need for technical assistance (experts and equipment).

This led to a proposal for technical assistance and on 30 June 1978, after an official request for assistance by the Government of Pakistan had been received, the United Nations Industrial Development Organization (UNIDO) approved project "Assistance in the design of preventive maintenance practice for Federal Chemical and Ceramics Corporation Limited" (SI/PAK/78/803).

B. Objectives

Within the overall development objective of strengthening and supporting the national industry of Pakistan, the immediate objectives of the project are the following:

(a) To increase the productivity of the plants of FCCCL through improved maintenance practices;

(b) To introduce new preventive maintenance techniques in these plants;

(c) To develop a maintenance management scheme and establish it in the Corporation.

The outputs of the project will be:

(a) Better profitability of the Corporation through decrease of down-time due to breakdowns of machinery;

(b) Improved maintenance skills;

(c) Improved management performance.

C. Phasing of the project

The project was divided into two phases. The activities of phase I are:

(a) To design, with the assistance of the engineers of FCCCL, a preventive maintenance scheme which is to be implemented in phase II;

(b) To prepare the project document for phase II considering all needs of FCCCL for the proper implementation of preventive maintenance techniques;

(c) To advise on repairs and safety problems as may be practical;

(d) To advise on corrosion problems.

This report deals only with activities (a), (b) and (c), covered by the expert on maintenance. As for activity (d), this will be dealt with by the expert on corrosion. Both reports should be used as reference for phase II.

D. Work accomplished during the project

The expert on safety, repair and maintenance who's mission started on 8 April and ended on 7 October 1979, was first briefed at UNIDO, Vienna where the objective and the activities of the project were explained to him. He was further briefed at Islamabad by M. K. Hussain, Senior Industrial Development Field Adviser, who introduced him to A. Taqvi, Deputy Secretary, Ministry of Production. During the Meeting A. Taqvi raised the problem of lack of qualified maintenance engineers due to the attractive offers given to them from abroad.

The effective starting date was 17 April 1979, when the expert met Mushtaq Ahmed, the General Manager Technical (GMT) of FCCCL. The preliminary discussion with him led to calling the national staff to join the team (see annex VIII) and establishing a plan for the visits of all factories of FCCCL. The expert was further requested to prepare a questionnaire for the units before visiting them.

Questionnaire

It was important to start the project activities by preparing questionnaire forms to be filled by the maintenance staff in all FCCCL units. The purpose was:

(a) To collect the necessary information concerning the maintenance level in each unit;

(b) To make the maintenance staff in each unit aware of the purpose of the project;

(c) To give a sort of preliminary training to maintenance staff before visiting them.

The maintenance staff was allowed two weeks to study and complete the questionnaire forms. During this period the expert prepared two technical instructions concerning lubrication planning and safety rules. These reports were sent to the maintenance staff of the factories for study before visiting them.

Visits to factories

As the FCCCL's factories are scattered all over Pakistan, the route was planned to go from the south (Karachi) via mid-country (Lahore and Pindi) to the north (Swat) and then to return through mid-country (Daudkhel) to Karachi via Pindi.

The time table of the visits is given in annex IX.

Preparation of technical reports on instructions

The expert prepared a series of technical instruction covering the following aspects:

Maintenance organization	(annex I)
Lubrication planning	(annex II)
Preventive maintenance planning	(annex III)
Inspection planning	(annex IV)
Spare parts control	(annex V)
Maintenance costs budgeting	(annex VI)
Safety rules	(annex VII)

He further elaborated technical reports containing advice on specific repair problems and prepared the draft project document for phase II of the project (annex X).

CONCLUSIONS AND RECOMMENDATIONS

Conclusion	Recommendation
Lack of engineering guidance (trouble shooting) from FCCCL to units	1. Assign a senior maintenance engineer (B.Sc mechanical) to this job. His responsibilities will be: (a) To join all international experts assisting the Corporation in engineering works as may be practical; (b) To collect and distribute to all units concerned technical reports, literature and research studies in the field of maintenance; (c) To visit all units according to a schedule and advise them in the area of preventive maintenance; (d) To bring to the attention of the chairman concerned any problems emerging during his visits; (e) To visit and survey the workshops in the country and feed the information collected to the units concerned; (f) To submit monthly to the chairman of FCCCL a report on the variance of maintenance costs, including breakdown records of each unit together with his comments; (g) To advise on repair problems if requested by the units; (h) To follow-up the training programmes for the maintenance personnel (phase II).
Lack of proper maintenance organization schemes at unit level	2. The general manager of administration at the FCCCL head office, in collaboration with the maintenance managers of the units, should implement the schemes proposed in this report (annex I). 3. FCCCL should restudy the ranges of its salary scale with a view to reduce discrepancies appearing in the organizational structure.

Conclusion	Recommendation
Lack of proper control by managerial level of workers' level	4. The Government and the administration of FCCCL should work out regulations and sanctions which could help the administration of the plants to improve its control over subordinates and workers with a view to eradicate unsafe working practices.
Need of maintenance engineers	5. Experienced engineers should be recruited on contractual basis with limited duration (e.g. for one year). This will allow the Corporation to offer them salaries which can compete with those paid in the private sector.
	6. The maintenance departments should be supervised by technical managers.
Continuous leaving of a high percentage of skilled maintenance engineers and lack of adequate training for maintenance managers and supervisors	7. A training centre should be established at Ravi Rayon's premises and continuous training of staff of all units of FCCCL should be institutionalized, thus maintaining a second line of qualified engineers for all units.
Lack of proper spare parts inventory and maintenance facilities	8. The approach to spare part planning and inventory control recommended by the expert (see annex V) should be adopted and for the implementation further expert assistance should be sought, as indicated in the draft project document for phase II.
	9. All necessary instruments and equipment as per list attached to the draft project document for phase II (annex X) should be procured.
Lack of proper maintenance performance	10. The preventive maintenance scheme designed during the first phase of the project (annexes II, III, IV and VI) should be implemented. Here again, the implementation will require further expert assistance from UNIDO, as proposed in the draft project document for phase II (annex X).

I. FINDINGS

A. Data collected from the questionnaires

During the factory visits it was interesting to see the response of the maintenance staff to the questionnaire sent to them. Pakistan PVC, Ittehad Chemicals, Ittehad Pesticides, Swat Elutriation, Ravi Rayon and Kurram Chemical reacted positively and gave all information that was available. Nowshera DDT did not respond due to the fact that the production of DDT had apparently been stopped and all maintenance staff of the unit had either transferred or left the factory. The units Antibiotics (Private) and Pakdyes and Chemicals had no maintenance engineer to fill out the forms properly.

The information and data thus obtained, which are summarized in the following sections, have a 80-per cent confidence. The original questionnaires are being kept in the head office of FCCCL.

Maintenance organization at management level

The following charts reflect the present maintenance organization of some units of FCCCL.

Figure 1. Maintenance organization of Pakistan PVC

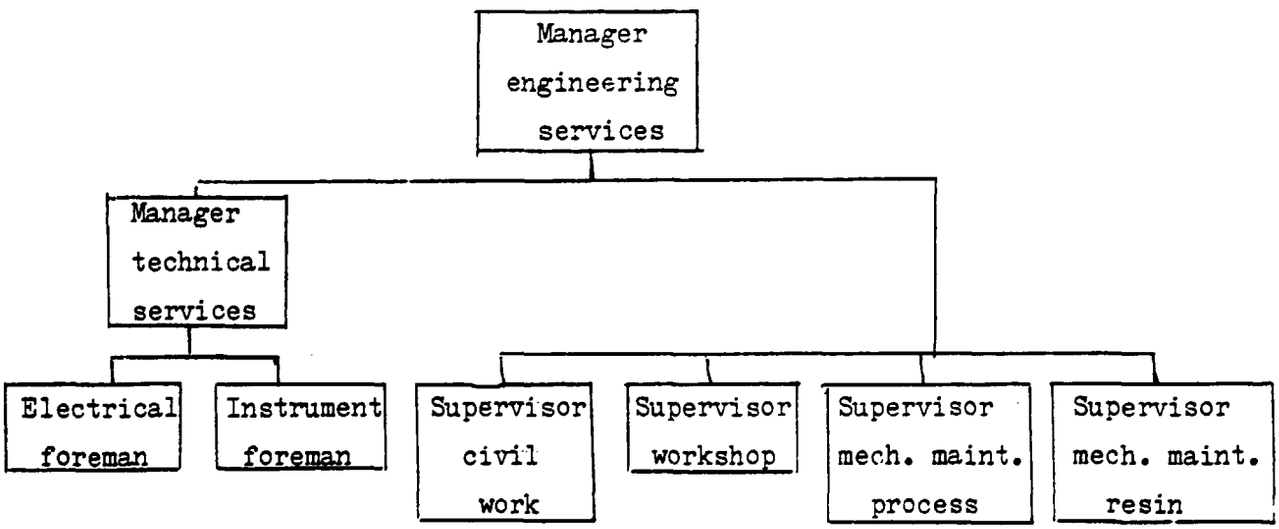


Figure 2. Maintenance organization of Ittehad Chemicals

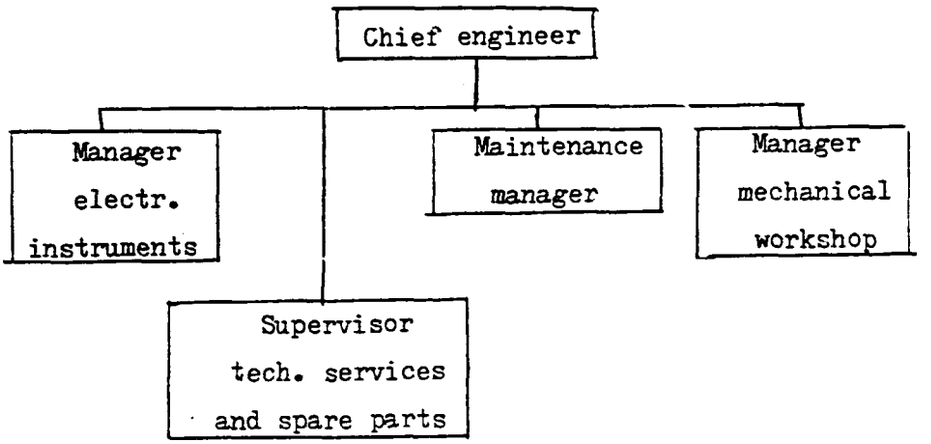


Figure 3. Maintenance organization of Ittehad Pesticides

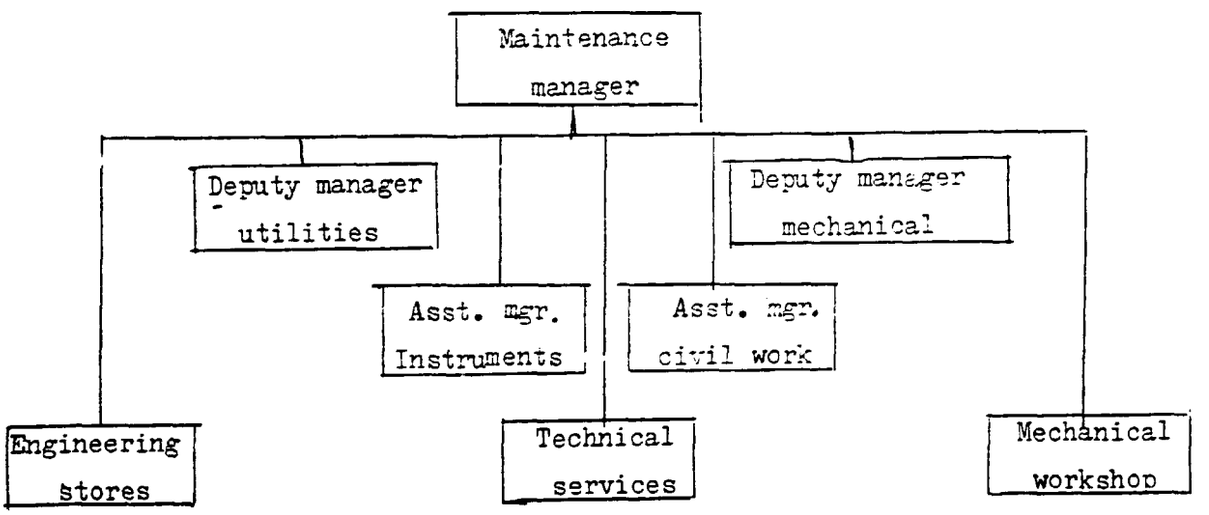


Figure 4. Maintenance organization of Ravi Rayon

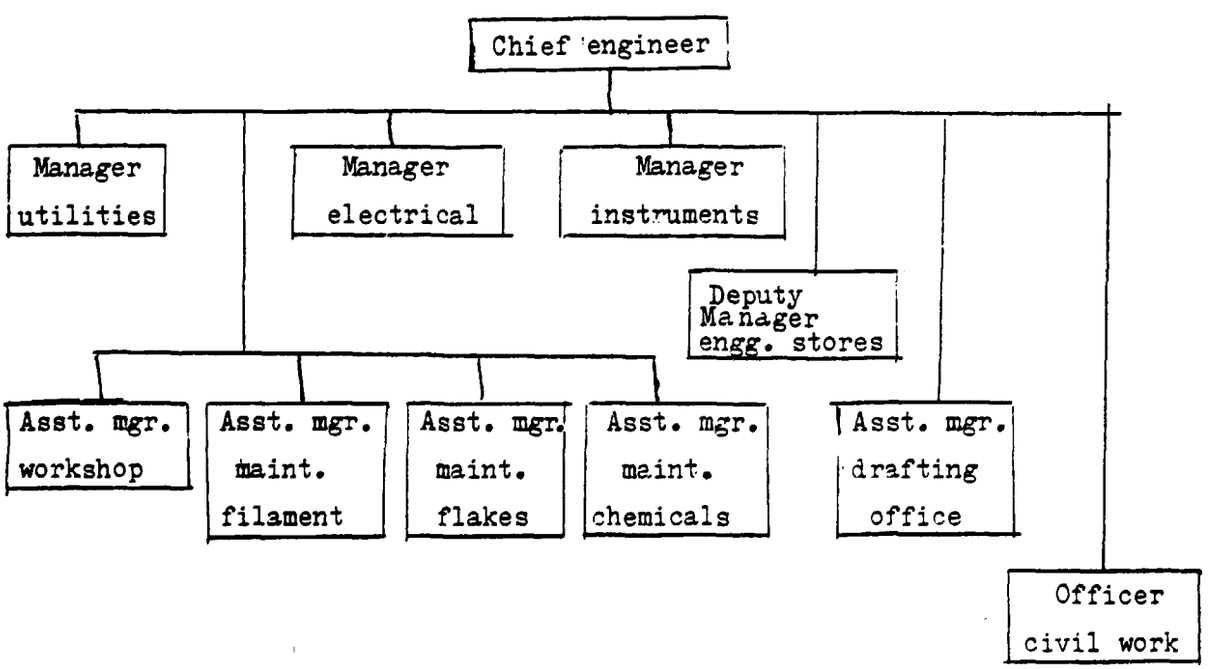


Figure 5. Maintenance organization of Kurram Chemicals

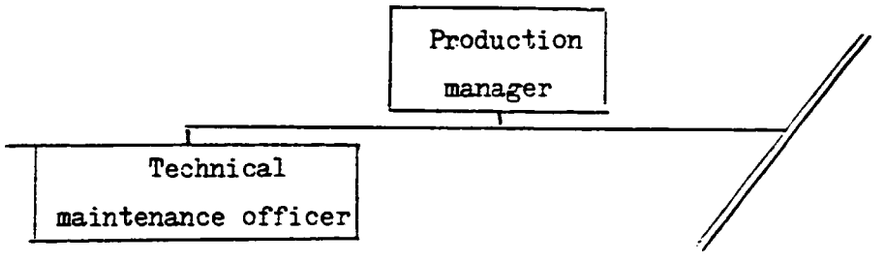
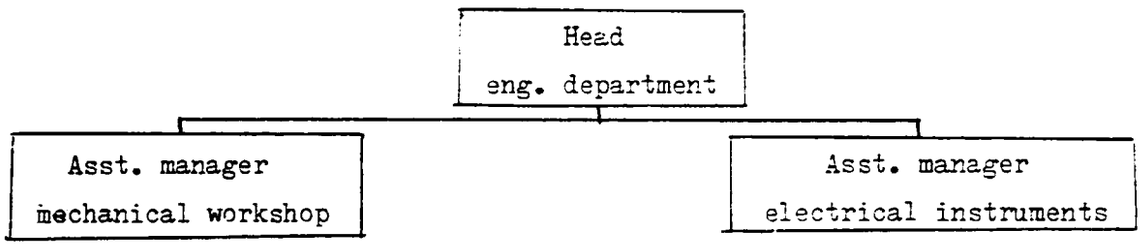


Figure 6. Maintenance organization of Swat Ceramics



The other units do not have organization charts or they are still awaiting their approval by FCCCL.

It can be seen that the various units of FCCCL have quite different maintenance organization schemes, some of which are considered satisfactory, whilst others are inadequate. Ravi Rayon (figure 4) for example, has ten sections reporting to the chief engineer, and the organization chart of Ittehad Pesticides (figure 3) shows seven sections reporting directly to the maintenance manager.

During discussions with the management the following reasons for this problem transpired: after a certain period of service in a given category, there are no further increments in the salary scale and therefore the incumbent of the post cannot get any financial benefit unless he is promoted to a higher grade. This situation led to such agitation that managerial positions were created to promote persons who had only practical skills and lacked managerial capabilities. Suitable maintenance organizations for the different sizes of units are described in annex I.

