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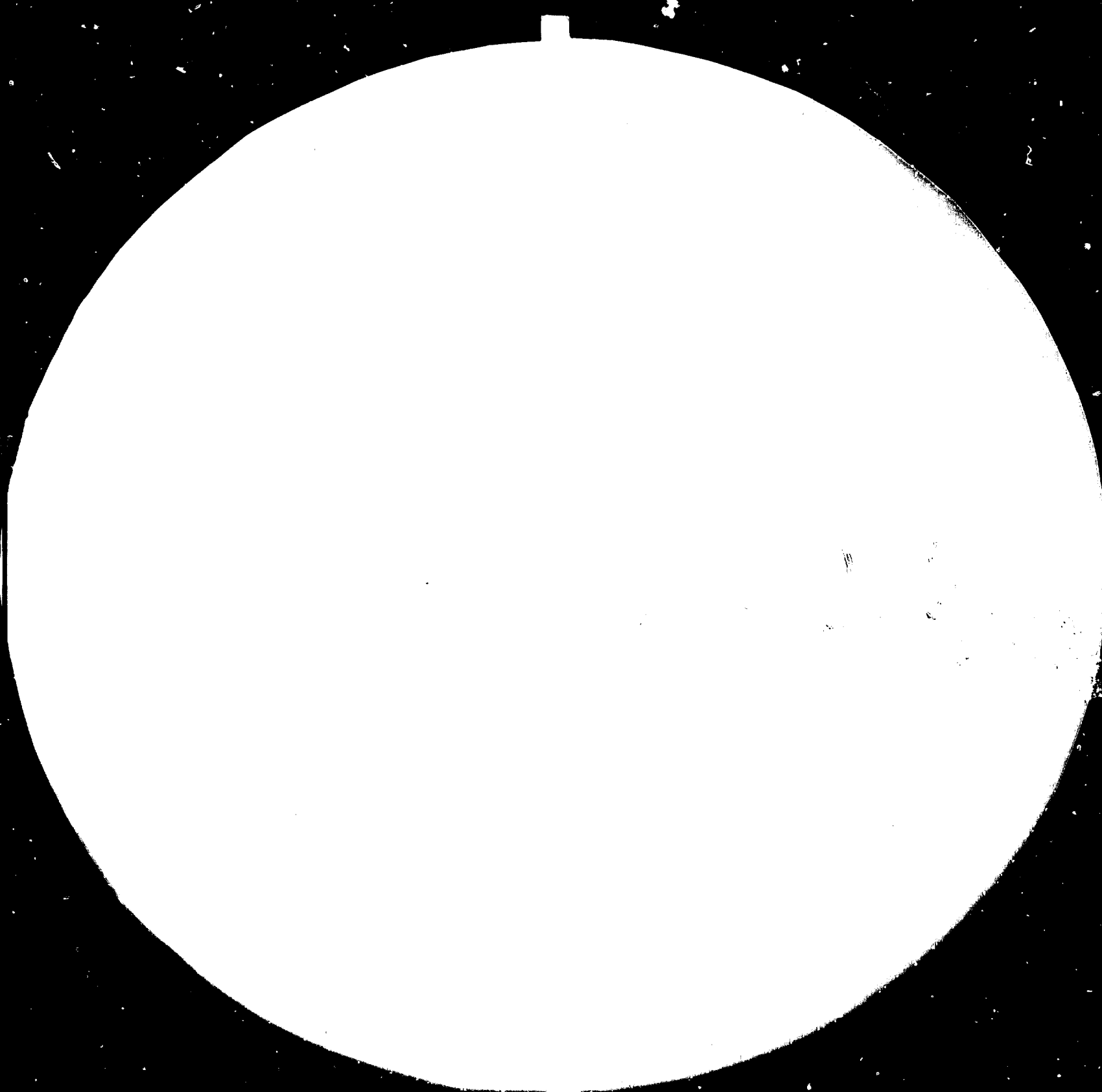
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22 April 1983  
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REGIONAL CO-OPERATION PROGRAMME FOR THE DEVELOPMENT  
AND PROMOTION OF FERTILIZER PRODUCTION AND UTILIZATION

DP/RAB/78/021

SYRIAN ARAB REPUBLIC

Syria.

Technical report: Maintenance of fertilizer  
plants at Homs, Syria

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

Expert: S R. SAHORE

1045

United Nations Industrial Development Organization  
Vienna

Explanatory Notes

The monetary unit in the Syrian Arab Republic is the Syrian pound (£S). During the period covered by the report the value of this pound in relation to the United States dollar was \$1 = £S 3.90.

The following abbreviations are used in the report:

AIDO	The Arab Industrial Development Organization
CAN	calcium ammonium nitrate
AN	ammonium nitrate
GFC	General Fertilizer Company
NDT	non-destructive testing
TSP	triple super-phosphate.

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#### ABSTRACT

The project "Regional Co-operation Programme for the development and promotion of fertilizer production and utilization" (DP/RAB/78/021) is being carried out by the United Nations Industrial Development Organization (UNIDO) as the executing agency for the United Nations Development Programme (UNDP). The report covers the mission of a UNIDO expert who visited the General Fertilizer Company (GFC) at Homs, Syrian Arab Republic, for a period of three weeks at the beginning of 1983. The GFC complex has recently developed from a small plant with restricted capacity into a large-scale plant producing large quantities of urea and ammonia in addition to its original production of nitrogen fertilizer. The consultant was asked to study GFC systems and services, assess industrial performance, analyse organizational and staffing procedures with particular reference to maintenance, and make recommendations for improved maintenance methods and facilities. It was foreseen that the management team at GFC would benefit from the experience of a highly qualified expert.



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## INTRODUCTION

The project "Regional Co-operation Programme for the development and promotion of fertilizer production and utilization" (DP/RAB/78/021) is being carried out by the United Nations Industrial Development Organization (UNIDO) as the executing agency for the United Nations Development Programme (UNDP). The report covers the mission of a UNIDO expert who visited the General Fertilizer Company (GFC) at Homs, Syrian Arab Republic, for a period of three weeks at the beginning of 1983.