Existing and needed maintenance staff, and number of separations during the last three years

Table 1. Existing and needed maintenance staff in large units, and number of separations during the last three years

Unit	Chief engineers			Senior engineers			Junior engineers and diploma holders		
	Existing	Needed	Left	Existing	Needed	Left	Existing	Needed	Left
Pakistan PVC	-	1	-	-	1	2	5	-	-
Sind Alkalis	-	1	...	2	-	...	-	1	...
Ittehad Chemicals	1	-	3	1	1	1	3	-	4
Swat Ceramics	-	1	-	-	1	2	4	-	1
Ravi Rayon	1	-	2	2	1	3	1	1	...
Total	2	3	5	5	4	8	13	2	5

Table 2. Existing and needed maintenance staff in medium units, and number of separations during the last three years

Unit	Senior engineers			Junior engineers and diploma holders		
	Existing	Needed	Left	Existing	Needed	Left
Ittehad Pesticides	1	-	-	1	-	3
Antibiotics (pt) Ltd	-	1	...	-	1	...
Pakdyes and Chemicals	-	1	...	-	1	1
Nowshera DDT	-	1	1	-	1	1
Total	1	3	1	1	3	5

Table 3. Existing and needed maintenance staff in small units, and number of separations during the last three years

Unit	Diploma holders		
	Existing	Needed	Left
Kurram Chemicals	3	-	-
Swat Elutriation	3	-	2
Ravi Engineering	1	1	...
Total	7	1	2

From the tables 1, 2, and 3 the following can be concluded:

(a) The average number of senior engineers leaving per year is $\frac{5+8+1}{3} = 5$;

(b) The number of senior engineers needed at the moment is 3+4+3 = 10;

(c) The average number of junior engineers and diploma holders leaving per year is $\frac{5+5+2}{3} = 4$;

(d) The number of junior engineers and diploma holders needed at the moment is 2+3+1 = 6.

When this high rate of turnover of staff was pointed out during discussions, the managements of all units maintained that the salaries of FCCCL cannot compete with the attractive offers coming from either local private companies or from abroad. No complaint was made regarding the lack of skilled workers like fitters, welders, riggers etc.

Date on production, breakdowns and maintenance cost

The indicators given in table 4 represent the performance of maintenance in each factory though other factors external to maintenance are affecting the utilization of plant facilities (further explanation is given in the following section B). Below the units are categorized in a descending order, starting with the healthiest one:

Swat Elutriation
Ittehad Chemicals
Ravi Rayon
Kurram Chemicals

Table 4. Production output, breakdowns and maintenance costs in various units of FCCCL 1978/79

Unit	Year of first operation	Product	Actual production as percentage of designed capacity	Hours of breakdown as percentage of yearly working hours	Maintenance cost as percentage of net sales value
Pakistan PVC	1967	Caustic soda,	74	10	1.6
		PVC	40	29	
Sind Alkalis	1960	Soda ash	59	...	5.8
		Bicarbonate	100	...	
		Caustic soda	11	...	
Ittehad Chemicals	1964	Caustic soda	86	4	7.6
		Chlorine	49	5	
		Hydrochloric acid	76	4	
		Sulphuric acid	90	6	
		Lime	58	23	
Ittehad Pesticides	1966	BHC	68	7.5	6.7
		DDT (technical)	51	9.5	
Ravi Rayon	1966	Acetate yarn	72	...	6.3
Kurram Chemicals	1952	Santonin	66	...	1.8
		Syrups, tablets etc.	100	...	
Swat Ceramics	1977	Wall tiles	67	23	0.8
		Sanitary wares	44	...	
Nowshera DDT	1954	DDT (technical)	37	...	68
Swat Elutriation	1974	China clay	94	3	4.2
Antibiotics (Pt) Ltd	1957	...	...	...	0.5
Pakdyes and Chemicals	1959	Sulphur black	26	15	2.9
		Azodyes	46	8	

Ittehad Pesticides

Pakistan PVC

Swat Ceramics

Sind Alkalis

Pakdyes and Chemicals

Antibiotics (Private) Ltd.

Nowshera DDT

In general, all units need to implement preventive maintenance techniques to eleminate losses due to improper maintenance performance and in order to reduce breakdowns.

Data on number and kind of accidents

Table 5. Number and kind of accidents in various units of FCCCL, October 1978 to March 1979

Kind of accidents	Pakistan PVC	Ittenad Chemicals	Ittehad Pesticides	Ravi Rayon	Swat Ceramics	Nowshera DDT	Pakdyes and Chemicals	Total
Gas or vapour	3	5	-	-	-	-	-	8
Hand tools	2	-	-	2	-	-	2	6
Slipping	4	-	-	1	-	-	-	5
Chemicals	1	4	-	-	-	-	-	5
Electricity	1	-	-	-	1	1	-	4
Burning	1	-	-	-	-	-	2	3
Eye accident	-	-	2	1	-	-	-	3
Hand accident	-	-	2	-	-	-	-	2
Foot accident	-	-	1	-	-	-	-	1
Other reasons	-	-	-	-	-	1	-	1

Other units of FCCCL did not supply any relevant data.

From table 5 can be concluded that Ittehad Chemicals has a large number of accidents with gases and chemicals. This high accident rate was due to leaks of chlorine gas in the mercury cells hall and the fact that no rubber gloves had been used in the sulphuric acid filling section. The PVC factory has an excess number of accidents due to slipping and it was noted that a large part of the working area is covered with a slippery slurry. In general, the personnel does not observe safety rules and the safety officers have no authority to remedy this situation. No portable explosive gas detectors were available in the units having explosive gases in their working media.

A set of safety rules was prepared (see annex VII) and distributed by the expert to the safety officers during his visit
where required, further explanation was given.

B. Observations made during factory visits

Pakistan PVC Ltd., Karachi

The major problem of this plant is corrosion due to the damp climate and the working media (chlorine gas). The advice of the corrosion expert is for this factory essential. The factory would need an experienced senior maintenance engineer. Since there are five qualified junior engineers working in the maintenance department, their skills could be developed by training them in Sind Alkalis which has more experienced staff.

The mercury-cells section is maintained by the production manager of that section who is applying a preventive maintenance programme and the section is considered to be trouble-free. The monomer and polymer sections are frequently stopped due to lack of calcium carbide which is bought from a local private company.

The pipe extrusion, calender and compounding sections were not working at the time of the visit. Since these sections are working in a batch system, pipes produced were accumulating in the production hall. An experienced foreman is responsible for the maintenance of these sections and the equipment was in good condition since there is enough time available for checking and maintaining.

The stripper in the brine section needs immediate replacement and the roof of mercury-cells hall should be renewed as soon as possible.

The factory has a large workshop equipped with machine tools, welding, forging, foundry and rubber-lining facilities. It covers a large amount of repairs and produces some of the spare parts. The spare parts storage is the weakest point due to the limited storage area (about 10 x 5 m) and because there was no inventory control system observed. Spares are being ordered when there is an emergency need.

Sind Alkalis, Karachi

The maintenance department is lacking junior engineers at the supervisory level although the management of the maintenance department is highly experienced and preventive maintenance schemes were already existing. The major problem in this factory is the corrosion effect on equipment and buildings and the advice of the corrosion expert is needed.

Out of the three lime kilns existing, one only was working. The size of the raw lime stone is presenting problems and the expert suggested to investigate the installation of a crusher and screen downstream the kilns. It was mentioned to him that Krebs of France is going to study bottlenecks and the modernization of the existing plant.

The carbondioxide screw-compressors are frequently stopped due to improper filtration downstream the compressors. The expert advised to study the possibility of increasing the capacity of the existing electric filter.

The factory posesses a large workshop equipped with machine tools, forging and foundry shops, an assembly hall, a draftsmen is office, a balancing machine and vibration and sound analyzers. These facilities could be used for the training of engineers and diploma holders from the Karachi area in preventive maintenance techniques.

Synthetic Chemicals, Karachi

During meetings with the managing director of the factory and the Chairman of FCCCL (see annex IX) the following information was obtained: The factory was making heavy losses when it was handed over to FCCCL in 1972. The experienced engineers left the factory and continuous breakdowns led to a complete stoppage of production on 1976. The consulting firm Salzgitter (Federal Republic of Germany) surveyed the factory and concluded that about $US 8 million would be needed to renew the plant. FCCCL, with the agreement of the Ministry of Production, decided to liquidate the factory. The estimated sales price will be about $US 4 million.

National Fibres Ltd., Karachi

This factory which is under construction at the moment, is expected to start operation at the end of 1980. A discussion with the general manager of the factory about the required maintenance staff gave the following results: three senior maintenance engineers and 12 junior engineers and diploma holders will be needed.

Ittehad Chemicals, Kala Shah Kaku

The maintenance department of this factory is supervised by qualified and experienced engineers. The only complaint made, which later was found to be a general complaint in all the units, was that labour laws prevent the management from rewarding or punishing labourers and this was considered a major constraint affecting the maintenance performance.

At present the following total replacements are in hand:

(a) Replacement of rubber-lined pipes by fibreglass piping with rubber expansion joints. Already 20 per cent of pipes have been exchanged;

(b) Rubber-lined storage tanks for brine solution will be replaced by fibreglass tanks and the new tanks have been ordered;

(c) The chlorine disposal plant which is 16 years old, is in such shape that further repairs are practically impossible and uneconomical. A new plant in another location is now under construction;

(d) Concrete supports and bridges for piping are in a very bad shape due to effect of corrosion. The drawings for replacement by steel structures are ready and some supports have already been replaced by the maintenance department;

(e) The HCl furnaces are highly corroded and complete new plant is under construction at the moment;

(f) The graphite anodes of the mercury cells are to be replaced by dimensionally stable anodes (DSA). The purchase order for their importation has already been placed.

The factory has large maintenance workshops equipped with machine tools, facilities for forging, rubber lining, electric motor winding, instrument repair and welding. This workshop is situated between Ittehad Chemicals and Ittehad Pesticides and serves both factories.

The expert advised the general manager of the factory to remove the hydrogen gas holder from its present location in the middle of the factory, a place where it is almost impossible to eliminate fire hazards. This advice was accepted and it was decided to remove it in the near future.

Ittehad Pesticides, Kala Shah Kaku

Most of the equipment of this factory is glass-lined. The repair of the glass lining is done efficiently by bolt and lead capping.

The ventilation system in the formulation section is not powerful enough to keep fresh air in the hall, and dust is accumulating on the machinery which needs continuous cleaning. The expert advised the management to use heavy-duty vacuum cleaners and to study the possibility of installing different ventilation fans.

The production of DDT was reduced following the WHO report on that product and an acceptable product, zolone D.T., has been introduced. Yet, the unit is still not working at full capacity. The management expressed the need for advice and technical assistance with regard to the production of new pesticides to overcome this problem.

Ravi Rayon, Kala Shah Kaku

The maintenance department is controlled by highly-experienced engineers and preventive maintenance schemes were already existing. The department is equipped with large workshops including a machine tool shop, forging shop, electrical shop, instrument shop and welding shop. The necessary instruments for fault detection are available in the instrument shop.

The equipment in the factory was in general in good working condition without any specific problems.

The safety department is well organized and a highly-skilled safety officer is controlling all safety hazards properly.

The factory was facing problems in the raw material supply. Since sugar cane molasses are difficult to obtain, tests are being carried out with beat molasses, a raw material which is more easily available on the market.

Ravi Engineering, Kala Shah Kaku

This unit is made to serve all FCCCL's factories with all plate-metal works. It is equipped with plate rollers, a dish and forming machine (3/4" thickness), a shear (12.5 mm thickness), 20 welding sets, a sheet corrugating machine and a plate bending machine (40 mm thickness). A new section for heat treatment and argon welding of stainless steel has been added.

The mechanical engineer who acts as production manager of this unit, is looking after the maintenance section properly. His major problem was that finished products for the Ministry of Defence have been laying in the shop for eight years, thus occupying 40% of the working area and limiting his financial possibilities (the order amounted to 8 million rupees). The expert recommended that this engineer, who has excellent experience, should in addition to his duties at Ravi Engineering, act as maintenance trouble shooter for all units.

Kurram Chemicals, Rawalpindi

The production manager of this unit is supervising the maintenance work. The factory is equipped with a small workshop covering the needs of maintenance section.

At the time of the expert's visit, one of the Santonin extractors was being replaced. The only problem raised during the visit was the high fluctuation in voltage of electric current supplied by the city power station, which led to burning of motor insulation. After investigations the expert advised the management to ask the Water and Power Development Authority (WAPDA) to replace the existing transformer by a larger one to be located inside the factory and serving no other users. This will eliminate voltage drop at peak hours.

Swat Ceramics, Shaidu

The equipment for this new factory was obtained from the best manufacturers of ceramic machinery (Dorst, Netsch etc.). The management still faces technical problems due to lack of experience in this field. The chief accountant who acts as the factory manager has to make a wide range of important decisions and this is causing severe maintenance problems. On the other hand, the maintenance manager who holds a diploma in electrical engineering, cannot with his qualification handle management activities, although he has a wide practical experience.

One problem coming up during the expert's visit was the adjustment of the wall-tile ball mill. A detailed check-list for the adjustment of the ball mill was prepared and handed to the maintenance manager. An inspection revealed that the following maintenance was necessary:

(a) Relining of ball mill;

(b) Exchange of used flints.

For the factory's workshop a surface grinding machine should be purchased, to polish tne surface of the die liners of the wall tile presses. This operation is now done twice a week at Rawalpindi causing delay and excess expenses. The spare parts stores were apparently empty and due to lack of decision-making, many requisitions for spares have been held by the management for two years. This will lead to maintenance problems in the future.

Nowshera DDT, Nowshera

This factory was a gift from the United Nations Children's Fund (UNICEF) to the Government of Pakistan. It was handed over to FCCCL through the Ministry of Production in 1975. The factory was closed down in March 1979. The mono-chlorobenzene (MCB) section was dismantled and tne equipment was stored in a large yard.

Most of the equipment of the DDT section has already served its expected life and needs total replacement. The only section which was in better condition was the formulation section. The report of WHO stating that the vector has already developed resistance to the use of DDT and consideration of the fact that BHC has a toxic effect on human beings and animals, led to the legislation prohibiting the production of DDT and BHC.

The production manager expressed his interest in producing another type of insecticide, namely malathion. The expert also found out that in 1974 a consultant had suggested that this unit should produce chemicals for tanning of leather and textiles and/or keltane which is obtained by further processing of DDT. The project was abandoned due to financial reasons.

Swat Elutriation, Mingora

This is a new factory working one shift per day and closed on Fridays. The equipment of the factory is fully utilized and it is in a good working condition. It was noted that the factory is lacking a maintenance workshop to assist in repairs and to produce small spare parts.

The plant's maintenance engineer kept a record of breakdowns from which it was noted that the vibrating screen was often out of order. The sieve got out of its position and operation had to be stopped for refixing the sieve. After an investigation of the problem, the expert recommended the following corrective action:

(a) Weld or bolt two angle plates to the sides of the screen at a level of 50 mm above the sieve;

(b) Fabricate two tapered wooden wedges; and

(c) Hammer the wedges between the sieve and the plate angles to secure it in position.

The expert was later informed that there were no further breakdowns.

Antibiotics (Private) Ltd., Daudkhel

This factory was a gift from UNICEF to Government of Pakistan.

There was no maintenance engineer to provide information about the factory and the maintenance level, yet the production manager, who is acting now as maintenance manager, explained his views about maintenance.

The factory is equipped with a workshop with all necessary facilities for maintenance and repair jobs. The maintenance craftsmen have good experience, yet they need an experienced mechanical engineer to supervise and guide them.

Pakdyes and Chemicals, Daudkhel

During the visit the factory had its annual shut down and major overhauls were taking place. The condition of the equipment was normal and two corroded tanks were being replaced. The maintenance workers were highly skilled possessing experience with and knowledge of the equipment of the plant.

The factory has a workshop covering all needs of the maintenance department. The expert observed that the wood shop had been installed in the same hall as the machine-tool shop which may cause fire hazards. The manager admitted this and promised to transfer the wood shop.

The factory is making losses due to heavy governmental taxes and marketing problems which led to a reduction of financial means for the procurement of spare parts and, according to the information obtained, the situation is worsening.

C. Observations on the head office of FCCCL

In the organization scheme of FCCCL, the only technical decision-making centre is the general manager technical (GMT). The policy of the new chairman of FCCCL is decentralization of decision-making by giving the units more authority and freedom in their activities. This policy has improved to a large extent both productivity and profitability of the units, as can be seen from the 1978/79 budget.

The post of GMT is at present occupied by a senior chemical engineer; he is assisted by a librarian and a clerk. The GMT has a vast experience in special chemical processes, but no knowledge of maintenance functions. Guidance from FCCCL in engineering questions is therefore lacking and communications

between the head office and the units have apparently stopped. It seems necessary to have a mechanical engineer to act as a trouble shooter for all the units and the expert recommended for this function the production manager of Ravi Engineering, who could perform this job in addition to his original duties.

II. PROJECT OUTPUTS

A. Designing a preventive maintenance (PM) scheme

In most factories of FCCCL preventive maintenance is carried out during an annual shut down. However, planned routine maintenance, lubrication, inspection, spare part control, maintenance cost control etc. was mostly based on oral advice from the supervisors who relied on their own experience. Only two units, Sind Alkalis and Ravi Rayon, had a complete preventive maintenance system, but application was irregular due to reasons external to maintenance.

Planned preventive maintenance (PM)

Twelve engineers obtained training in PM from the expert. The following simple system for the designing of PM techniques, requireing a minimum of form filling, was followed in each unit visited:

(a) List all equipment in the factory and register availability of stand-by or spare for each equipment;

(b) Establish with the help of maintenance manager and production manager the most critical equipment i.e. which need most attention, and relist those items;

(c) Decide on frequency of stopping this critical equipment as well as duration of stoppage for checking and changing worn parts and obtain approval of both maintenance manager and production manager.

The resulting schedules (see annex III) can be considered master schedules for a PM programme, from which the maintenance managers can prepare monthly and annual PM schedules.

A complete detailed report (see annex III) was distributed to the factories' maintenance managers, including control cards, breakdown records etc.

Lubrication planning

After explaining to the engineers the system of lubrication planning, the lubrication schedule was completed in the following units: Pakistan PVC, Ittehad Chemicals, Ittehad Pesticides, Swat Ceramics, Swat Elutriation and Kurram Chemicals. The maintenance engineers of these units are already following the scheme. In the other units, the lubrication cards of the machinery had not been prepared by the engineers; yet, a complete explanation of lubrication planning was given to the maintenance staff of these units (see annex II).

Inspection planning

Inspection planning, using non-destructive testing instruments for early fault detection, was explained to the maintenance staff and a complete detailed report, including an inspection planning system, was sent to them (see annex IV).

Spare parts planning and inventory control

The system in the units should be corrected to get the most economical turnover of the stock. Annex V contains a full explanation of the problems and includes recommendations on manning, coding, control cards, inventory control etc. This report was sent to the maintenance managers of all units.

Maintenance cost budgeting

From data on maintenance costs indicated in table 4 and from discussions with maintenance managers the expert got the impression that the latter are not enough involved in the company budgeting. The only item they consider during the preparation of the annual budget was the cost of capital items, i.e. items that had to be replaced. The expert therefore prepared a technical report (see annex VI) describing a system of maintenance costs budgeting and monthly cost control, as a guide for the management in a future implementation.

B. Second phase of the project

There are many problems which cause losses at FCCCL and, as described earlier, not all are directly related to maintenance. Within maintenance, the most serious problems are caused by breakdowns, which are due to lack of good preventive maintenance techniques and a lack of maintenance staff.

Phase I of the preventive maintenance scheme is now established and a project document for phase II has been prepared (see annex X) to provide further assistance in the implementation of the systems developed, in the training of a team of national maintenance instructors to insure the continuity of the system, and in the preparation of junior engineers to fill vacancies caused by engineers leaving.

In addition to the technical benefits which can be derived from establishing a fixed training shop in Kala Shah Kaku, as proposed by the expert for phase II of the project, a continuous and adequate supply of maintenance staff to all the units of FCCCL could be ensured in order to cover the great number of experienced

engineers leaving due to better offers from abroad. The following cost comparison between a mobile training unit (as proposed in the project document phase I) and a fixed training shop (as proposed by the expert in the draft document for phase II, annex X) proves that it is also economically better if the fixed training shop is established. Items not included in this list are the same for both alternatives.

UNDP input

Code		Mobile training unit		Fixed training shop	
		m/m	$US	m/m	$US
10.	Experts				
	19. Component total	26	130,000	21	105,000
30.	Training (fellowships)	6	9,000	9	13,500
40.	Equipment				
	49. Component total		41,000	71	71,000
50.	Miscellaneous				
	51. Operation/maintenance equipment		18,000		6,000
	54. Duty travel (regional)		12,000		3,000
94.	Grand total		231,500		200,500

Government input

Code		Mobile training unit (Rs)	Fixed training shop (Rs)
40.	Equipment		
	43. Building	-	250,000
50.	Miscellaneous		
	51. Operating expenses	200,000	100,000
	54. Duty travel	200,000	-
	55. Accommodation expenses	100,000	-
99.	Grand total	715,000	700,000

With regard to the other problems of FCCCL, the Board of Directors of the company is studying several proposals for UNIDO assistance, namely:

(a) Diversification of pesticides products;

(b) Production of other types of penicillins;

(c) Establishment of a plastics training shop.

These projects would fall under the development programme of the Pakistan chemical industries.

Advice on repair problems

During the survey of the factories the expert's advice was needed on the following repair problems:

(a) Mercury cells repair system and procedure;

(b) Pumps check-list;

(c) Specification of surface finish and painting of steel;

(d) Belt conveyors quick repair method;

(e) Ceramic factory ball mills' check-list.

Reports on the above subjects were prepared by the members of the team and distributed on the maintenance staff in the factories for their guidance.

Annex I

MAINTENANCE ORGANIZATION

Objectives of maintenance

Maintenance has the following objectives:

(a) To maximize the availability of machinery and equipment for production;

(b) To preserve the value of the plant by minimizing wear and deterioration;

(c) To accomplish these goals as economically as possible on a long-term basis.

Basic functions of maintenance

The most important functions of maintenance are the following:

(a) Select and train qualified personnel to carry out the responsibilities and duties connected with maintenance and to provide adequate replacement for skilled workers;

(b) Develop effective planning and scheduling of all maintenance work;

(c) Arrange for release of production machines and equipment in order to accomplish planned maintenance;

(d) Maintain, repair and overhaul production machinery and equipment, portable power-driven tools, and materials handling equipment to maintain all in good operating condition;

(e) Maintain and repair all buildings, grounds, utilities, furniture, office equipment, kitchen and mess equipment;

(f) Install, rearrange, or remove machinery and equipment to provide for the requirements of production;

(g) Review specifications issued for the procurement of new machinery, equipment and process systems to assure that maintenance requirements are met;

(h) Select and provide for the application, at regularly scheduled intervals, of the proper lubricants for all machinery and equipment;

(i) Initiate and maintain conservation programmes for the efficient use of lubricating oils, greases and hydraulic oils;

(j) Provide plant-wide cleaning services for machinery, equipment and process systems such as spray booths, soluble oil tanks, washers, dust collectors, ducts etc.;

(k) Provide plant-wide sweeping and sanitary services;

(l) Collect, seggregate, and dispose of combustible wastes, scrap metal and solvable material;

(m) Develop data for incorporation into local and company-wide maintenance procedures and standards;

(n) Initiate requests for maintenance tools, maintenance supplies, special replacement parts for machinery and equipment necessary for the maintenance operation;

(o) Prepare spare parts requirements for machines and equipment, revise spare parts lists as required, and monitor the spare parts and maintenance materials conservation programme;

(p) Assure that inventories of spare parts, maintenance supplies, and special replacement parts are maintained at optimum level;

(q) Maintain safety control devices and enforce accepted safety standards for equipment.

Communication

It is of great importance to all units that information flows easily between the various departments of the company. This flow of information has to include both, transmission and reception in order to constitute a complete process of communication. Communication does not require agreement, but it does require understanding. Throughout our lives, we transmit and receive ideas, facts, feelings and experiences. Industrial communication takes the form of orders, directives, suggestions, plans, objectives, instructions, records, requests, inquiries, replies, reports, letters etc.

This flow of information not only links the units of the maintenance department, but also connects the maintenance department with other departments and with the organization as a whole. Without purposeful communication, there can be no co-ordination of activities towards the achievement of the organization's goals.

The flow of communication moves both horizontally and vertically (upwards and downwards). The downward flow of information is used to communicate to subordinates directives, company policy, procedures etc., whilst messages going upwards usually are reports on the progress of activities, on actions undertaken by subordinates etc., on issues on which a desired action by the management is being sought.

Horizontal communication, which is equally essential for the successful functioning of the organization, is concerned primarily with the passing of information between people and departments at the same level. Co-ordination of work between a maintenance foreman and a production foreman could not possibly be achieved without horizontal communication.

If barriers to effective communication develop within an organization, the result is friction, misunderstanding, and confusion. The actual job cannot be carried out as planned, attitudes and reactions cannot be provoked

as intended. These barriers can be due to various factors, such as the nature of the organization (geographic dispersion, lack of policy, poor organization, poor supervision etc.), language difficulties (different geographic, ethic, educational or economic background etc.) and psychological factors (individual differences, emotions, feelings, interests etc.). From the recognition of the fact that such barriers exist, one has to proceed to an analysis of why they exist and finally to their removal.

It should be remembered that communication develops in a certain atmosphere which is difficult to define. In the absence of a favourable atmosphere for communication, friction, inefficiency and failure can arise. Communication is not an end in itself, however, it is an important management tool whose ultimate objective is effective management.

Maintenance organization design

The size of a unit determines to a large extent the relationship of the decision-making centres. The following three types of maintenance organization charts should be used as guidance for the different units of FCCCL.

Figure 7. Maintenance organization suitable for small plants (Kurram Chemicals, Swat Elutriation and Ravi Engineering)

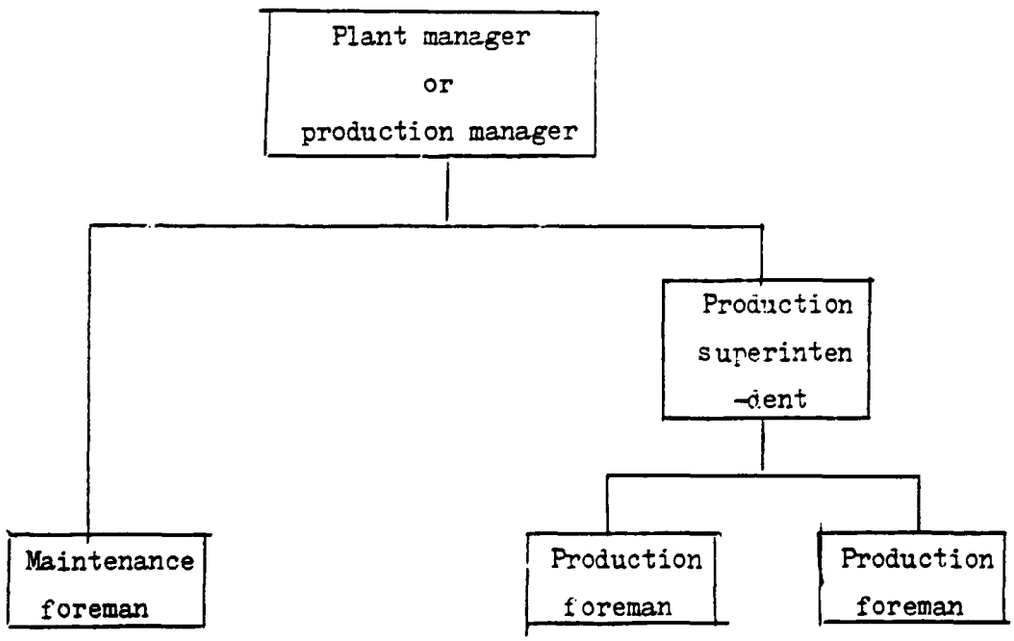


Figure 8. Maintenance organization suitable for medium-size plants (Ittehad Pesticides, Antibiotics (Pt) Ltd., Pakdyes and Chemicals and Nowshera DDT)

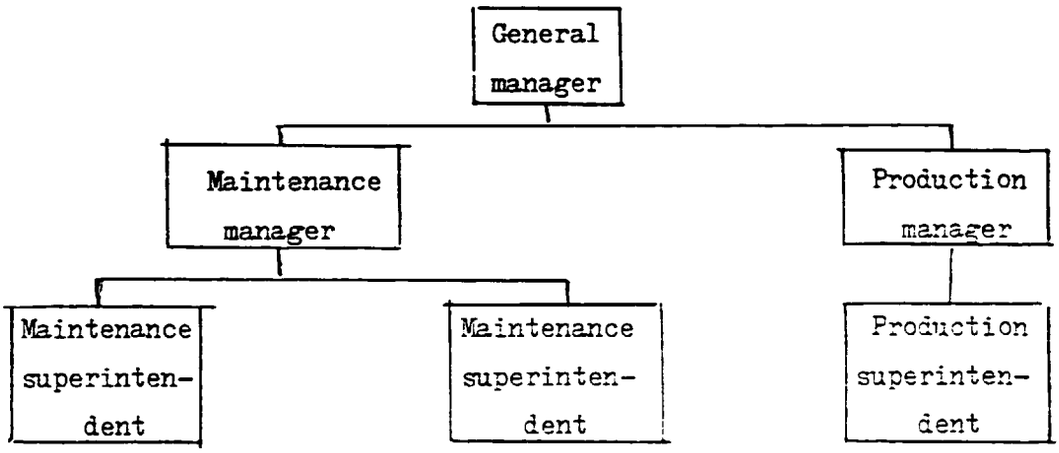
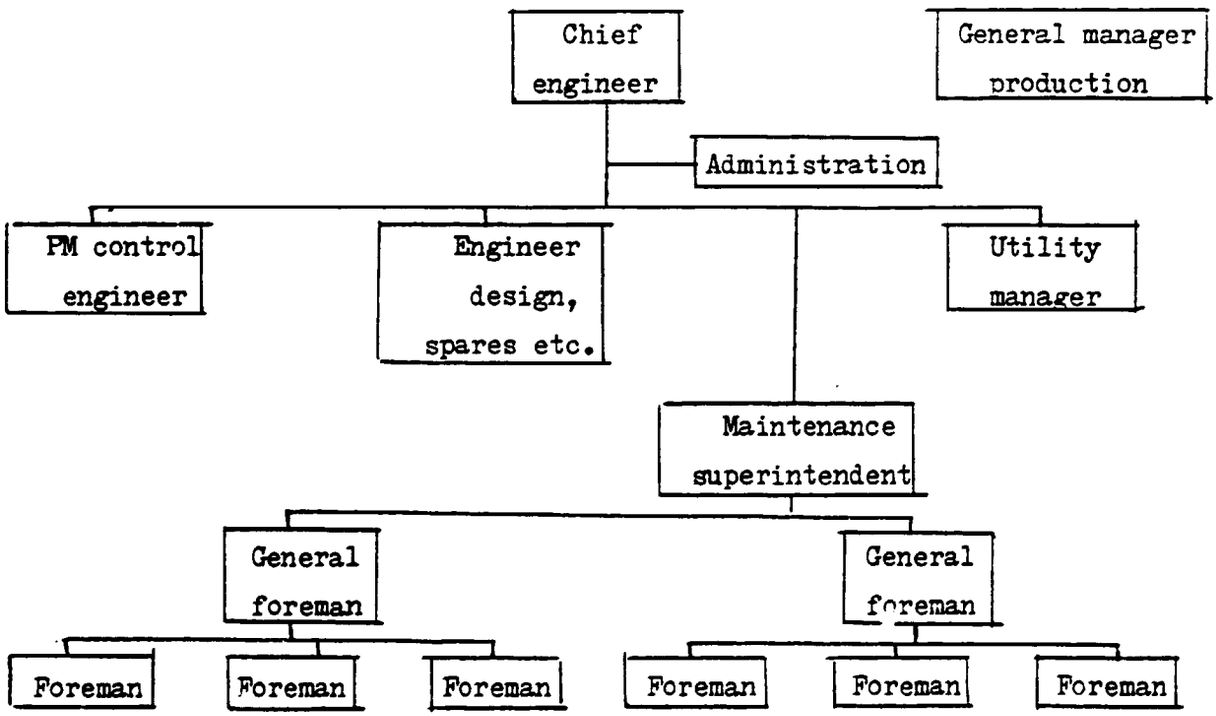
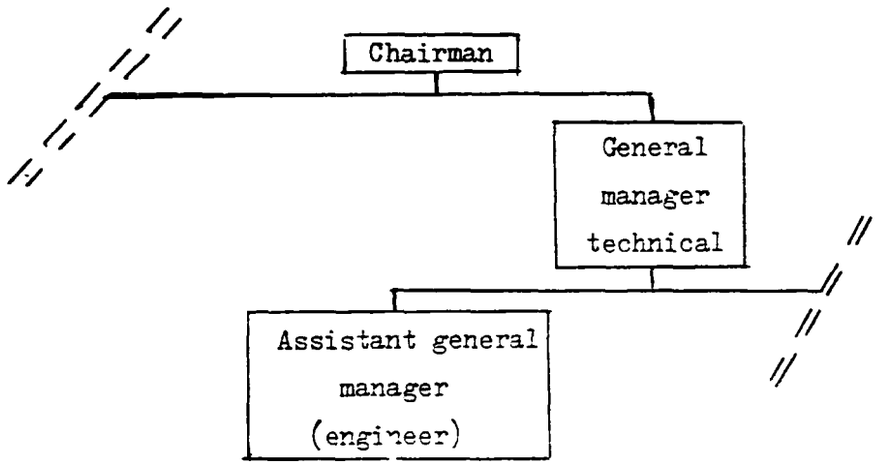


Figure 9. Maintenance organization suitable for large plants (Ravi Rayon, Pakistan PVC, Ittehad Chemicals, Swat Ceramics and Sind Alkalis)



As outlined in the expert's recommendations, the following centre should be established for the whole corporation:



The task of an assistant general manager of FCCCL should comprise the following activities:

(a) To follow up the implementation of the PM scheme designed by the UNIDO expert;

(b) To supervise and control training centres (phase II of project);

(c) To re-examine specifications, review terms and conditions for, and accept delivery of capital investments of large scale (e.g. exceeding $US 10,000) for all units;

(d) To collect and analyse data on maintenance costs;

(e) To plan and co-ordinate the work of experts or consultants assigned by international agencies as part of technical assistance projects.

The assistant general manager should be a bachelor of science in mechanical engineering and have some 15 years of experience as a maintenance chief engineer in one of the units of FCCCL.

Annex II

LUBRICATION PLANNING

A well functioning lubrication plan for plant machinery depends on good organization, classification and systematic record keeping. The following contains some practical aspects to be considered when adopting lubrication planning.

Staff requirement

It is part of the duties of the maintenance engineer to collect technical data and information concerning required lubrication operations for all machines and equipment in use. He should refer to machine operation handbooks, if available, or rely on his own experience if no manuals exist.

A maintenance clerk is responsible for keeping a file of all documents containing technical information with regard to lubrication. He also issues the daily job order(s) to the worker(s), which lists the lubrication work to be done on that day.

The lubrication worker lubricates all machines in his section and keeps his lubricating tools in perfect condition and ready for use. He takes care of the normal daily lubrications as well as of lubrication work required weekly or monthly etc. according to the lubrication cycle.

Elements of lubrication planning

Lubrication instruction cards

As a first step, a lubrication instruction card, as shown in figure 10, has to be prepared for each machine.