A relatively small nitrogen fertilizer plant, comprising a 150 t/d ammonia plant, a 87,500 t/a nitric acid plant and a 142,000 t/a calcium ammonium nitrate (CAN) plant, managed by the General Fertilizer Company (GFC) has been in operation for over a decade at Homs, Syrian Arab Republic. A modern ammonia-urea complex with production capacities of 1,000 t/d of ammonia and 1,050 t/d of urea have been added, being commissioned in 1981. Also a triple super-phosphate (TSP) plant with sulphuric acid, phosphoric acid and TSP units with production capacities of 1,700 t/a, 530 t/a and 1,400 t/a, respectively, has been operating since 1981. Here the Romanian contractors are carrying out the requisite rectifications and modifications to meet the guarantees and make the plant acceptable to the owners.

The Company expressed its desire for a review of the set-up and organization of the maintenance department, in order to establish improved methods of maintenance planning and management commensurate with the requirements of the three plant complexes. Previously, there had been a centralized maintenance system, but with the addition of new plants this has been changed to one having decentralized maintenance groups.

Approximately a year ago the Snam Progetti organization had carried out a study, without cost, of the existing maintenance systems and submitted their suggestions for improvement.

The expert stayed for three weeks at Homs from 15 January 1983. His job description is reproduced in the annex.

### CONCLUSIONS AND RECOMMENDATIONS

1. The whole of the existing organizational structure needs to be changed commensurate with the importance of the operations for which the company exists. The introduction of an operations director (or deputy general director) under whom production and maintenance are integrated is called for. The extent of control at all management levels must be reduced to manageable levels.

2. To ensure better co-ordination there is a need to introduce production and maintenance heads to all plants.

3. Services for production and maintenance units should be transferred to the operations level.

4. Central offices should be freed from day-to-day management of the plants in order to concentrate upon policy and future planning.

5. The existing decentralized maintenance system should be reorganized into a mixed-maintenance organization structure, with day-to-day and minor maintenance work being carried out at the individual plants, while major repairs and maintenance during turnaround etc. are the responsibility of central workshops.

6. A predictive maintenance system based upon continuous non-destructive testing (NDT) inspections and the monitoring of critical and semi-critical equipment should be adopted.

7. The maintenance schedules based on predictive maintenance should be synchronized with planned annual turnaround. Equipment or components should be opened for repair or overhaul only when the condition indicates a deterioration in which the item may not last until the next turnaround.

8. A thorough planning for each turnaround is necessary in order to minimize downtime, since standard annual turnaround for ammonia plant is about 3 weeks. Initially, GFC should target for completion in 4 weeks.

9. The existing machine tools in the central workshops are adequate despite occasional failure and lack of use. At present the capacity utilization of the workshops is only 10-15 per cent, based on 40-45 per cent optimum utilization in one shift only. Many of the machine tools can be repaired and put to productive use after procurement of spares etc. The following machines, however, should be procured:

(a) A horizontal boring machine with:

Spindle diameter	110 mm
Spindle speed	12-1,200 rev/min
Headstock travel	1,200 mm
Table size	1,200 X 1,200 mm
Traverse	1,600 X 1,200 X 1,800 mm

(b) A dynamic balancing machine, horizontal type, with:

Weight balanced	2.1-10,000 kg
Maximum diameter of component	4,000 mm
Maximum distance between bearings	15 m
Sensitivity	0.2 mm

(c) A foundry shop for the central workshops, if eventually considered necessary, and after optimizing its utilization to at least 50 per cent.

(d) Two mobile cranes of 60-75 t and 15 t capacity are immediately necessary to cater for the maintenance needs of the plants.

10. The role of the metallurgical laboratory and NDT Inspection Team must be altered from passive to active, and this may prove possible with the proposed reorganization and the positioning of a maintenance manager. The team needs to develop expertise and confidence in the use of the NDT tools already held, and the interpretation of results therefrom.

11. It is recommended that procurement and storage of materials needed for maintenance should be the responsibility of the operations director. Long delays in procurement and difficulties in identification and retrieval of spare parts when they are needed hampers efficient maintenance. Procedures need to be streamlined, and inessential passing of papers and authorizations must be eliminated as a contribution towards an improved management service to the maintenance department.

12. The existing 7-digit codification is inadequate for the increased needs and therefore an 11-digit codification of store items is recommended. After computerization, screens must be installed in the offices of the maintenance manager and the head of stores.

13. Excessive categorization and unnecessary diversity of stores is better avoided. Rationalization and consolidation are necessary for an improved inventory management.

14. Engineers should be immediately deputed to the stores to identify all the items of spare parts relevant to their plants.

15. Samples of unidentifiable rods, pipes, plates etc. should be collected and sent to the nearest reliable testing laboratory where the material should be expertly classified.

16. Orders should be placed immediately for equipment to test the chemical composition of metals, especially carbon, chromium, nickel, molybdenum, tungsten, vanadium, manganese, iron, copper and zinc.

17. Procurement of an auto-analyser is recommended to quicken feed-back of product analysis to the production department.

18. More than half of the maintenance problems in fertilizer industry are caused by poor operation and control of operational parameters. Utilities, which tend to be neglected in comparison with main plants, are very important for smooth operation, longer on-stream efficiency and the elimination of avoidable maintenance. Quality of water, steam and other raw materials must not be compromised.

19. Quality and expertise of operators and maintenance technicians must be enhanced very quickly. Until then dependence on outside (international) help is unavoidable. There is a need for at least two more specialists in mechanical maintenance.

20. The M.W. Kellogg Company holds annual ammonia club meetings where senior operation and maintenance engineers working in Kellogg ammonia plants correlate and exchange their experiences. This year a meeting is proposed to be held at Denver, Colorado, United States of America, during August. It is recommended that one nominee each from the production and maintenance department should be sent.

21. Exchange of visits of operations and maintenance engineers to similar fertilizer plants in the Arab States or developing countries should be organized to enrich staff experience and to learn their management techniques at first hand. Care should be taken to choose only relatively successful fertilizer plants for visits.