Time required for lubrication

After completing the lubrication instruction card, the time necessary to perform the different lubrication operation has to be estimated, making use of the experience of both, maintenance engineer and worker. For the beginning it is recommended to proceed as follows:

(a) Working hours per day - e.g. 8 h;

(b) Effective working hours per day - e.g. 5 h;

(c) Time required for all daily lubrications - e.g. 2 h;

(d) Time left for less frequent (W,M,Q,H or Y) lubrication work - e.g. 3 h.

Figure 10. Lubrication instruction card

Unit.....	Machine	Machine no. [a]	Location [b]
.....	.....	.....	.....

Parts to be lubricated	No.	Type of lubricant [c]	Cycle of lubrication [d]	Method of lubrication [e]	Quantity [f]	Capacity [g] (litres)	Complete change [d]
Gearbox	1	Monoma 82	M	Manually	Fill	6	Y
Motor	1	M.P. E.P.2	H	Grease gun	1 or 2 shots	-	-
etc.							

a/ Do not use the serial number indicated on the machine name plate but the same code number as in the process flow sheet. This number should be pointed on the equipment.

b/ Use either an internal code number or refer to a section number.

c/ Insert either the brand name or use your own code.

d/ Use abbreviations such as: D - daily, W - weekly, M - monthly, Q - quarterly H - half-yearly, Y - yearly.

e/ E.g. grease gun, oil can, manually, splashing etc.

f/ E.g. to be filled, 1 or 2 shots, fill to oil level mark etc.

g/ Indicate the quantity which the container or gearbox can take.

After some time, when the worker is acquainted with his job and can do it faster, he will attend to other minor maintenance jobs in the extra time.

Route for lubrication worker

The most suitable route which the lubrication worker should follow has to be mapped by the maintenance engineer.

Central file for lubrication

For this file loose leafs of hard, pre-punched paper should be used and the table shown in figure 11 should be printed on them.

Classification is according to lubrication cycle (i.e. D, W, M etc Therefore all daily lubrication work has to be identified from the lubrication instruction cards and entered into the first table.

Then proceed with the weekly operations by picking all of them from the lubrication instruction cards, and grouping them so that each group will require a total estimated time of 3 hours. Each of these groups should be given a serial number (W1, W2, W3 etc.).

The same procedure is repeated for monthly, quarterly, half-yearly and yearly lubrication work.

Lubrication calendar

An annual lubrication calendar sheet is to be prepared in the following way (for a model see figure 12): the year is divided in 13 periods (i.e. 13 squares), each period into 4 weeks and each week into 6 working days (Friday holiday). The week starts with a Saturday and ends with a Thursday.

Note that the daily lubrication work, i.e. two hours per day, is not shown on this calendar sheet.

To give an example, it is assumed that the following cycle, which has been taken from the central file, has to be carried out:

W1,	W2,	W3,	W4
M1,	M2,	M3,	M4
Q1,	Q2,	Q3	
H1,	H2,	H3	
Y1,	Y2,	Y3	

In filling in the lubrication plan, attention has to be paid to cover all lubrication work. As shown in the completed calender (figure 13), each day is divided in two parts, one for the date and the other for the job.

A clerk will then issue every day a job order showing all work to be done on that day.

Figure 11. Central lubrication file card

Cycle		Duration.....(h)		Serial.....
Ser. no.	Machine	Machine no.	Part lubricated	Type of lubricant

General considerations

When selecting a lubrication worker from among maintenance personnel, only dependable persons with some experience in the lubrication process should be considered. Several staff members should be tested before assigning the lubrication work to one of them. Also, lubrication workers should get some incentives in order to perform well.

Since the lubrication calendar is prepared once a year, the duration of the cycles should be revised for the next calendar year in the light of previous experience (e.g. it is almost certain that the breakdown time of the machinery will be reduced by at least 30% after the implementation of the lubrication plan).

Additional days free of lubrication work can be used for minor maintenance work. National holidays should be considered when establishing the lubrication on calendar and during annual leave of the lubrication worker his job has to be performed by someone of the maintenance personnel.

The lubrication worker should report to the maintenance foreman any abnormal behaviour (noise, vibration, leak etc.) discovered on any machine he is attending.

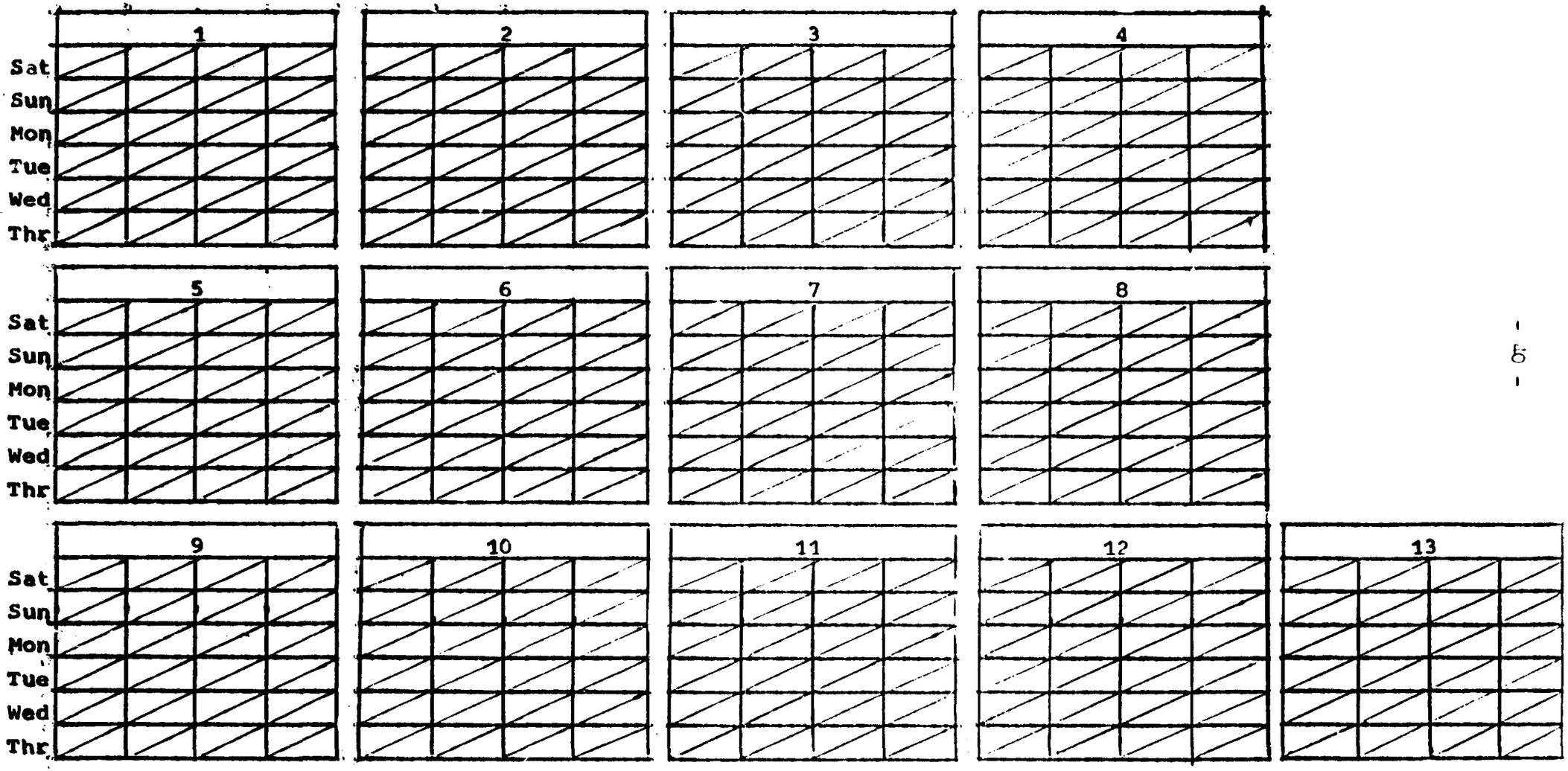
Lubrication control

The daily breakdown record of machines will show the cause of failure. If there is evidence of repetitive breakdowns due to the lack of lubricant or of overheating due to the use of the wrong type of lubricant, consequences have to be taken such as to replace the lubrication worker or to consult with the manufacturers of the lubricant.

Unit: _____

Section: _____

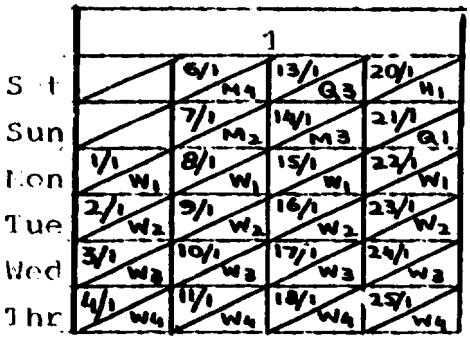
Figure 12. Specimen lubrication calendar

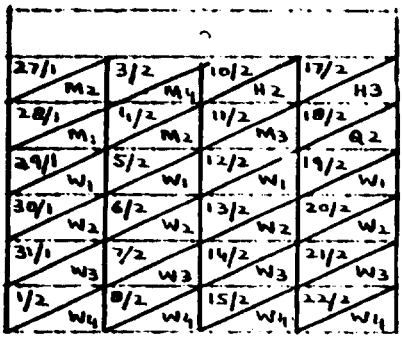


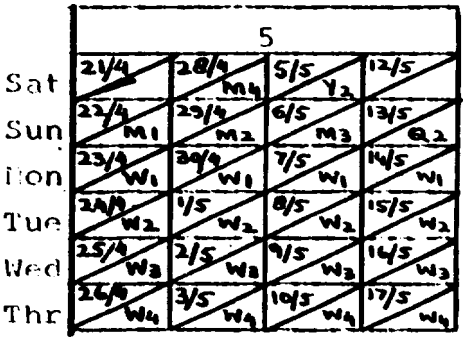
Unit:

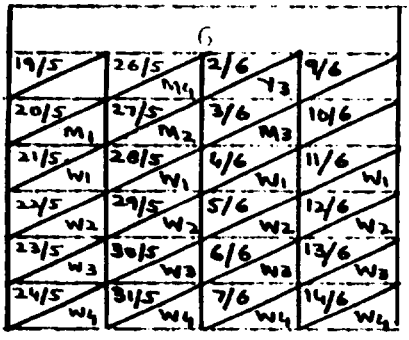
Section:

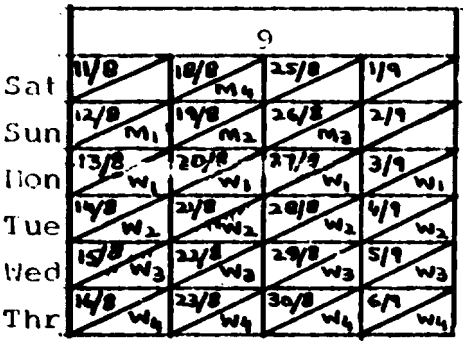
Figure

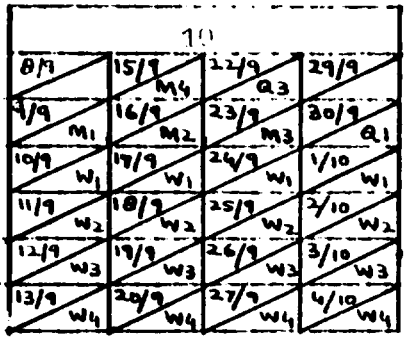




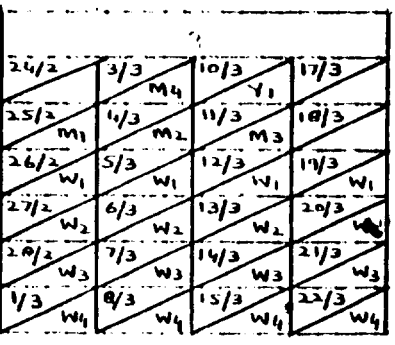


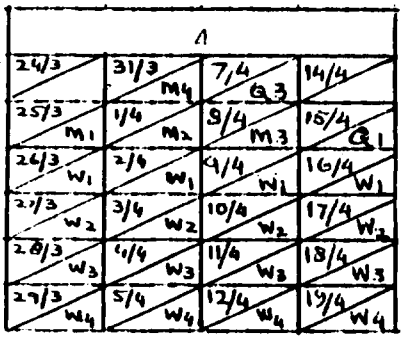


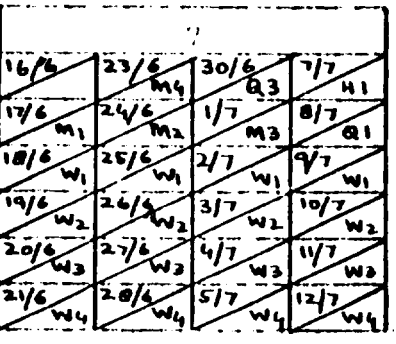


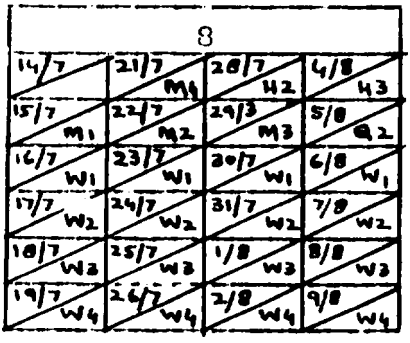


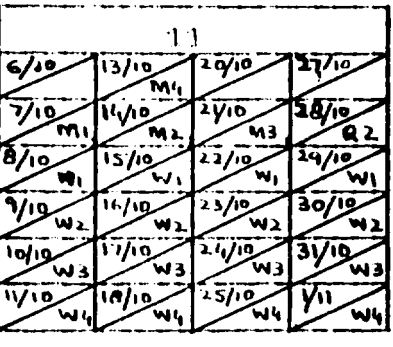
13. Completed lubrication calendar

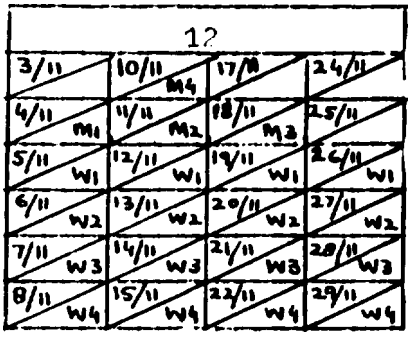


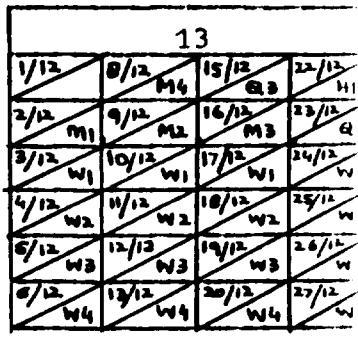












Annex III

DESIGN OF A PREVENTIVE MAINTENANCE SCHEME

The major advantage derived from the introduction of a preventive maintenance programme (PMP) is a reduction in cost to which the following factors contribute:

(a) Reduced production downtime (DT) resulting from fewer machine breakdowns (BD);

(b) Better preservation and increased lifetime of assets, thus avoiding premature replacement of machinery and equipment;

(c) Less overtime and better use of the maintenance workers, who work according to a scheduled, rather than on a crash basis to repair breakdowns;

(d) Fewer large-scale reparis, since major repairs can be avoided by making timely routine repairs;

(e) Reduced repair costs due to early detection of defective parts which often cause damage to other parts of the equipment;

(f) Fewer product rejects and scrap as a result of the better overall condition of the equipment;

(g) Identification of equipment causing excessive maintenance costs which indicates the need for corrective maintenance, operator training, or replacement of obsolescent equipment.

PMP certainly also contributes to improve overall safety conditions.

Design of PMP

As a first step, preliminary master plan of all equipment has to be established for each unit of FCCCL. The maintenance manager should for this purpose prepare a list for each section of the plant indicating all equipment, including the stand-by for each machine. For a model master plan see figure 14. a/

Placing all equipment under PMP is not always the most economical course of action, because some equipment may not warrant the expense of PMP, although the percentage of such equipment is usually very low. In deciding which equipment to place under PMP, the following factors should be considered:

(a) Will a breakdown seriously affect production?

(b) Is there probability of failure that could cause injury or loss of life?

(c) Is the cost of PM for a given equipment greater than the cost of repair following a possible breakdown?

(d) Is breakdown and/or serious damage of a given equipment most unlikely, whether with or without PM?

(e) Will the equipment become obsolete before it is likely to break down?

---

a/ With the assistance of the maintenance staff and production staff, the expert has prepared preliminary master plans for all units, except for Nowshera DDT and Ravi Engineering.

Figure 14. Specimen preliminary master plan of equipment for PMP

Ser. no.	Equipment	Total no.	Stand-by no.	Preventive maintenance		Remarks
				Frequency	Duration	
1.	Caustic soda section					
	1.1 Bucket elevator	1	-	Monthly	8 h	
	1.2 Mixer agitator	1	-	Monthly	4 h	
	1.3 Brine pumps	15	5	Monthly/5	8 h each	Repair pumps in stand-by position, then rotate
	1.4 Chemical pumps	3	1	Monthly/1	8 h each	
	1.5 Slurry pumps	3	1	Monthly/1	8 h each	
	1.6 Mercury pumps	26	2	Monthly/2	24 h each	Arrange with production
	1.7 Chlorine fans	5	1	Monthly/1	16 h each	
	1.8 Hydrogen fans	3	1	Monthly/1	16 h each	
2.	Monomer and polymer section					
	2.1 Acetylene generator	1	-	Monthly	8 h	Production stop
	2.2 Polymerizers	4	-	Weekly/1	6 h	25% production stop
	etc.					