22. In order to enhance job knowledge, particularly of operating and maintenance personnel, training at all levels is recommended. Well-planned short-term courses should be conducted on a regular basis.

23. Training manuals should be prepared at post or section level for each plant; a need which is urgent at the ammonia and urea plants. Training aids, such as audio-visual equipment should be procured.

24. A specialist having experience of handling turnarounds at similar ammonia and urea plants should be invited to the first annual turnaround, 4 to 6 weeks in advance.

25. Two mini workshops, at the ammonia-urea and TSP plants respectively, are recommended. They require only one lathe, one radial drilling machine, one bench drill, one bench grinder and welding equipment including an argon-arc welding set. Care must be taken to prevent these from developing into big workshops at the cost of central workshops. Hot ovens for keeping the welding electrodes should be provided in workshops and at all plants.

26. Extreme caution should be exercised when considering any increase of manpower, especially in the maintenance departments where work is not measurable, as maintenance engineers tend to ask for more and more manpower. The maintenance department should never be organized for peak demands. Existing personnel in the plants now seems to be about adequate, but more manpower is needed in the central workshops, which should provide a common pool to meet extra demands.

27. Experience is valuable and therefore inter-departmental transfers should be avoided for the present. Indeed some of the experienced engineers now in the central offices should be sent to the plants.

28. Safety consciousness should be fostered.

29. Good housekeeping in the plants is very important, less for the sake of appearance than to improve safety standards for plant and personnel. A sense of cleanliness must be nurtured, and all unwanted materials, stores, scrap, debris etc. disposed of.

30. The addition of one steam boiler, identical to those existing in utilities section of the ammonia urea complex should now be considered to ensure that maintenance work or the shutdown of one boiler does not enforce complete closure.

31. Ways and means must be discovered as early as possible to utilize excess ammonia capacity in order that the plant can achieve optimum economic viability. Taken annually, ammonia and urea plants must run on full capacity at least for 80 per cent of the whole time or 90 per cent of 330 working days. Active plants are less maintenance-prone than idle ones. Frequent shutdowns due to external causes should be minimized.

32. Manufacture of spare parts should be initiated and pursued gradually; an experienced engineer and two draughtsmen being allocated to it. Wherever a shutdown occurs and a component opened, a detailed drawing must be prepared, although equipment should never be opened solely to provide drawings of spare parts. Raw materials required for the manufacture of spare parts should be gradually procured, but only after ensuring that the material does not already exist in the stores. See recommendation No. 15 above.

33. Authority to hire and fire employees should be vested in the Director General so that all staff realize that non-performance may lead to dismissal. Complete job security and a slack control of performance are detrimental to the efficient running of any organization, especially a fertilizer plant. The authority to dismiss an employee on justifiable grounds will be a rarely-used deterrent; but it is an effective sanction in improving industrial performance.

## I. EXISTING GENERAL FERTILIZER COMPANY ESTABLISHMENT

### A. CALNITRO plants

The General Fertilizer Company, Homs, formerly called the Homs Nitrogen Fertilizer Plant, established ammonia, nitric acid and CAN plants with related facilities in 1972. The production capacities were:

Ammonia	150 t/d
Nitric acid	280 t/d or 87,500 t/a, 100% acid
CAN plant	450 t/d or 142,000 t/a

A central workshop with sufficient holdings of machine tools was also established, but many of these facilities are now either defunct or not in use.

The old ammonia plant constructed by Snam Progetti was based on the steam reforming of naphtha, with two reciprocating air-cum-synthetic gas compressors, the rest of the plant being on single train basis. Now for the first time the primary reformer tubes have been replaced with new ones, and otherwise the plant is in fairly good condition for its age. However, the management has shut down this plant because of excessive availability of ammonia from a new 1,000 t/d capacity ammonia plant. To keep the old plant ready for emergencies, it is run for 15 to 20 days every 6 months. Experienced operation and maintenance staff is available. The necessary connections to draw ammonia from the new plant are complete and operating.

The nitric acid plant is divided into two streams, with two burners or waste-heat boilers and two absorption towers per stream. The compressors are driven by steam turbine. A gas turbine rotor is combined with the compressor rotor sharing a common casing. Three gauges of platinum-rhodium (92.5%-7.5%) have now been replaced by one such gauge and a 10 mm thick bed of FeO catalyst. This has given very good results. The feed ammonia is first vaporized and then put in a gasholder before use. The super-heater coils have already leaked and a replacement made from spare stores was also found to be leaking, possibly on account of inadequate protection in storage. The nitric acid plant is in good condition.

The CAN plant is a very simple and compact plant, based on prilling of ammonium nitrate (AN) mother liquor mixed with ground dolomite. The nitric acid heater has now been removed altogether because of corrosion problems. The ammonia and nitric acid sprayers in the reactor/neutralizer are subject of repeated maintenance as the holes merge after extended use. It is thus advisable to drill a double row of holes in the sprayers, and to increase the pitch or spacing to overcome the problem. The scraper in the prilling tower is also problematic, and plans exist to dispense with the rail.

Though the old plant complex (CALNITRO) has been in operation for over 11 years, targeted production was only achieved last year. In the 1982 calendar year 116,543 t of CAN production is the maximum annual production achieved at this plant so far, against rated capacity of 142,000 t. The capacity utilization in the best year, therefore, works out at about 80%.

The Government of the Syrian Arab Republic and GFC have not yet decided to change over to AN production. Should this be done alternative storage and transportation arrangements will have to be made, apart from other necessary modifications, since AN may never be stored in bulk. At a recent meeting, the Government asked GFC to prepare and submit feasibility and economic viability studies for a conversion from CAN to AN production.

#### B. Ammonia-urea plants

The new ammonia-urea plants with their own utilities, product storage and bagging facilities have been set up by M/S Creusot Loire Enterprise of France acting as general contractors. The 1,000 t/d ammonia capacity is based on steam-reforming of naphtha and Kellogg technology. The identical quality of naphtha is used for feed and fuel in the primary reformer, having ICI catalyst S-46-1 and S-46-4 in equal quantities. Most of the equipment is steam-turbine driven and the ammonia plant is self-sufficient in steam. Carbon dioxide removal is effected by CARSOL solution. A minor explosion in the absorber and back-firing of a burner in an auxiliary boiler were experienced during the commissioning. The plant meets required standards and has been accepted by GFC. Since only 600 t of ammonia is required by the 1,050 t capacity urea plant and about 150 t by CALNITRO, the ammonia plant has necessarily to be run at low load although normally it operates at about 80% load.

The 1.050 t/d capacity urea plant is based upon the Stami-carbon process. The ammonia and urea reciprocating pumps have been giving problems in respect of the gland packings which hardly last one month. The plant has performed well and operates at 105%-106% if conditions are favourable. Oxygen content in CO<sub>2</sub> is maintained at around 0.8%. The steam supply to the urea plant is a limiting factor as there are only two boilers of 60 t/h capacity producing steam at 40 kg/cm<sup>2</sup> in the utilities. Though there is no mandatory inspection of boilers in the Syrian Arab Republic, marginal capacity of steam production can be considered a bottle-neck, and augmentation of steam from a nearby power plant is not considered reliable. There is only one boiler of 30 t/h producing steam at 40 kg/cm<sup>2</sup> in TSP utilities; the other three boilers have lower pressure ratings (16 and 10 kg/cm<sup>2</sup>). Installation of one more boiler in the utilities section of the ammonia-urea plant should be considered in the near future. During 1982, 83,415 t of urea was produced.

Lack of experienced staff, especially in the maintenance sector is recognized. The spare parts have not been properly identified and taken over, but stocks in any case are considered inadequate, as various recommended spare parts were not ordered at the project stage, probably owing to financial constraints. Orders for fresh lists of spares have yet to be released by the commercial department. Completion of data and history cards, already printed, should be started this year. A German expert in maintenance is allocated to the ammonia-urea complex, while two mechanical engineers and six technicians have been recruited from Pakistan in addition to operations personnel.

Tenders for conversion of feed stock from naphtha to natural gas have been invited. It may take about 4 years for the change-over however; the major job of laying the gas line being outside GFC's scope.



### C. Triple super-phosphate plants

The TSP plants have the following production capacities:

Sulphuric acid	1,700 t/d or 560,000 t/a (excess of 40,000 t)
Phosphoric acid	532 t/d
TSP (46% P <sub>2</sub> O <sub>5</sub> )	1,400 t/d or 450,000 t/a

These plants are still in the charge of the Romanian general contractors and have not yet been accepted mainly because of the following problems:

Damage to rubber linings in pipes and valves in the phosphoric acid plant

Damage to impellers of acid pumps

Unsatisfactory water balance

High moisture content in the product: high temperature of product

Unsatisfactory size of the granules

The general contractors are working on these and other problems and it is hoped that the plants will be brought to acceptable standards within 3 to 4 weeks.

The sulphuric acid plant has two streams with double absorption. It has three turbine-driven air blowers, one for each stream, while the start-up/stand by is motor-driven. The sulphur storage has a low plinth, and as it floods in rain or snow, it needs to be raised. The phosphoric acid plant also has streams with a prayon filter, pre-reactor and main reactor. It uses 29% P<sub>2</sub>O<sub>5</sub> rock and produces 33% P<sub>2</sub>O<sub>5</sub> acid, which is further concentrated to 52% P<sub>2</sub>O<sub>5</sub>. The TSP plant, using 31% P<sub>2</sub>O<sub>5</sub> phosphate rock has three streams up to saturation and two streams for granulation. There are six pan granulators for each stream. Of these, four must be running at a given time to provide the required capacity. Mechanical vibrating screens and oversize crushers (two-roll type) are giving mechanical maintenance problems.

The TSP plant produced 59,140 t in 1981 and 115,746 t in 1982, the phospho-gypsum being trucked and dumped near Kattinah Lake. Various alternatives to dispose of this residue are still in the planning stage.

### D. Costs of production

The ex-works cost of production is:

	(\$/t)
CAN	148
urea	239
ammonia	576
TSP	249

These prices are based upon the official price of naphtha and rock phosphate, and in order to earn foreign exchange, plans to export surplus urea and TSP should not be abandoned, even if the ruling international prices are unduly low. Losses can subsequently be made up by the Government.

## II. EXISTING MAINTENANCE SYSTEM AND EQUIPMENT

Initially, GFC possessed a centralized maintenance system, but this has since been completely decentralized, and no single person is now responsible for maintenance of all the plants. Maintenance engineers report to a common technical head with regard to mechanical, electrical and instrument maintenance, and he reports to his own plant chief. There are thus three groups pertaining to the CALNITRO, ammonia-urea and TSP plants. Proper co-ordination between these groups and their central workshops and spares stores is also lacking by reason of the complete decentralization. The workshop and stores heads report to different directors or managers who have neither connection with nor responsibility for maintenance. The central inspection group with its various instruments for on-line and off-line inspection and monitoring, is also independent of the maintenance groups.

The central workshop has a reasonable stock of machine tools, but lacks a dynamic balancing machine, a heavy hydraulic press and a foundry. The workshop also served the old plant and the addition of a few precision tools with a revamping of the existing facilities as yet unused is sufficient to cope with the new ammonia-urea and TSP complexes apart from providing nominal workshops with a lathe, drilling machine, hack saw, hydraulic press etc. at the two new locations.

The heat treatment section should be activated by the addition of a furnace. Good housekeeping in the workshop and in the disposal of all scrap, unwanted material and even unwanted tools is badly needed. The work of the workshops is seriously hampered for lack of necessary raw materials. The bulk of bar stocks, pipes, plates and sheets in the stores are not identifiable, their chemical composition being unknown. The GFC central laboratories are not equipped to undertake the analysis of metals.