Based on the preliminary master plan, the maintenance manager should, in consultation with the production manager, establish the annual preventive maintenance programme, a specimen of which is given in figure 15. When filling in this form consideration should be given to the date and duration of the annual shut-down for major repairs (if needed), the availability of stand-by or spare machines, the production target for that year, and the seasonal effect on the production plan. The total down-time should not exceed 30 days per year. Maintenance should be planned in a staggered way as can be seen from figure 15, where a triangle has been hatched in the respective week, above which the number of hours required for work is inserted. The final copy of the annual PMP should be submitted to the manager of the factory for approval.

On the 25th of each month the maintenance manager should pick from the annual PMP all equipment to be maintained during the next month and complete the monthly PMP form given in figure 16. In doing this, he should consider the following:

(a) Fridays and national holidays should be cancelled by hatching the column under those days;

(b) Jobs should be staggered along the remaining days of the month, by inserting a triangle for each maintenance day and writing on top of it the time required (in hours);

(c) The manpower needed should be considered in order to minimize overtime.

The monthly PMP has to be approved by the production manager and in case of interference with the production programme the PMP has to be ammended accordingly. After final approval, a copy of the plan should be sent to the factory manager, the production manager, the spare parts engineer and the foremen concerned.

When the annual and monthly PM schedules have been prepared, the maintenance manager or PM engineer should determine exactly what kind of work has to be done when a machine is stopped for maintenance. In this connection he should consult equipment manuals, if available; file of equipment breakdowns; inspection reports file; and any specific requests from the production department. A maintenance job card (see figure 17), listing all jobs to be carried out on a given machine, is handed to the concerned foreman on the 28th of each month.

Figure 15. Specimen annual preventive maintenance programme

UNIT : _____

Year ____

Ser. no.	EQUIPMENT	MONTH												REMARKS
		JAN		FEB		MARCH		.....			DEC.			
1	Ammonia Compressor	8	9	8	9	8	9				8	9		
2.	Brine Pump No. 1	10		10		10					10			
3.	Brine Pump No. 2		10		10		10					10		

MAINTENANCE MANAGER

PRODUCTION MANAGER

FACTORY MANAGER

Figure 16. Specimen monthly preventive maintenance programme

UNIT _____

Month_____ Sheet No._____

Ser. no.	EQUIPMENT	DAYS OF MONTH 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	REMARKS
1.	Air compressor	8	
2.	Centrifuge no.1	12	

MAINTENANCE MANAGER

PRODUCTION MANAGER

Figure 17. Specimen maintenance job card

MAINTENANCE JOB CARD

Equipment _____ No._____

Scheduled data for maintenance_____

Ser. no.	Service required	Manpower		
		Skilled	Semiskilled	Unskilled

Control of PMP

PMP can be controlled in a systematic way with a minimum loss of time and effort. To this end, the system described below should be adopted by the maintenance manager or his PM engineer.

Daily inspection tours

Every day the maintenance manager should make a two round tour in the factory checking the equipment scheduled for maintenance on that day. This will keep maintenance personnel more active on their job. The duration of each tour should be between 1/2 to 1 hour.

Daily down-time report

Every morning the maintenance manager receives the down-time report for the previous day. The information for this report, which can be collected by a technical clerk from the production shift book and the maintenance shift book, should be filled in a simple report form as shown below.

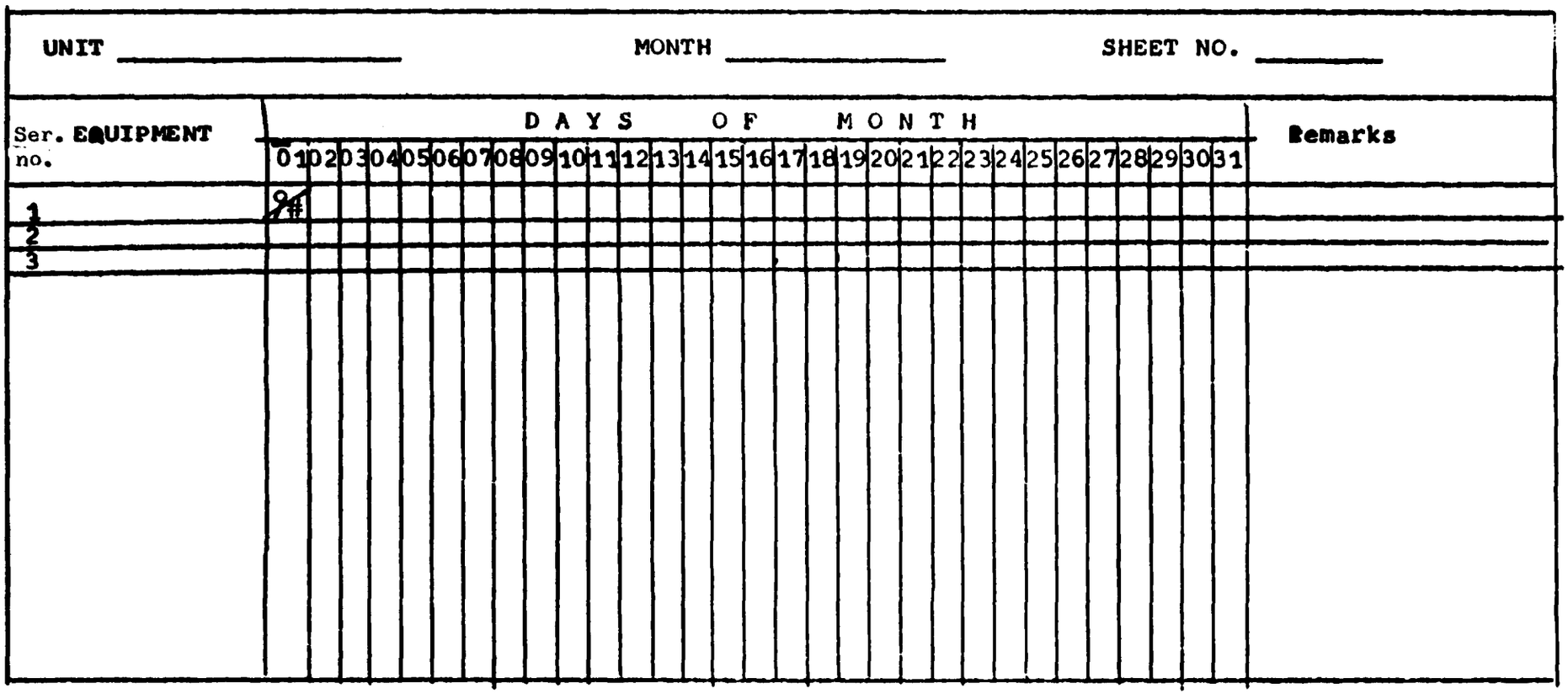
Unit _____ Date _____

Ser. no.	Equipment	Downtime (h)			Reason	Action
		From	To	Total		

The following questions will have to be asked if there is any BD shown on report:

(a) When was the last inspection (for early warning)?

Figure 18, Monthly breakdown report



(b) When took the last scheduled preventive maintenance place?

(c) Has any negligency happened?

If BD has not been caused by negligence, the monthly PMP has to be modified.

Monthly breakdown report

During the fourth week of each month (around the 23rd) a table of breakdowns should be prepared by the PM engineer and submitted to maintenance manager. The information can be taken from the daily down-time reports and should be compiled in a table as shown in figure 18.

In the preparation of that report the following points should be considered:

(a) If the unit is divided into sections or areas, use a separate table for each of them;

(b) Do not record breakdowns of less than one hour;

(c) Each square should be divided into two parts (see figure 18):
o - for recording breakdowns in hours and minutes
- for recording the cause of the breakdown;

(d) Use abbreviations for indicating the main cause of failure, such as:

Oil leak	OL
Element breakage	EB
Excessive vibration	EV
Material leak	ML
Electric fault	EF
Instrument fault	IF
Corrosion	C
Overheating	OH
Normal wear	NW

(e) Record the actual time and day for planned maintenance, it should be differentiated from unplanned repairs by giving the planned green colour and unplanned red colour ink.

Any BD of more than four hours should be investigated carefully and a separate report should be written by the supervisors concerned. A file containing such reports should be opened for all critical equipment. Equipment BD files will be a major guidance for the PM engineer when preparing the maintenance job card for the monthly PM.

Weekly meeting of maintenance engineers

A weekly meeting, of two to three hours, of all maintenance engineers and supervisors, presided by the maintenance manager, should be held to discuss all aspects of PMP. Standard items on the agenda of the meeting should be needed modifications of PMP, spare parts and manpower for PMP, revision of worksheet to follow-up the last agreed worksheet, inspection and BD reports for short- and long-term action and revision of the latest worksheet (see model) in the light of the result of the meeting.

Worksheet

Date of meeting _____ No. _____

Ser. no.	Work to be done	Person concerned	Date of completion

Analysis of BD data

The analysis of the data given in the monthly BD report should facilitate corrective maintenance. To this end the maintenance manager and the PM engineer should group BD by cause of failure. If it is noticed, for example, that a bearing of a machine has to be changed every three weeks, and an investigation of the problem shows that misalignment of the shaft was causing the bearing failure, the shaft alignment can be adjusted and the bearing problem will most likely disappear. It is recommended to make this analysis every month as long as PMP is in an initial stage. After one year of PMP application it will no longer be necessary to analyse the data more often than every six months.

The frequency of BD and the average duration of BD should be established for each machine on a quarterly basis. The maintenance manager of the PM engineer will calculate the average duration of BD in hours as follows:

$$d_{av} = \frac{TBD - (d_h + d_l)}{N}$$

Where d_h = highest (longest) experienced breakdown, in hours

d_e = lowest (shortest) experienced breakdown, in hours

TBD = total breakdowns experienced, in hours

N = number of machine stops

The corrected average duration (in hours) is obtained in the following way:

$$d_{avc} = \frac{d_h + 4 \times d_{av} + d_l}{6}$$

The corrected average duration of BD per month is therefore:

$$d_{avc} = \frac{N \times d_{avc}}{3}$$

and the average frequency (F) of breakdowns per month is:

$$F_{BD} = \frac{N}{3}$$

Calculate the planned duration (d) and frequency (F) of PM provided for in the annual PMP on a monthly basis, and fill the data into the following table for comparison:

Ser. no.	Equipment	Planned		Experienced	
		F	d	F_{BD}	d_{avc}

Results of the above comparison will lead to either reduction or increase of duration of PM and reduction or increase of frequency of PM.

A continuous adjustment of PMP and the application of corrective maintenance will lead to an almost perfect estimate of PM time. It will, however, take about two years to reach this stage.

In the following two examples for PMP adjustment are given

(a) Estimated frequency and duration of PM was too low;

Result obtained from analysis

Equipment	Planned		Experienced	
	F	d	F_{BD}	d_{avc}
Brine pump	1 per m	8 h	2 per m	6 h

Adjustment made

Equipment	Planned	
	F	d
Brine pump	every 3 W	8 h

(b) Estimated frequency and duration of PM was too high

Result obtained from analysis

Equipment	Planned		Experienced	
	F	d	F_{BD}	d'_{avc}
Air compressor	1 per m	12 h	$\frac{1}{3}$ per m	2

Adjustment made

Equipment	Planned	
	F	d
	every 2 m	8 h

Finally, once a year, one month before the beginning of the major repair programme, the PM engineer should calculate from the BD tables of the last 11 months the following percentage for each piece of equipment:

$$\frac{\sum \text{BD time (h)} + \sum \text{PMP time (h)}}{\sum \text{Working time (h)}} \times 100$$

If the resulting figure exceeds 75%, that equipment should be scheduled for total replacement; if the figure exceeds 40%, the machine or equipment in question should be planned for major repair. These limits are, of course, only guidelines and can be modified, depending mainly on the experience of the maintenance manager.

Annex IV

MAINTENANCE INSPECTION PLANNING

A proper inspection plan and its regular execution will provide the PM engineer with all necessary information about the condition of the equipment and supply him with the necessary data for filling in the maintenance job cards (see annex III). The following scheme is recommended for inspection planning.

Manpower

Each unit should have one inspector. The selection of this inspector is important for the success of PMP. Usually the inspector is selected from among the craftsmen in the maintenance department. Although the inspector will normally not be required to perform repairs himself - he may occasionally make some minor adjustments - he should be able to perform them and have some trouble-shooting experience, since this will qualify him to detect and diagnose defects more rapidly.

It is recommended to rotate the job of maintenance inspector as a means of upgrading the craftsmen involved. In this way the maintenance inspectors will keep a fresh viewpoint and at the same time will preserve their skills in performing maintenance work. Also, in the case of absence of an inspector, he can be replaced by another one and the inspection plan can be carried out without interruption. Finally, it is also advantageous for all maintenance staff to be eventually trained to be able to function as competent inspectors.

Design of inspection system

A workable inspection system for plant machinery depends on good classification and record keeping. The steps described below should be taken in order to achieve a good result.

Maintenance inspection card

The PM engineer will start to prepare a maintenance inspection card (see model in figure 19) for each piece of equipment in the plant, containing the following information:

(a) Machine number - it is preferable to use the unit's own code number (the same as in the lubrication instruction card) and not the serial number indicated on the machine name plate;

Figure 19. Maintenance inspection card

Unit PVC — Card no. _____

Section Caustic soda — Machine (e.g.) Brine pump — Machine no. 01/010/000

Ser. no.	Part to be inspected	Quantity	Action required	Frequency	Method of inspection
1	Bearings	2	a. Check temperature	W	Thermometer
			b. Check sound	W	Soundmeter
2	Glands	1	a. Check leak	W	Visual
3	Motor	1	a. Check amperage	M	Amperemeter
			b. Check earth	M	Visual
	.		.	.	.
	.		.	.	.
	.		.	.	.
	.		.	.	.

(b) Part to be inspected - list only major parts which are considered critical, and leave space for later additions. With increasing experience, parts may have to be added and others cancelled. Use also the back of the card;

(c) Action required - investigation of each part of the machine, information contained in vendor's manuals plus the concerned supervisor's experience, will furnish the preliminary data for the type of checks needed;

(d) The frequency of inspection is determined by the frequency of failing of that part. If, for example, the hydraulic pump is expected to run trouble-free for eight months, it should be inspected every six months, provided that the trouble-free period cannot be extended. Frequencies will have to be corrected on a continuous basis and in order to avoid over-inspection, the PM engineer should, after examination of the daily inspection reports, decide whether it is advisable to increase the intervals, thus contributing to a reduction of the inspection costs;

(e) Method of inspection - either visual, aural etc. or by using measuring instruments.

Inspector's route map

A map should be prepared, showing the shortest route for inspection of all machines (by number) to be inspected on a given day. In the beginning the PM engineer should accompany the inspector to explain the map and to verify the time required for the inspection of each machine.

Central inspection file

A central file for inspection, similar to that for lubrication (annex III), should be opened by collecting the central inspection file cards (see figure 20) which should be filled in in the following way:

(a) Prepare a list of all jobs contained in the maintenance inspection cards, grouped according to their frequency (i.e. all W, F or M jobs together);

(b) Estimate the time required for each job or take the actual time with a stop watch. Inscribe the time needed on the list, next to each job;

(c) Put the daily jobs on the first card(s) of the central file; indicate the total time needed to finish these jobs at the bottom. It is assumed that the total time will not exceed one hour per inspector in all units;

(d) After deduction of one hour for daily inspection from the effective number of working hours per day (5 hours) we are left with four working hours per day per inspector. Therefore, all weekly, monthly etc. inspection work is divided into lots which will consume about four hours each and are then numbered in a series. If, for example, the total time required for all weekly inspection jobs is 12 hours, this can be divided into three lots of four hours each and be assigned the numbers W1 W2 and W3. Repeat the same procedure for jobs with F, M, Q, H and Y frequency;

(e) File the cards in the central file beginning with the daily jobs and ending with the yearly ones.

Figure 20. Central inspection file card

Frequency W Duration 3 h Frequency no. W1

Ser. no.	Machine	Machine no.	Part to be inspected	Activity	Method of inspection
1	Brine pump	01/010	Bearing	Check temperature Check sound	Thermometer Soundmeter
2	Compressor	02/011	Foundation bolt	Check looseness Check vibration	Visual Vibration meter

Inspection calendar

The annual inspection plan or calendar is prepared in the same way as the lubrication plan (see figure 12). From the central cards the information is inserted into the boxes of the calendar, beginning with all weekly, then fortnightly, monthly etc. inspection jobs. Daily work should not be included in the plan and national holidays as well as the period of planned annual shut-down for major repair should be kept free. On days for which no work is planned in the calendar, the inspector can take care of minor repairs or of the calibration of his instruments.

Daily inspection report

Part of the time scheduled for carrying out the daily inspection work (about one half hour) should be reserved to write the inspection report covering all equipment inspected on that day. The inspector will submit this report to the PM engineer on a form as shown below.

INSPECTION REPORT

Name of inspector _____ Date _____

Machine name	Machine no.	Part inspected	Condition

In case of emergency, the PM engineer can take immediate action, or in less urgent cases information contained in the inspection reports will be considered during the revision of jobs to be put on the maintenance job card for the monthly PMP.

Annex V

SPARE PARTS CONTROL

To improve maintenance and to minimize breakdown time, it is important to have the correct spare parts available at the proper time. This can be achieved by introducing a spare parts control scheme along the lines described below.