The lack of adequate spare parts, the difficulty of identifying and properly retrieving existing spares in the stores, and the lack of experienced maintenance personnel are considered to be major constraints of the plants, apart from the non-existence of an organized maintenance organization. Experience has been effectively diluted by the frequent rotation of engineers, and the transfer of experienced engineers to central offices. Training of engineers and operators and maintenance technicians at all levels is most essential, and there is a need to produce training manuals for all plants.

GFC needs to procure at least two mobile cranes, one of 60-75 t capacity and a boom length of approximately 45 m and one of 15 t capacity and a boom of approximately 20 m.

### III. GFC ORGANIZATIONAL STRUCTURE

Study of the existing organizational structure (figure I) reveals a very wide span of control and a fragmentation of the production and maintenance departments and services. In order to achieve effective management and two-way communication, only five or six persons should normally report to one person. Since the present GFC establishment comprises three fertilizer complexes, it is necessary to introduce the concept of one operations director (a sort of mini general director) who would be given full authority and responsibility for production and maintenance at all plants. All the direct services required for production and maintenance of the plants, such as central workshops, laboratory, materials management (purchase and stores), fire and safety, NDT inspection team etc. should report to him either directly or through production and maintenance managers.

#### A. General Director

A very wide span of control exists, with 11 directors/managers reporting to the General Director (figure I). This has been reduced in the recommended structure to only 5 directors by introducing the concept of an operations director, and combining all finance activities under one finance director (figure II-1). If Syrian Law requires separate finance and accounts departments, the point can be met by having one finance manager and one accounts manager, both reporting to the finance director.

The second alternative suggests posts of only two directors - operations and finance - with the three other posts being designated as managers (figure II-2). Their work load and responsibility is equivalent to that of the production and maintenance managers.

#### B. Operations Director

Under the two alternatives stated above, the following department heads would report to the operations director:

<u>Proposed alternative 1</u> (figure III-1)	<u>Proposed alternative 2</u> (figure III-2)
Production Manager	Production Manager
Maintenance Manager	Maintenance Manager (Mechanical)
Materials Manager	Maintenance Manager (Electrical and Instruments)
Laboratory Manager	Laboratory Manager
Superintendent of Fire and Safety	Materials Manager

The first alternative, then, would be to have a common head of department for all maintenance functions - mechanical, electrical and instruments - for all plants in order to ensure effective co-ordination. However, if GFC desires, posts of two maintenance managers, one mechanical and the other electrical and instruments, could be created. In doing so, co-ordination between these two wings would become the responsibility of the operations director.