Organization and staff requirement

For a spare part section, which should come under the maintenance manager, the following personnel is required:

(a) Mechanical engineer for spare parts and inventory, with at least five years experience;

(b) Two to four draftsmen, depending on the size of the unit;

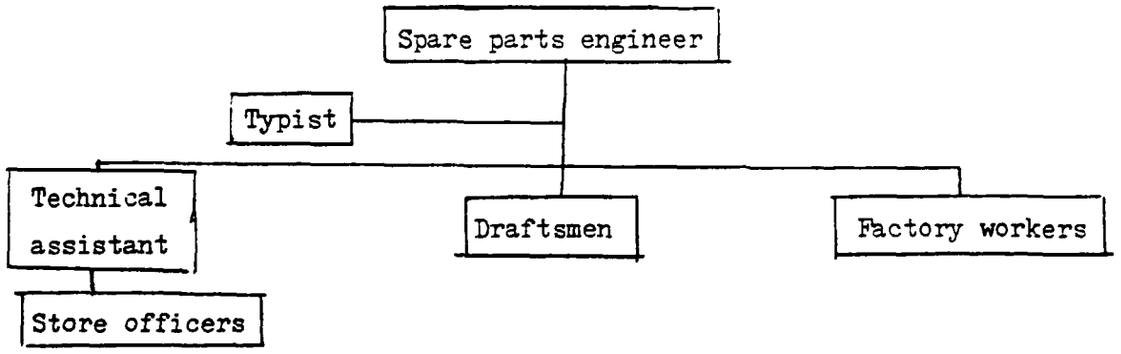
(c) A technical assistant, with a diploma in mechanical technology;

(d) Two store officers;

(e) A typist.

The organigram of the section is given in figure 21.

Figure 21. Organigram of spare part control section



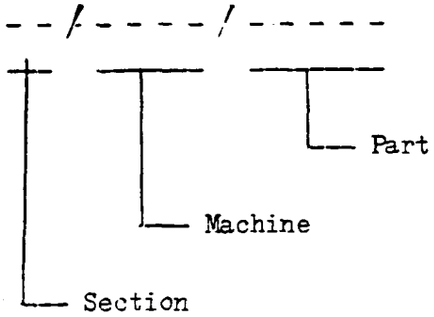
The drawing office will have to be equipped with drawing boards, measuring instruments and tools, drawings cabinets, handbooks and international standards and a copying machine.

Design of work system

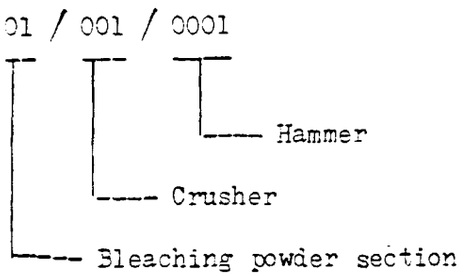
Preparing, coding and filing of drawings

Drawings of machine assemblies and non-standard parts will be prepared in the drawing office by referring to available catalogues or by taking the actual measurements of parts if they are on stock or when the machine is disassembled for a planned major repair. All changes and modifications carried out on a given machine during its life should be incorporated in the original drawing.

The drawings should have code numbers for easy reference. The following serial coding system can be used:



e.g.



According to this system, drawing 01/000/0000 shows the general layout of the bleaching powder section, drawing 01/001/0000 is the assembly drawing of the crusher and drawing 01/001/0001 is a detailed drawing of the hammer of the crusher in the bleaching powder section.

An index book for drawings of all sections will be maintained up-to-date for reference purposes. Files of all drawings, as well as of hand-books, international specifications of machine catalogues etc. should be maintained.

The engineer assisted by his team of draftsmen will perform the above work on a long-term basis.

Spare part cards

First and equipment specification card as shown in figure 22 and a list of spare parts for each machine (see spare parts card, figure 23) have to be prepared. Then standard parts are picked from the spare parts lists and grouped in consolidated lists (see figure 24). The engineer with the assistance of the technical assistant will perform above functions on a long-term basis.

Figure 22. Equipment specification card

Section _____ Supplier's name _____

Equipment name _____ Date of supply _____

Equipment code no. _____ Date of first operation _____

Description

1. Drive

_____

_____

2. Specification and capacity

_____

_____

3. Accessories

_____

_____

4. Depreciation life

_____

5. Original price

_____

6. Cost of working hour

_____

Figure 23. Spare parts card

Equipment name _____

Equipment code no. _____ Ser. no. _____

Supplier's item no.	Code/drawing no.	Description	Quantity on stock	Standard or non-standard	Annual requirement

Figure 24. Standard parts card

STANDARD GROUP (e.g. V-belts) Ser. no. _____

Standard number	Description	Code no.	Quantity on stock	Annual requirement

Non-standard spare parts manufacturing

Non-standard spares will either be manufactured in the factory's workshop, in local workshops or imported. For a more efficient procurement of spares, the responsible engineer should prepare the following two lists:

(a) A list of all local workshops, with indication of their facilities and capability to fulfill spare part orders. He should plan for regular visits to these workshops to follow-up on company's orders and to give technical assistance in the execution of the work. He should also survey new local manufacturing facilities and add them to the list of local manufacturers if they were found to be acceptable

(b) A list of all foreign manufacturers for all factory equipment.

This should enable him to advise the purchase department on suitable companies for the manufacture or supply of spares and to approve the best quotations. A further duty of the engineer should be to supply the purchase department with detailed drawings of spare parts.

Inventory control

If we want to describe what a stock is, we can say that:

(a) It consists of physical parts the cost of which is known;

(b) It needs a lot of capital investment which must show some sort of return;

(c) It has to be housed, maintained and regularly inspected with a good deal of skill;

(d) It performs a definite service to the organization.

One of the most important duties of the spare parts engineer is the control and organization of stock movement, i.e. of both, input and output. Too little thought and skill is usually devoted to these duties and the spare parts engineer is therefore advised to check what really happens in his organization as regards stock, stock control and the usual yearly inventory.

What is the function of a stock? In its simplest form the stock balances supply and demand. If the output is exactly equal to the input, regular and without variation, the stock has to cover only the period of delivery.

We know, however, that both the supply and demand usually are irregular and therefore spare parts over and above the quantity required for the period of delivery have to be stored to ensure proper maintenance of the equipment at all time.

There are two systems of storage and control:

(a) The two-bin system, by which material is stored in two separate bins - one for use and the other for stock. When the material in the first bin is exhausted, issue is made from the second bin and an order is immediately placed to replenish the stock. Of course there is no need for physical separation of the parts in two bins; a single bin would do just as well if a marker is placed in the bin to indicate when the predetermined level for ordering is reached. Another possibility is the use of a bin card where issues and stock are recorded. The bin card is reviewed regularly and a replenishment order is placed when the stock has reached a predetermined low level. The quantity to be ordered should also in every case be fixed in advance;

(b) The periodic order system, which is most widely used, by which stocks are regularly reviewed, e.g. weekly, monthly, quarterly or even yearly, depending on the usage of the stock. In some cases groups of similar material or components are reviewed together, but normally we would expect that the period is set for each item separately. The shorter the interval between reviews, the less danger there is of fluctuation in demand or supply. In fact it may be possible to do away altogether with the safety or buffer stock. Moreover, if the requirement is known with almost certainty, the maximum stock would be the stock necessary for the particular period.

The periodic order system is easier to install than the bin system since no reorder points for each item have to be set. Also, a reduction in stock holding can be expected with this system, but the cost of ordering would be increased.

Breakdown of inventory

Both systems of inventory control described above, as well as combinations of them merely tell us when to restock and how much to order but not what is the most economical inventory investment. For this purpose the relation between item usage in pieces and item usage in terms of money has to be established. If the cost of the total annual requirement is calculated for each item and the items are listed in descending order according to their total cost in a table similar to the one shown below, it will be noted that a relatively small percentage of pieces used usually accounts for the biggest percentage of the value of the inventory.

Item	Code no.	Cost per piece	Annual requirement (pieces)	Annual cost	Class	Percentage of total pieces
					A	20
					B	25
					C	55

If the inventory is broken down into classes of items according to their total annual cost, the result will be a marked distinction between the classes. As an example, the actual classification of a company inventory is given below.

Inventory class	No. of pieces used	Percentage of total pieces used	Total annual value	Percentage of total annual value
A	184	4.0	827,398	46.8
B	1 196	26.0	760,201	42.9
C	3 182	70.0	184,446	10.3

It can be concluded that:

(a) Since class A contains few items and most of the value, these items should be ordered at short intervals to increase the turnover and thus reducing the money tied up in the inventory;

(b) Since class A contains few stock items and at the same time represents a large value, we can afford to control these parts closely. For example, we can wait to the last moment to order or to produce such parts, this way reducing storage and lead time. We can also afford to spend a little more on expediting these items. If items are purchased, we can specify delivery at the date the part will be required and not ahead of time;

(c) The purchase department can be instructed to concentrate on items of class A. A 10% price reduction for an A item is better than a reduction of 50% for a C item;

(d) A detailed record should be maintained of all items of class A. An example (card form) is given in figure 25;

(e) If class A items are manufactured in the factory's own workshop, they should also receive careful technical attention in order to reduce the cost for their production;

(f) For C items the controls can be relaxed. In some companies stock record cards are eliminated and only skeleton record cards are kept for annual re-ordering. A two-bin system would also be suitable for C items. With the small investment involved in C items, we can be more liberal with the quantity kept in the bins thus taking care of contingencies and fluctuations;

(g) Re-ordering of C items will be infrequent (once or twice a year). B items could be ordered on a quarterly basis.

Most of the units follow a policy of equal treatment of all items in the inventory which is expensive. The distribution-by-value method does spotlight on which items efforts should be concentrated to reduce the cost by better

Figure 25. Example of detailed inventory for items of class A

Part name _____ Minimum level _____

Order level _____

Code number _____ Maximum level _____

Date of receipt	Supplier	Unit	Price/unit	Quantity received	Date of issue	Quantity issued	Balance

purchasing or cheaper production. It shows also where to put emphasis in spare part inventory control and how often orders should be placed.

It is essential, however, that a periodic review of the system be carried out, as items tend to shift from one class to the other.

Annex VI

MAINTENANCE COST BUDGETING

A budget is a financial plan representing the management's best estimate of expenditures for a definite future period. It should reflect actual plans and should be based on actual expectations rather than on educated guesses as to what is likely to happen. Improved planning as a result of budgeting will occur only if future operations are carefully thought through and if the budget figures represent the anticipated result of actual plans for future operations. A well-prepared budget can become an effective control instrument in as much as reports comparing actual performance to budget allowance provide a basis for corrective action.

As production increases and decreases, the operating budget should reflect these changes. It must be understood, however, that even though production may not attain the planned volume, maintenance at times has to continue at a fairly high rate. The maintenance budget, therefore, must be so devised that it fluctuates with the income and that sufficient funds are provided at lower production rates to permit the performance of the maintenance required to keep the plant in such condition that it will adequately meet the demands of production.

Establishment of maintenance cost budget

To establish a maintenance cost budget, the maintenance manager or chief engineer has to collect the necessary data from the annual PM plan and estimate the cost for each budget item. Budget items should be coded in agreement with the finance department to cope with the unit's whole budget. A model maintenance cost budge is given in figure 26 which can be used for all units. It lists the following items:

(a) Salaries, including all insurances (pension, social, health etc.) required by existing laws;

(b) Total cost of materials, including direct (i.e. material required for a particular task) and indirect materials;

(c) Other costs, such as repairs which have to be done in outside workshops and any other expenditures which do not come under budget items 1 or 2;

(d) Projects, which include major repairs that do not occur regularly, or total replacement programmes such as the rebuilding of an overhead conveyor system. Such project work is usually be accomplished during shut down.

Figure 26. Model maintenance budget

Unit _____

Year _____

Budget item no.	Description	Cost allocation	Description	JAN L	JAN F	FEB L	FEB F	MAR L	MAR F	APR L	APR F	MAY L	MAY F	JUN L	JUN F	JUL L	JUL F	AUG L	AUG F	SEP L	SEP F	OCT L	OCT F	NOV L	NOV F	DEC L	DEC F	TOTAL L	TOTAL F
1	Salaries (inclusive)	01	Permanent workers																										
		02	Short-term workers																										
		03	Overtime																										
		04	Overhead																										
			TOTAL																										
2	Material	01	Direct																										
		02	Indirect																										
			TOTAL																										
3	Others	01	Repairs done outside unit																										
		02	.....																										
		03	.....																										
			TOTAL																										
4	Projects	01	Engineering studies																										
		02	Procurement																										
		03	Contractors																										
			TOTAL																										
			GRAND TOTAL																										

Key: L - local currency
F - foreign currency

Control of maintenance budget cost

The maintenance manager will require from the finance department a monthly report as shown in figure 27, containing all budget items, planned and actual, and the budget variance. This report will permit the manager to determine whether performance is progressing satisfactorily or whether corrective action has to be taken before the end of the budget year.

Underspending will be reported as well as overspending, which is usually based on a 5 or 10 per cent variation. Budget variance will be investigated and explanations have to be found for both, underspending (e.g. due to deferred maintenance) and overspending (e.g. because of unforeseen breakdowns) and when needed action can be taken immediately.

Figure 27. Model budget variance report

Date		Department				
Monthly costs				Cummulative costs		
Budget item	Cost allocation	Budgeted	Actual	Budgeted	Actual	Variance

Maintenance cost index

The most important indicator for maintenance cost is its ratio to the sales value. The average expenditure for maintenance for all industry is 5 per cent of the sales; however, this percentage varies considerably depending on the type of industry. The percentages listed below for the chemical and pharmaceutical industry can be used as a guide for FCCCL units.

Industry	Number of firms represented	Five-year average (percentage)	Range by plant per year (percentage) Highest	Lowest
Chemical	6	6.8	10.5	2.4
Pharmaceutical	6	1.9	3.4	0.6

Annex VII

SAFETY RULES FOR DIFFERENT TYPES OF HAZARDS

Fire

Fire hazards can be minimized by introducing a good fire-fighting system. The following are the main elements for establishing such a system.

Personnel

A fire brigade is essential in each factory. For FCCCL's units it is recommended to have the following personnel for each:

(a) One safety officer who will organize and train the fire brigade;

(b) Four to eight full-time firemen;

(c) At least twelve to sixteen part-time workers, trained on the fire fighting system. They should be chosen from different sections and distributed over the three shifts. In emergency case they may join the firemen team.

Facilities

Fire-fighting facilities will depend mainly on type of fire which could break out. The following equipment is required for the various types of fire hazard:

(a) Normal fire (e.g. in offices, residentials etc.) - This can be extinguished by having an independent pipe network of water supply with a pressure of not less than 12 kg/cm^2 at outlets. The distribution of outlets on the whole area should be such that each outlet covers a circular area of 40 meters diameter. Fire-fighting hoses with reels could be either on mobile units or fixed at water outlet locations. Hoses should have a minimum length of 20 m, be equipped with a jet discharge device and the test pressure should be 21 kg/cm^2. The same network will be used for cooling purposes of surroundings when other types of fire hazard exist;

(b) Fire due to electric defects - This type can be extinguished by carbon dioxide (CO_2) extinguishers of adequate capacity, installed at control rooms, power generation rooms etc. Bottles must be equipped with calibrated springs enclosed in a sealed box with an indicator;

(c) Flammable fire - This is the most dangerous type of fire and for its extinction foam-extinguisher bottles could be installed near the equipment concerned. Another possibility is to provide a foam-premixer unit which is connected to foam loops to feed a number of fixed outlets. Foam monitors are connected to the outlets to cover an area of 400 m^2.

General alarm system

The alarm system should provide the possibility of signalling to the firemen alarms from the plant site, so that the necessary action can be taken. It should consist of:

(a) Push bottons covered by glass (rupture type), located at a visible place at section corners. These push buttons are cable-connected to the main safety alarm panel at the safety office;

(b) A safety alarm panel of the optic and acoustic type, with a shut-down switch for the electric supply.

General fire detection system

There are different types of detectors, such as smoke detectors, fire detectors and explosive mixture detectors. A detection system can give an early warning of any type of fire hazard. Detectors are connected to the general alarm system and located at the concerned areas.

Periodical tests

The following tests should be carried out at regular intervals as indicated below:

(a) CO_2 extinguishers monthly;

(b) Foam extinguishers as per manufacturer's instruction; do not forget to refill them;

(c) Fire fighting hoses every six months;

(d) Earthing system every six months;

(e) Once a year a fire drill involving all fire-fighting personnel and facilities should be organized and the time required recorded for future guidance.

Work permit for dangerous areas

In case of necessity to use torch or electric welding in an area subjected to flammable gases, a work permit should be issued by the maintenance engineer and approved by the safety officer before starting that job. The safety officer should take all possible precautions before the work starts such as using abestos blankets, ensuring continous water supply etc. and a fireman with a portable gas detector should be at the site all the time as long as that type of work is being carried out.

Toxic gases and vapours

Equipment working on toxic gases should be tightly sealed to prevent any leaks. To minimize accidents due to this hazard, a gas-control operator, equipped with a portable gas detector, should daily check all possible areas of gas leak such as flanges, pumps etc. and measure the percentage of gas contained in the air. A daily report on his findings should be submitted to the safety officer. Ultimately the safety officer will inform the maintenance engineer of any leaks detected.

In case of maintenance work in one of these components, a safety work permit should be issued by the maintenance engineer and approved by the safety officer before starting the job. A plan outlining the work procedure should be designed by the maintenance engineer and safety officer and the safety officer as well as the gas-control operator should be at the site during the work. Maintenance personnel shall be provided with gas masks to prevent any accident. Finally a re-test for any leak in the repaired area has to be performed by the gas-control operator.

Dust

Workers subjected to a dusty atmosphere in factories such as the elutriation plant and the PVC unit, should be protected against damage which the dust may cause to their lungs. Dust particles of a size of less than 1 micron enter the alveoli cells causing death after a period of 15 to 20 years. The most dangerous dust particles are the silica particles since they do not dissolve in the body and cause silicosis disease.

Preventive action should be taken by:

(a) Using nose covers made from synthetic sponge;

(b) Providing good ventilation with dust scrubbers;

(c) Urging workers in these areas to take annual leave of two consecutive weeks;

(d) Arranging medical check-ups for all workers every six months, including X-ray tests.

Accidents due to machinery

Different types of accidents are caused by machines. In general, the maintenance engineer should follow the following rules to prevent such accidents.