Figure 1. Existing organization

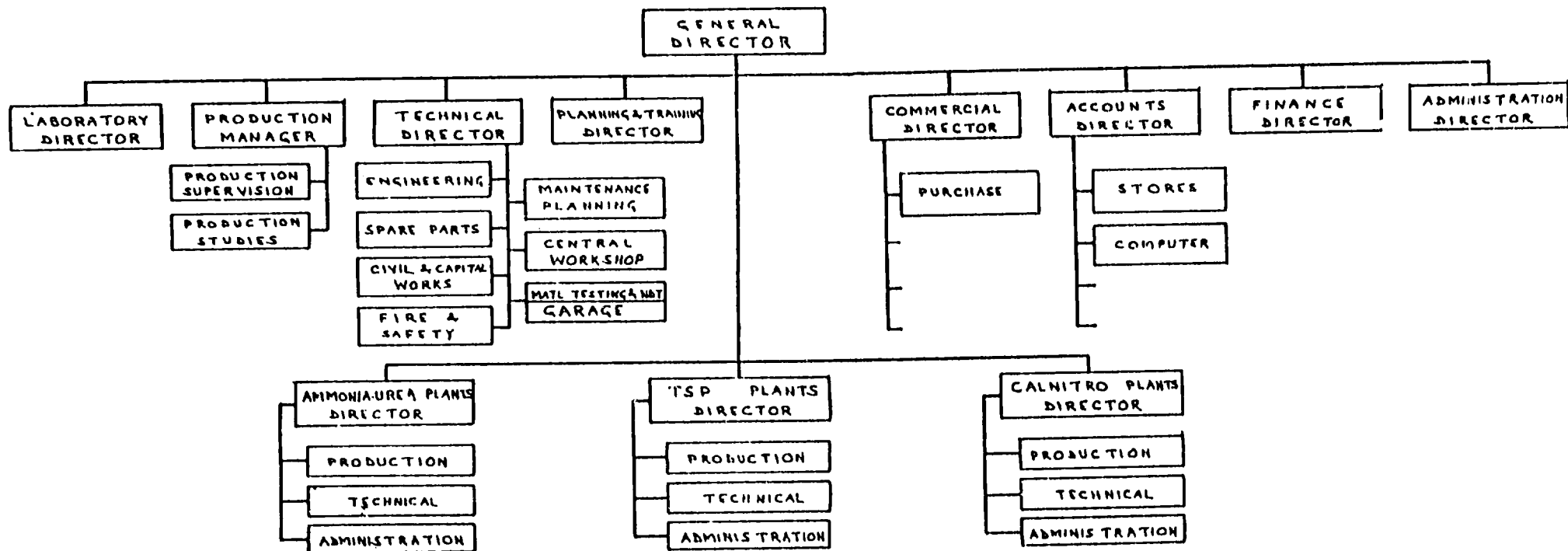


Figure II-1. Proposed organization chart for GPC: alternative 1

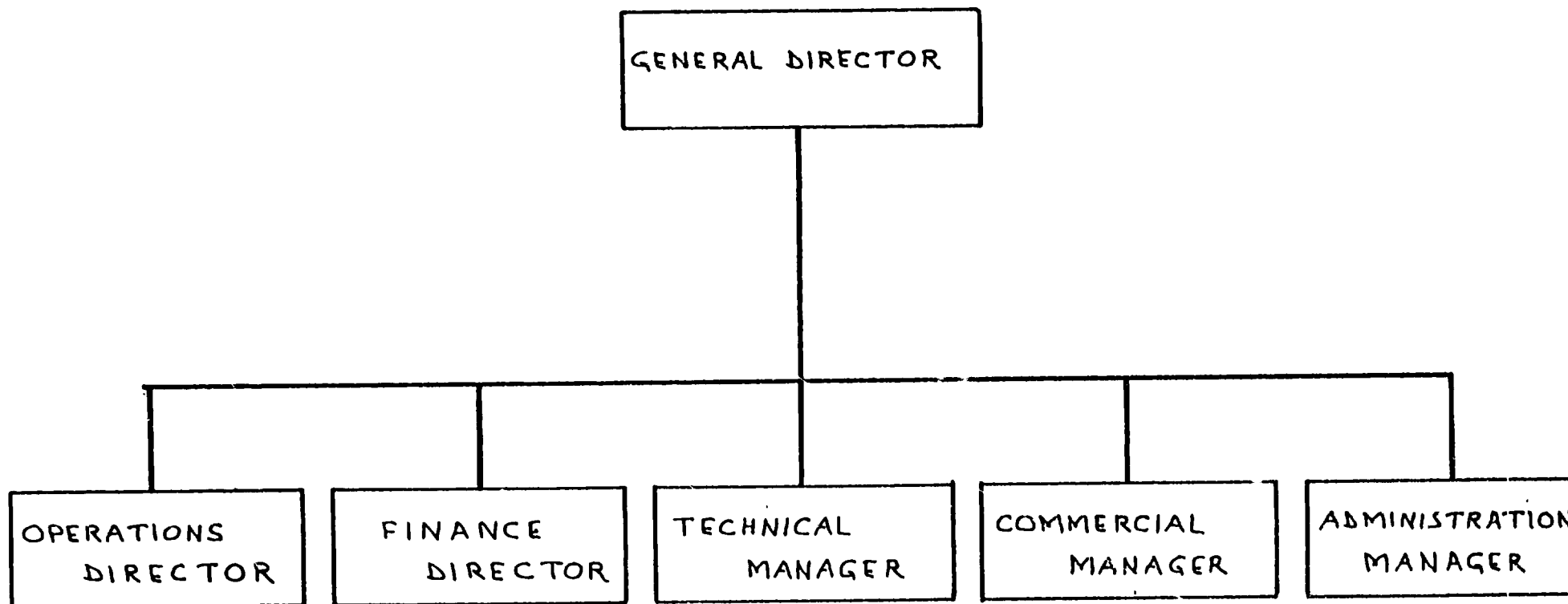
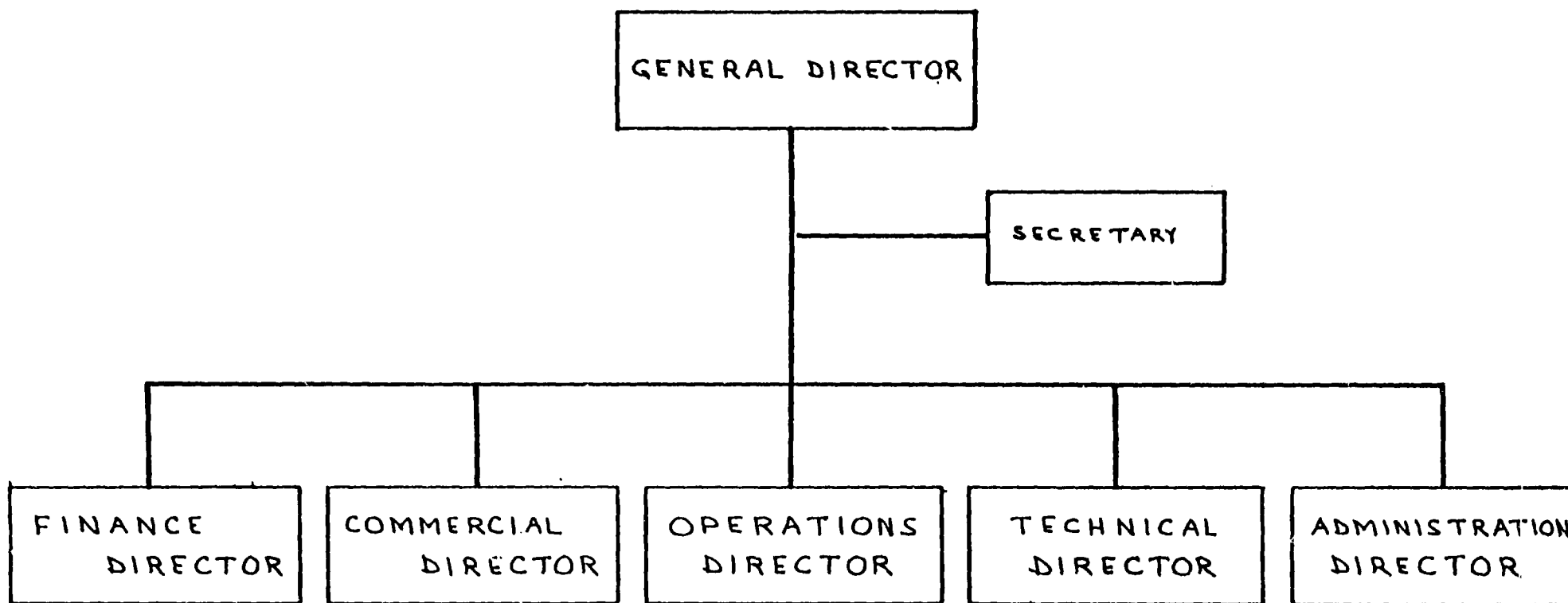


Figure II-2. Proposed organization chart for GFC: alternative 2



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Figure III-1. Operations Director: alternative 1