All rotating elements such as couplings, shafts, pulleys, V-belts, belt conveyors etc. should be shielded with a metallic cover with the following design considerations:

(a) Protective covers should be properly bolted to a fixed element;

(b) They should not prevent the operator from clearly seeing the protected moving elements, whether rotating or in idle position;

(c) Covers should have hinged gates to facilitate lubrication.

When maintenance job starts on a machine the following precautions should be followed:

(a) Disconnect the machine to be serviced from the electric supply. The electrician should take out the fuses and the maintenance worker should keep them in custody;

(b) Hang a caution plate announcing that machine is under maintenance on the main push button of the machine;

(c) Collect and check all necessary tools before and after the maintenance job;

(d) Refix the safety shield properly before starting the machine;

(e) Clean the area around the machine from grease, oil etc.;

(f) Test-run the machine for one to two minutes before handing it over to the production operator;

(g) Electricians should wear rubber shoes and use insulated tools before starting any maintenance job.

Chemicals

Acids and alkalis are the major types of chemicals which cause severe damage to the human skin. Since acids and alkalis have the property of absorbing water, they cause a burning effect as soon as they come into touch with the human body.

The necessary precautions for the workers dealing with such chemicals are to:

(a) Wear rubber gloves with long sleeves to protect hand and arm;

(b) Wear rubber boots with long neck to protect foot and leg;

(c) Wear rubber apparel to protect front surface of body;

(d) Wear colourless glasses to protect the eyes, specially when the chemical flow is under pressure;

(e) Maintenance workers should flush the equipment to be maintained with water before starting the work and make sure that the inlet and outlet of the flow are properly sealed;

(f) Provide an eye-washer and showers near the area with chemical hazards.

Heat

In units having kilns or furnaces such as the ceramics factory, the effect of heat on the human body can cause exhaustion and unconsciousness.

Heat hazards should be prevented by the following measures:

(a) Wear asbestos suit to prevent burning effect on skin;

(b) Wear asbestos helmets with glasses to protect the eyes and the head;

(c) Take salt tablets regularly during the working day to preserve the water in the body;

(d) When performing a maintenance job in a hot area, install a mobile cooling fan;

(e) Do not allow workers in that area to drink very cold water;

(f) Provide shoes with wooden soles for workers who have to walk on hot surfaces.

Safety aids

To increase the safety consciousness of the workers, posters showing different types of accidents and thus warning the workers of what might happen due to a breach of safety rules should be posted in visible places such as corridors, factory halls etc. The posters should have a size of at least 100 x 50 cm and preferably bright colours should be used to attract the attention of workers. The safety officer has to change them at least once a year to overcome monotony and to keep workers always conscious about safety.

Other duties of the safety officer

The safety officer should arrange a meeting with the managers of all departments on a monthly basis. Starting from a list of all accidents which occurred during the previous month, the necessary actions to be taken in each department should be discussed.

Every six months the safety officer should submit to the factory manager a report on all types of accidents occurred during the period in question and showing the trend of each type of hazard as well as the man-days lost in each month (for a model see figure 28). Immediate action against hazards tending to increase should be taken by following the afore-mentioned safety rules.

The safety officer should also establish a regular training programme for all workers to increase their safety consciousness and he should have the authority to impose a penalty on any worker who does not follow safety instructions.

Figure 28. Model accident report

Unit .....

Absenteeism (man-days)

Cause of accident	Oct.78	Nov.78	Dec.78	Jan.79	Feb.79	March.79	Total no.
Medicine							
Transport							
Electric							
Manual tools							
Dropping							
Gas or vapour							
Chemicals							
Burning							
Dust							
Crush							
Exhaust							
Other reasons							
Head accidents							
Eye accidents							
Foot accidents							
Hand accidents							
Contagious disease							
Total man-days lost (Rs)							
Total loss in production (Rs)							

Annex VIII

NATIONAL COUNTERPART STAFF

Name	Position	Period of time
Mushtaq Ahmed	General Technical Manager FCCCL	18 June to 5 July 1979
A. M. Shera	Maintenance Manager attached to FCCCL	21 April to 6 September 1979
Tanwirus Saqlain	Maintenance Manager Ittehad Chemicals	1 May to 1 June 1979
S. M. Shafi	Production Manager Pakistan PVC	25 May to 5 July 1979
Shakil Ahmed	Maintenance Manager Ittehad Pesticides	6 August to 20 August 1979

Annex IX

VISITS TO FACTORIES

Factory	Place	Time
Pakistan PVC	Karachi	8 to 14 May
Sind Alkalis	Karachi	15 to 22 May
CTA Meeting	Islamabad	23 to 25 May
Ittehad Chemicals	Lahore	26 May to 1 June
PITAC [a]	Lahore	2 to 3 June
Ittehad Pesticides	Lahore	4 to 9 June
Ravi Rayon	Lahore	10 to 17 June
Ravi Engineering	Lahore	18 June
Ravi Rayon	Lahore	19 to 20 June
Ittehad Chemicals	Lahore	21 to 22 June
Kurram Chemicals	Rawalpindi	23 to 24 June
Swat Ceramics	Shaidu	25 to 26 June
Nowshera DDT	Nowshera	27 June
Swat Elutriation	Mingora	28 June to 1 July
Antibiotics (Private) Ltd.	Daudkhel	2 to 3 July
Pakdyes and Chemicals	Daudkhel	4 to 5 July
NCRD [a]	Rawalpindi	6 to 8 July

a/ At the request of the Senior Industrial Field Adviser.

Annex X

DRAFT PROJECT DOCUMENT FOR PHASE II

United Nations Development Programme

Project of the Government of Pakistan

Project data sheet

Title: Assistance in Design of Preventive Maintenance Practice for Federal Chemical and Ceramics Corporation Limited - Phase-II

Number: DP/PAK/xx/xxx Duration: Twelve months

Sector: Industry

Sub-sector: Establishment and expansion of industries

Government co-operating agency: Federal Chemical and Ceramics Corporation Ltd. through the Ministry of Production

Executing agency: United Nations Industrial Development Organization (UNIDO)

Date of submission: Starting date: July 1991

Government contribution: Rs 700,000 UNDP/UNIDO contribution: $US 200,500

Approved:

on behalf of UNIDO Date

on behalf of UNDP Date

I. BACKGROUND AND JUSTIFICATION

In its development plans, the Government has placed emphasis on the expansion of the chemical industry. The need has therefore become evident for the development of the chemical industry controlled by the Federal Chemical and Ceramics Corporation Limited (FCCCL) established in 1972 under the Economic Reforms Order through the Ministry of Production.

FCCCL which owns 12 operating units and one new unit (under construction) and manufactures a variety of products ranging from general chemicals through pharmaceuticals and plastics to man-made fibres, strongly considered to maximize its productivity through better maintenance management as well as improved preventive maintenance systems.

A report on introducing a preventive maintenance scheme including expertise was prepared by a UNIDO mission in November 1975 (TS/PAK/75/039).

Phase I of project SI/PAK/78/803 was intimated by UNIDO (SIS) to provide assistance in the design of preventive maintenance practice to the Federal Chemical and Ceramics Corporation Limited (FCCCL). The project started in April 1979 and was completed in September 1979.

The expert in preventive maintenance designed a system and a procedure to form the basis of a complete preventive maintenance organization and method for all of the twelve units. A full description of the system is contained in the expert's final report which should be used as a reference document for the project manager of phase II.

The design of the system and of the vested forms and records is considered completed, the following documentation being available for each of the 12 factories:

(a) Master plans for preventive maintenance;

(b) Spare part inventories and control method;

(c) Maintenance cost and budget procedures;

(d) Forms and schedules for implementation and control of preventive maintenance including:

(i) Planned lubrication;

(ii) Planned inspection;

(iii) Routine maintenance;

(iv) Breakdown recording and analysis;

(v) Information reports to supervisor and management;

(e) Safety rules including:

(i) Accident record form;

(ii) Analysis of accidents and action.

These cover all the important system inputs and it is now essential to proceed to the implementational stage, which is the purpose of phase II.

II. OBJECTIVES OF PROJECT PHASE II

Immediate objectives

The immediate objective is to train engineers at all levels of the FCCCL management as well as supervisors in order to enable them to implement the preventive maintenance system. They will have to acquire the necessary skills to carry out all technical work and to maintain each plant according to the specified production requirements.

Long-term objectives

The long-term objectives are:

(a) To improve productivity through high machine utilization and avoidance of breakdown;

(b) To establish an ongoing training system for engineers and supervisors which can be continued by the FCCCL management to compensate for staff turnover.

III. PROJECT OUTPUTS OF PHASE II

1. Increased profitability of the Corporation through reduction of downtime due to breakdown of machinery
2. Experienced maintenance managers
3. Experienced maintenance engineers
4. Experienced maintenance supervisors
5. Availability of qualified staff (2, 3 and 4 above) at all time.

IV. WORKPLAN

1. Description of project activities

1.1 In the factories, provide technical assistance to the maintenance managers in the implementation of the preventive maintenance scheme designed during phase I.

1.2 Assist in the procurement of equipment, instruments and tools for the training shop (see appendix II)

1.3 Advise on maintenance problems arising while the project is operative

1.4 Supervise the installation of the equipment in the training shop

1.5 Select three national staff for fellowships training (for recommended courses see appendix III)

1.6 Design, organize and present training programmes for junior engineers and/or diploma holders selected from FCCCL's factories; after completion of the training that staff should be able to continue to give courses to a second group (for recommended training subjects see appendix IV)

1.7 Select the participants for the first training programme

1.8 Evaluate the participants after the end of the training programme

1.9 Have appropriate maintenance manuals printed and disseminated

1.10 Prepare progress reports of the project

1.11 Prepare a terminal report of the project

2. Timing of the project

2.1 The delivery of equipment for all units (see appendix I) is expected to be completed in the mid of 1981

2.2 The site and the building for the training centre in Ravi Rayon at Kala Shah Kaku will be prepared by FCCCL according to the floor-plan shown in appendix V. The target date for completion is late 1981

2.3 The delivery of equipment for the training centre (see list in appendix V) is expected to be completed by January 1982

2.4 The training of three counterparts abroad for three months each will be carried out in fourth quarter of 1982

3. Description of UNDP/UNIDO inputs

3.1 Assignment of international staff

(a) Project manager

Duties: The expert is expected to:

(i) Organize, supervise, co-ordinate and participate in the activities of the project;

(ii) Establish close working contacts with the maintenance department of FCCCL and take into account the programmes of the Company's future development;

(iii) Organize and guide the work of short-term experts;

(iv) Assist the national maintenance managers in the implementation of the preventive maintenance schemes designed in phase I in Kala Shah Kaku units, Daudkhel units and Kurram Chemical at Rawalpindi for the first six months of the life of the project;

(v) Advise on repairs and spare-part inventory in the above factories;

(vi) Supervise the installation of equipment, provided for by UNIDO, at the Ravi Rayon training centre;

(vii) Organize and supervise the rational utilization of equipment in the training shop;

(viii) Train ten to twelve junior engineers and/or diploma holders selected from the FCCCL factories (except Pakistan PVC and Sind Alkalis) at the new training shop.

Qualifications:

Extensive experience in maintenance management in chemical industry;

Ability of training in the field of maintenance;

Familiarity with testing equipment such as balancing machine, vibration and sound analyser, flaw detector etc.;

Experience in spare-part inventory control.

Language: English
Duration: Twelve months
Duty station: Lahore with travel to plants of FCCCL.

(b) Expert in maintenance (A)

Duties: The expert will:

(i) Assist the national maintenance management in the implementation of the preventive maintenance schemes designed in phase I in the PVC factory and in Sind Alkalis factory;

(ii) Advise on repairs and spare-part inventory in the above factories;

(iii) Train four to six junior engineers and/or diploma holders of the above factories in the workshop of Sind Alkalis in the use of testing equipment, fault prediction etc.

Qualifications:

Extensive practical experience in maintenance in the chemical industries, preferably in PVC and caustic soda production; familiar with testing equipment such as balancing machine, vibration and sound analyser, flaw detector etc.

Language: English
Duration: Six months
Duty station: Karachi

(c) Expert in maintenance (B)

Duties: The expert will:

(i) Assist the national maintenance management in the implementation of the preventive maintenance schemes designed in phase I in Swat Ceramics factory and Swat Elutriation factory;

(ii) Advise on repairs and spare-part inventory in the ceramic factories.

Qualifications:

Extensive practical experience in maintenance of ceramic industry; familiar with testing equipment; practical experience in spare-part inventory; good knowledge of machinery for ceramic production made in the Federal Republic of Germany is desirable.

Language: English
Duration: Three months
Duty station: Nowshera, with travel to Shaidu and Mingora.

3.2 Fellowships

Three fellowships will be provided for three months each for training abroad. The training will take place in the second half of 1981 according to the schedule shown in the bar chart of the work plan. The fellowship holders will be selected from the local staff. After their return, they shall assist the project manager in developing and presenting the training programme in the training shop and then take over the on-going training course after the end of the project. Recommended training courses abroad are given in appendix III.

3.3 Equipment and supplies provided by UNDP/UNIDO

Item	Quantity	Cost ($US)	Delivery date
Plan paper copier (for Ravi Rayon)	one	3,000	January 1982
Plain paper copier (for Sind Alkalis)	one	3,000	January 1982
Epidiascope (for Ravi Rayon)	one	3,000	January 1982
Books and periodicals	-	2,000	January 1982
Equipment for training shop (see appendix II) including spare parts	-	60,000 a/	January 1982
Total		71,000 a/	

a/ Any additional equipment suggested by the corrosion expert to be added to that figure.

4. Description of FCCCL input

4.1 Assignment of national staff

The maintenance managers of ten factories of FCCCL who have been trained during phase I shall act as counterparts for experts. One of the maintenance managers will be selected to act as counterpart to the project manager and then, after he will have been trained abroad, as instructor in the training shop at Ravi Rayon. The two diploma holders who will be awarded fellowships will, upon their return, act as counterparts for the practical training, one associated with the project manager in the training shop at Ravi Rayon, the other one with the expert at Sind Alkalis.

4.2 Building, equipment and supplies provided by FCCCL

FCCCL will undertake the following:

(a) Procure all equipment and instruments needed in each unit for the proper implementation of preventive maintenance (for details see appendix I). The estimated cost of that equipment is Rs. 3,300,000 plus any additional equipment suggested by the corrosion expert;

(b) Make available an area of approximately 250 m^2 at Ravi Rayon (Kala Shah Kaku) and build on it a training shop as detailed in appendix V; the estimated cost at 1981 prices is Rs. 250,000;

(c) Procure furniture and equipment and provide all necessary facilities in the training shop as specified in appendix V; the estimated cost at 1981 prices is Rs. 50,000;

(d) Board and lodging for 10 national participants from outside Lahore (existing in Kala Shah Kaku Colony).

Furtheremore, FCCCL will commit Rs. 100,000 in operating funds to be used for:

(a) Electricity, water etc.;

(b) Material for training purposes;

(c) Reserve.

The above funds could be recovered, if desired by FCCCL, through charges for services rendered by the new training shop to outside factories.

5. Pre-project review

A senior industrial field adviser or a UNIDO consultant should visit the FCCCL units for five to seven days in order to verify that the equipment specified under item 4.2 (a) is available and to check on the progress made in connection with establishing the training shop (items 4.2(b) and (c)) before the project starts. This review should take place in May 1981.

BAR CHART OF WORK PLAN

	1981 M J	1981 J A	1981 S O	1981 N D	1982 J F	1982 M A	1982 M J
I. Assignment of international experts							
1. UNIDO pre-project review	x						
2. Project manager		x	------	------	------	------	------x
3. Expert A			x	------	------	------x	
4. Expert B			x	—x			
II. Assignment of counterpart		x	------	------	------	------	------x
III. Training: 3 fellowships, 3 m/m each			xxx				
IV. Delivery of equipment (UNDP/UNIDO)							
1. Equipment specified in appendix II					x		
2. Supplies					x		
V. Availability of Government inputs							
1. Equipment specified in appendix I	x						
2. Buildings				x			

V. PROJECT BUDGETING

1. UNDP/UNIDO contribution

Code		Total m/m	Total $US	1981 m/m	1981 $US	1982 m/m	1982 $US
10	Project Personnel						
	11 Experts						
	11-01 Project manager	12	60,000	6	30,000	6	30,000
	11-02 Expert A	6	30,000	3	15,000	3	15,000
	11-03 Expert B	3	15,000	3	15,000		
	19 Component total		105,000		60,000		45,000
30	Training		13,500		13,500		
40	Equipment						
	41 Expendable equipment.....		11,000		9,000		2,000
	42 Non-expendable equipment		60,000		60,000		
	49 Component total		71,000		69,000		2,000
50	Miscellaneous						
	51 Operation/maintenance equipment..		6,000		5,000		1,000
	52 Reporting cost		1,000		500		500
	53 Sundries		1,000		500		500
	54 Duty travel (regional)		3,000		2,000		1,000
	59 Component total		11,000		8,000		3,000
99	GRAND TOTAL		200,500		150,000		50,000

2. Government contribution (in Pakistani rupees)

Code		Total	1980	1981
40.	Equipment			
	42. Non-expendable equipment	350,000	350,000	
	43. Buildings	250,000	250,000	
	49. Component total	600,000	600,000	
49.	Miscellaneous			
	51. Operating expenses	100,000	20,000	80,000
	59. Component total	100,000	20,000	80,000
99.	GRAND TOTAL	700,000	620,000	80,000

Appendix I

MAINTENANCE EQUIPMENT, INSTRUMENTS AND TOOLS NEEDED FOR FCCCL UNITS

Equipment	Specification	Quantity	Recipient
Bench-type precision grinder	Working surface 14 x 15½", diameter of wheel 7", cross feed graduation 0.001", vertical feed graduation 0.005", magnetic chuck 10 x 5", 3-phase, 440 V, 50 Hz	1	Swat Ceramics
Horizontal lathe	Max. diameter of workpiece 440 mm, centre distance 1,500 mm, 3-phase, 440 V, 50 Hz	1	Swat Elutriation
Vertical drill	Max. diameter of drill 12 mm 3-phase, 440 V, 50 Hz	1	Swat Elutriation
Grinder	Double grinding wheels of - 440 mm diameter each, 3-phase, 440 V, 50 Hz	1	Swat Elutriation
Vibration/sound level meter	Portable with probe, frequency range 600-600,000 cycles per minute, vibration amplitude 0-100 mils peak to peak, sound amplitude 45-140 dB	4	One each Pakistan PVC Ittehad Pesticides, Swat Ceramics, Antibiotics (Pt) Ltd.
Digital thermometer	Portable, with NiCr/NiAl sensor, temperature range 25-500°C, resolution 1.0°C	4	One each Pakistan PVC, Ittehad Pesticides, Swat Ceramics, Antibiotics (Pt) Ltd.
Digital wall thickness meter	To measure up to 25 mm thickness; portable	4	One each Pakistan PVC, Sind Alkalis, Ittehad Pesticides, Antibiotics (Pt) Ltd.
Volt-ammeter recorder	Portable, voltage range 70-130 V and 140-260 V, current ranges 5-30-60-150-300 A, circuit voltage 6 900 V, auxiliary source 220 V, 50 Hz	4	One each Pakistan PVC, Kurram Chemicals, Swat Ceramics Antibiotics (Pt) Ltd.
Explosive gas detector	For all flammable gases and vapours, portable, complete with probe and accessories, visible and audible alarm	6	One each Pakistan PVC, Sind Alkalis, Ittehad Pesticides, Ravi Rayon, Kurram Chemicals, Antibiotics (Pt) Ltd.

Appendix II

EQUIPMENT, INSTRUMENTS AND TOOLS FOR

Item	Specification
Balancing machine	Suitable for general-purpose shop balancing, capacity 5,000 lbs
Vibration analyser dynemic balancer	Operating from standard line power or rechargeable batteries. To be used with an optical XY recorder or with a vibration/sound level meter as described below, for detailed noise analysis. Range 50-500,000 cycles per minute, amplitude ranges 0-100 mils peak to peak or in./sec peak
Vibration/sound level meter	Portable, battery operated, (ANSI 51.4 and IEC 123) with selectable A,B and C weighting network and slow/fast responses. Dual meter scale reads either sound or vibration. Frequency range: 600-600,000 cycles per minute, Amplitude range: Vibration 0-100 mils peak to peak, Sound 45-140 dB
Ultrasonic, digit wall thickness meter	Up to 25 mm thickness
Digital thermometer	With NiCr/NiAl Sensor Temperature range: 75-99 ^{o}C Resolution: 1.0 ^{o}C

TRAINING CENTRE

Quantity	Example
one	Model B 50 of IRD Mechanalysis Inc., Columbus, Ohio, United States
one	Model 350 of IRD Mechanalysis Inc.
one	Model 308 of IRD Mechanalysis Inc.
one	Model D-Meter DM 1 of Krautkramer GmbH, Cologne, Federal Republic of Germany
one	Model 8 003 of Jenway Ltd., Barintee, Essex, United Kingdom

Hydraulic puller (screw-type) with acessories	Max. reach $5\frac{1}{2}$"
Ultrasonic flaw detector	
Dial indicators	Graduation: 0.001"; Range: 1.000" Complete with magnetic holder
English and metric vernier caliper	Measures outside, inside and depth English range: 0-5¼" by 0.001" Metric range: 0-150 mm by 0.005 mm
Micrometers	0.01 mm metric reading Ranges: 0-25 mm, 50-75 mm and 100-125 mm
Thickness gauge	13 blades from 0.3 to 0.4 mm
Metric screw pitch gauge	For 150 metric threads; 30 blades, 60°, 0.25 to 3.0 mm; double end
Spring caliper	Outside spring caliper 150 mm Inside spring caliper 150 mm
Master precision level	12" long, sensitivity 0.0004" per 10"
Volt-ammeter recorder	Portable, rating voltage: 70-130 V; 140-260 V
Bench vice	8" size
Portable air compressor	Pressure: 10 kg/cm^2 Discharge: 60 m^3/h

one	Mc. Master Corr. Supply Co. Chicago, United States
one	Model ECMO 1 of 1 006, Karel Deutsch, Wuppertal, Federal Republic of Germany
one set	Brown and Sharpe Industrial Products Div., Rhode Island, United States
one	Same as above
one each	Same as above
one	Same as above
one	Same as above
one	Same as above
one	Same as above
one	Model PRK 21 of Take Moto Electrical Inst. Co. Ltd. Osaka, Japan
one	Any supplier
one	Any supplier

Universal stand	For assembly and test, anchored to foundation, fitted with clamps
Universal stand	For assembly and test, fitted with clamps
Travelling hydraulic crane	Capacity 1 t, lifting height 2 m
Torque wrench (set)	Dial type
Master mechanics wrench (set)	Metric size
Double-end spanners	Metric size - all sizes
Hexagonal keys (Allen key)	Metric size - all sizes
Spare parts	

one	Any supplier
one	Any supplier
one	Any supplier
one set	Any supplier
one set	Mc. Master Corr. Supply Co. Chicago, United States
one set	Any supplier
one set	Any supplier

Appendix III

FELLOWSHIPS

One senior engineer (B. Sc. holder) working in the field of maintenance, with experience of no less than 10 years. The training course should include the following subjects:

(a) Maintenance management;

(b) Preventive maintenance techniques.

Duration of course: three months

Language: English

Two supervisors (diploma holders) working in the field of maintenance, with experience of no less than 10 years. The training course should include the following subjects:

(a) Practical application of preventive maintenance:

(b) Methods of inspection;

(c) Data recording.

Duration: three months

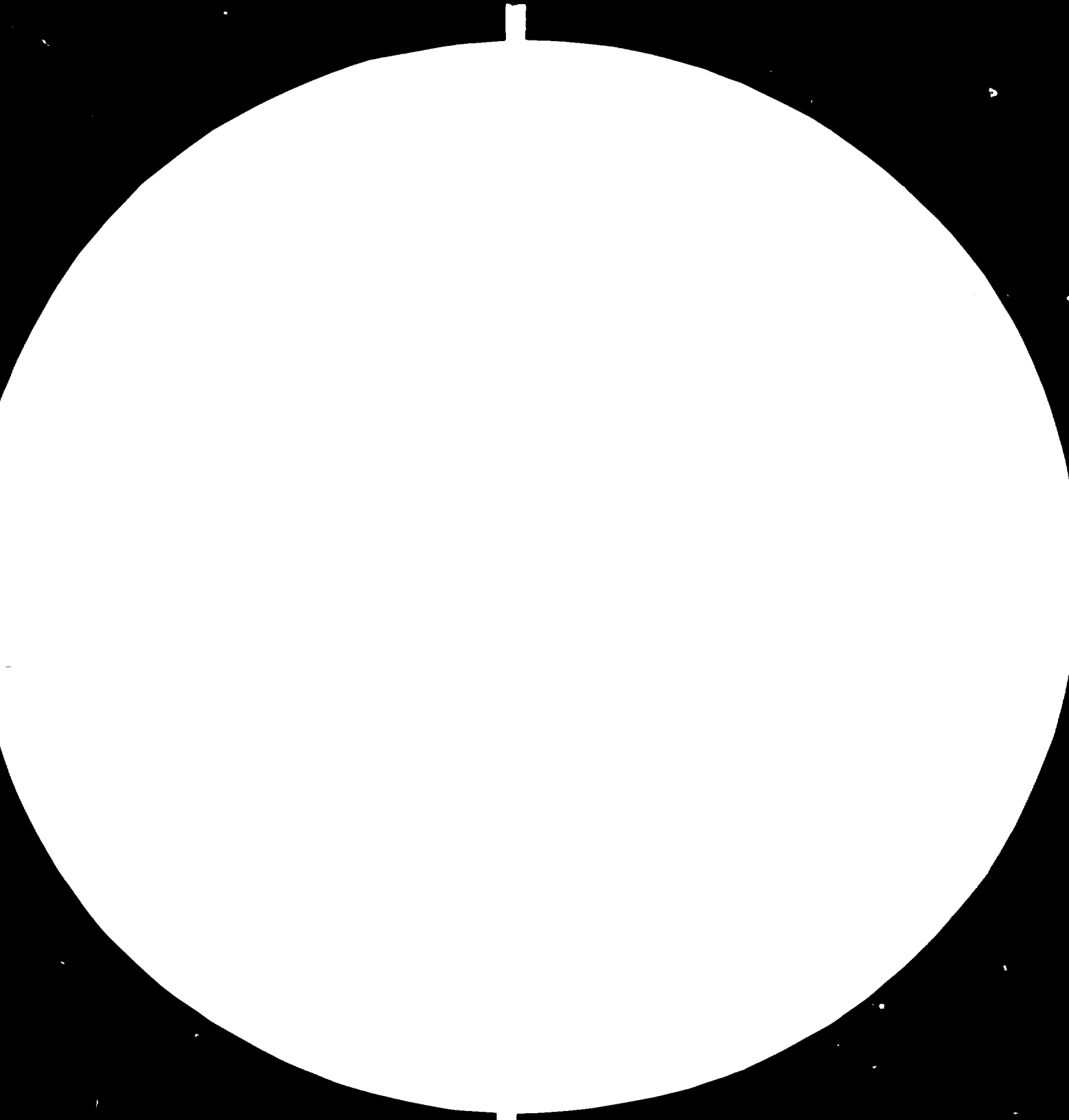
Language: English

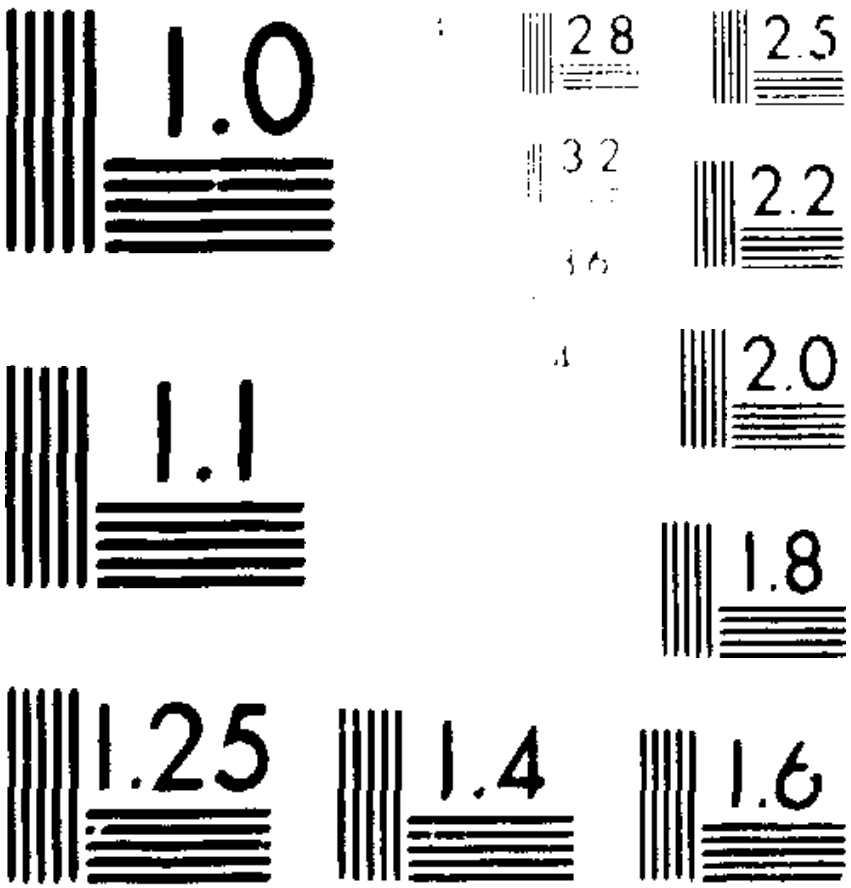
The place recommended for training is IRD Mechanalysis Inc., Columbus, Ohio, United States of America.

Appendix IV

TRAINING PROGRAMME FOR
JUNIOR ENGINEERS AND/OR DIPLOMA HOLDERS

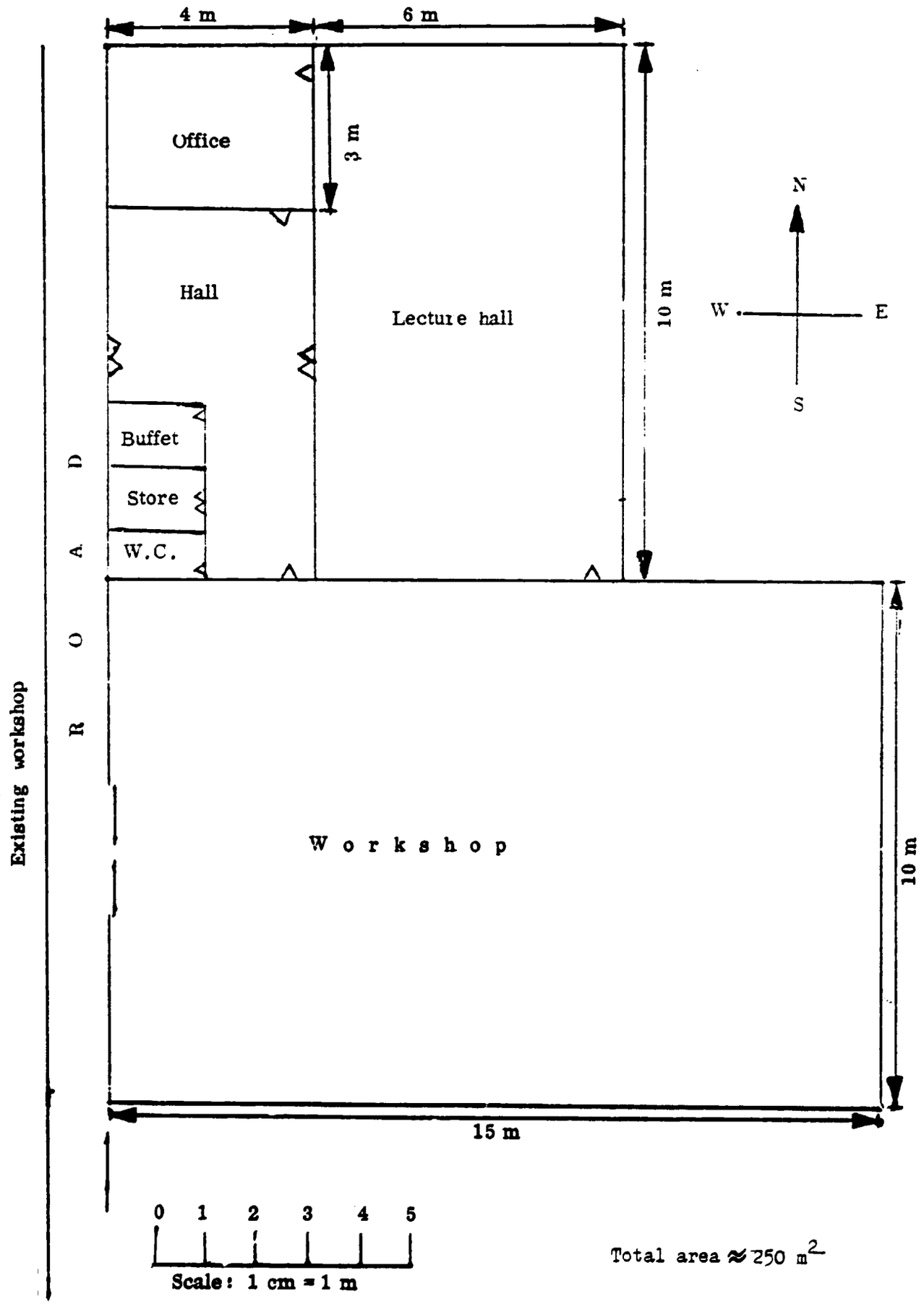
Subject	Number of hours		
	1st month	2nd month	3rd month
Maintenance planning	30		
Inspection technique	30		
Basic statistics	15		
Lubrication	15		
Work measurement	15		
Spare-part inventory	15		
Maintenance costing and budgeting	15		
Project planning	15		
Practical training in the training shop		150	
Practical training in the factory	—	—	150
Total	150	150	150





Appendix V

FLOOR PLAN AND EQUIPMENT FOR TRAINING CENTRE
WITHIN THE PREMISES OF RAVI RAYON



Total area ≈ 250 m^2

Equipment and facilities

1. Lecture hall (6 x 10 x 4 m)

The lecture hall should be equipped with:

Desert cooler of suitable capacity and fans on the ceiling

Fifteen desks with chairs

Lecturer's table and chair

Blackboard 2.0 x 1.5 m

The walls and the ceiling should be sound and heat-proof

2. Lecturer's office (4 x 3 x 4 m)

This office should be equipped with:

Air conditioner (suitable capacity)

Two desks and 4 chairs

Four filing cabinets with drawers

3. Workshop of garage type (15 x 10 x 6 m)

The workshop should have the following equipment and facilities:

Good ventilation system

Water tap and sewerage system

Three-phase current supply of 100 A, 440 V, 50 cycles

Single-phase current supply of 100 A, 220 V, 50 cycles

Fitter's bench (1 x 3 m) in steel with drawers for tools

Shelves

The floor should be made of concrete slabs.

4. Four toilets

5. Buffet room of suitable size equipped with tea-making facilities

6. Store room of suitable size for storing sensitive instruments, tools etc.

7. The foundations, except those of the workshop, should be designed strong enough to carry a second floor in case additional room for training should be required by FCCCL.