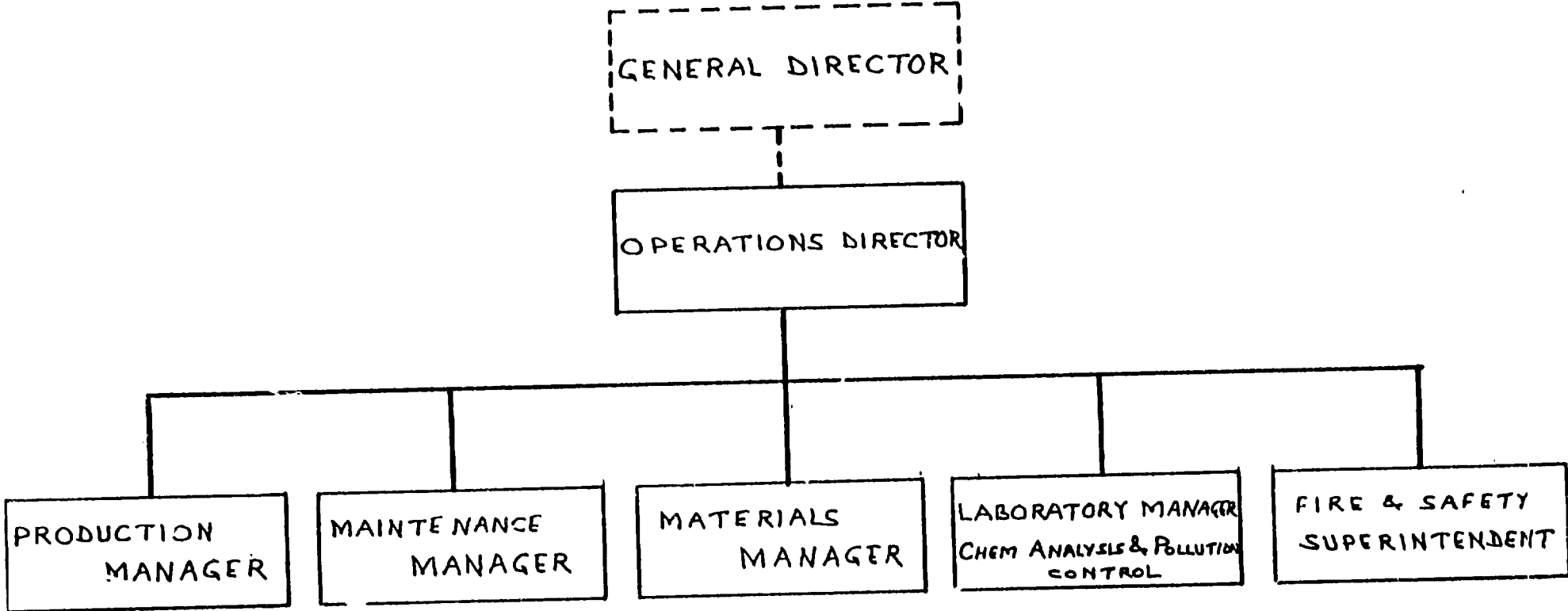
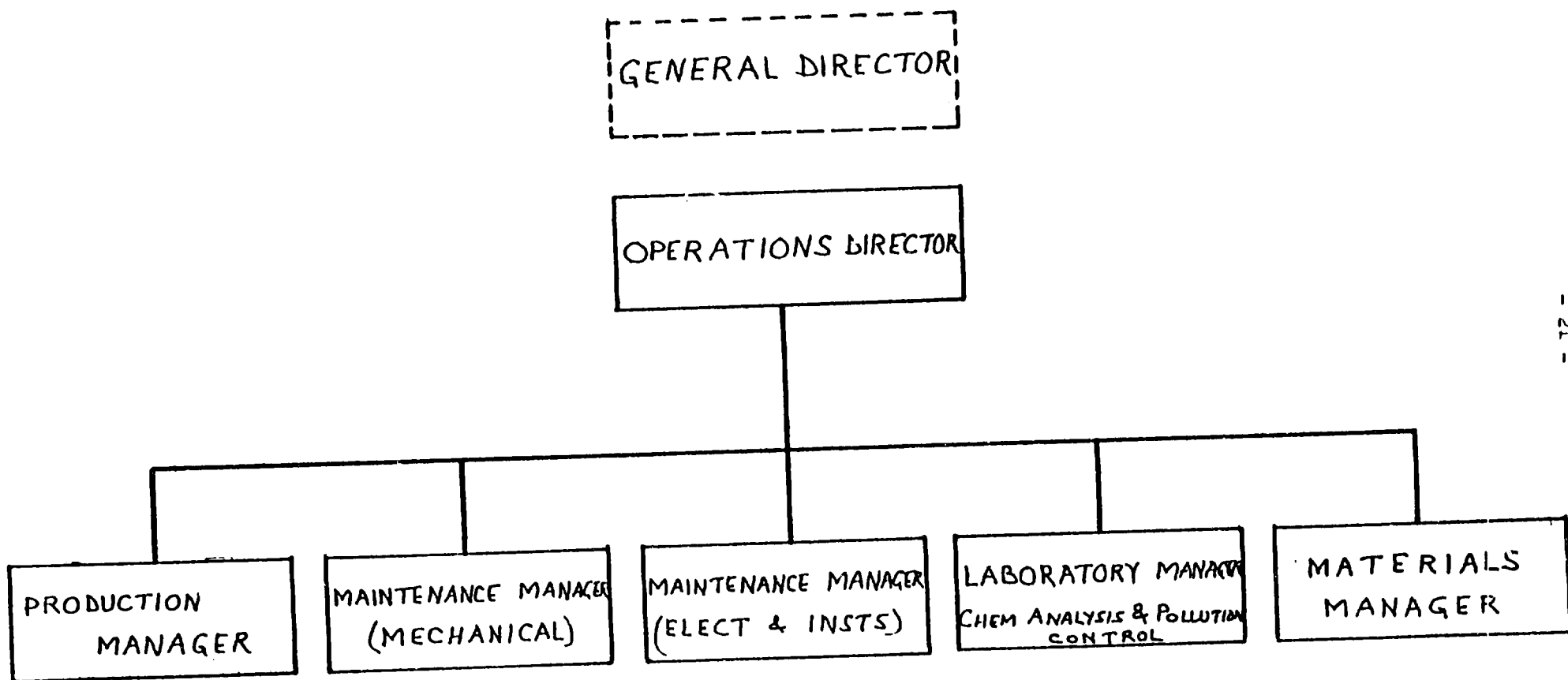


Figure III-2. Operations Director: alternative 2





### C. Production Manager

Here again two alternatives are suggested. In the first alternative, a concept of a utilities manager has been introduced. He would be responsible for looking after all the three utilities presently under different managers, and this would ensure better co-ordination as operational parameters, chemicals used etc. are common factors. It would also help in managing operating personnel more effectively, since they could easily be directed from one utility to the other. The personnel reporting to him would be:

#### Proposed alternative 1 (figure IV-1)

Utilities Manager

CALNITRO Manager

Ammonia-urea Manager

TSP Manager

#### Proposed alternative 2 (figure IV-2)

CALNITRO Manager

Ammonia-urea Manager

TSP Manager

Superintendent: Fire and Safety

### D. Maintenance Manager

With the concept of one maintenance manager responsible for complete maintenance of all the plants, the recommended organization brings under one head the central workshops, central inspection and condition monitoring team, and the various specialists. It envisages creation of posts of a deputy maintenance manager for each discipline indicated in figure V-1, which would facilitate better co-ordination of individual disciplines amongst the three plants.

The second alternative keeps the concept of common technical heads for three plants as at present (figure V-2). The variation would be to bring the central workshops and the NDT inspection team under the maintenance manager. In the third alternative (figure V-3), maintenance manager (mechanical) would be responsible for mechanical maintenance only, although the central workshops and the NDT team would continue to report to him.

#### E. Maintenance Manager (Electrical and Instruments)

Should the proposed alternative 2 for the operations director's organization be adopted, the position of maintenance manager (electrical and instruments) would be as in figure VI.

### F. Materials Manager

As discussed earlier, the concept of materials manager must be introduced. Purchase and stores report to the materials manager, and he reports to the operations director (figure VII). At present, purchase comes under the commercial director and stores come under the accounts director. If desired, only very major purchases such as naphtha fuel oil, rock phosphate, sulphur or dolomite, could be left with the commercial director.

Figure IV-1. Production Manager: alternative 1

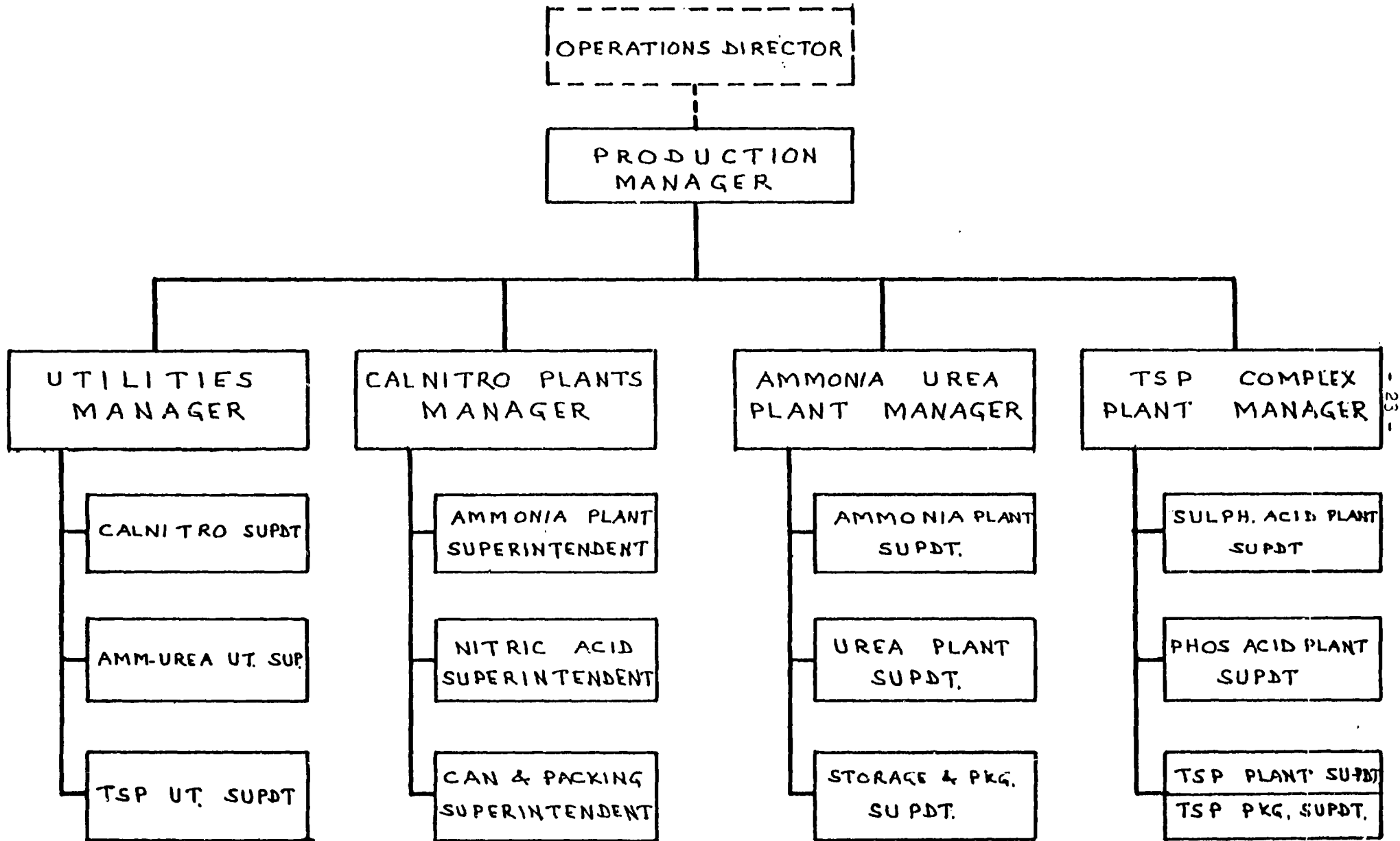


Figure IV-2. Production Manager: alternative 2

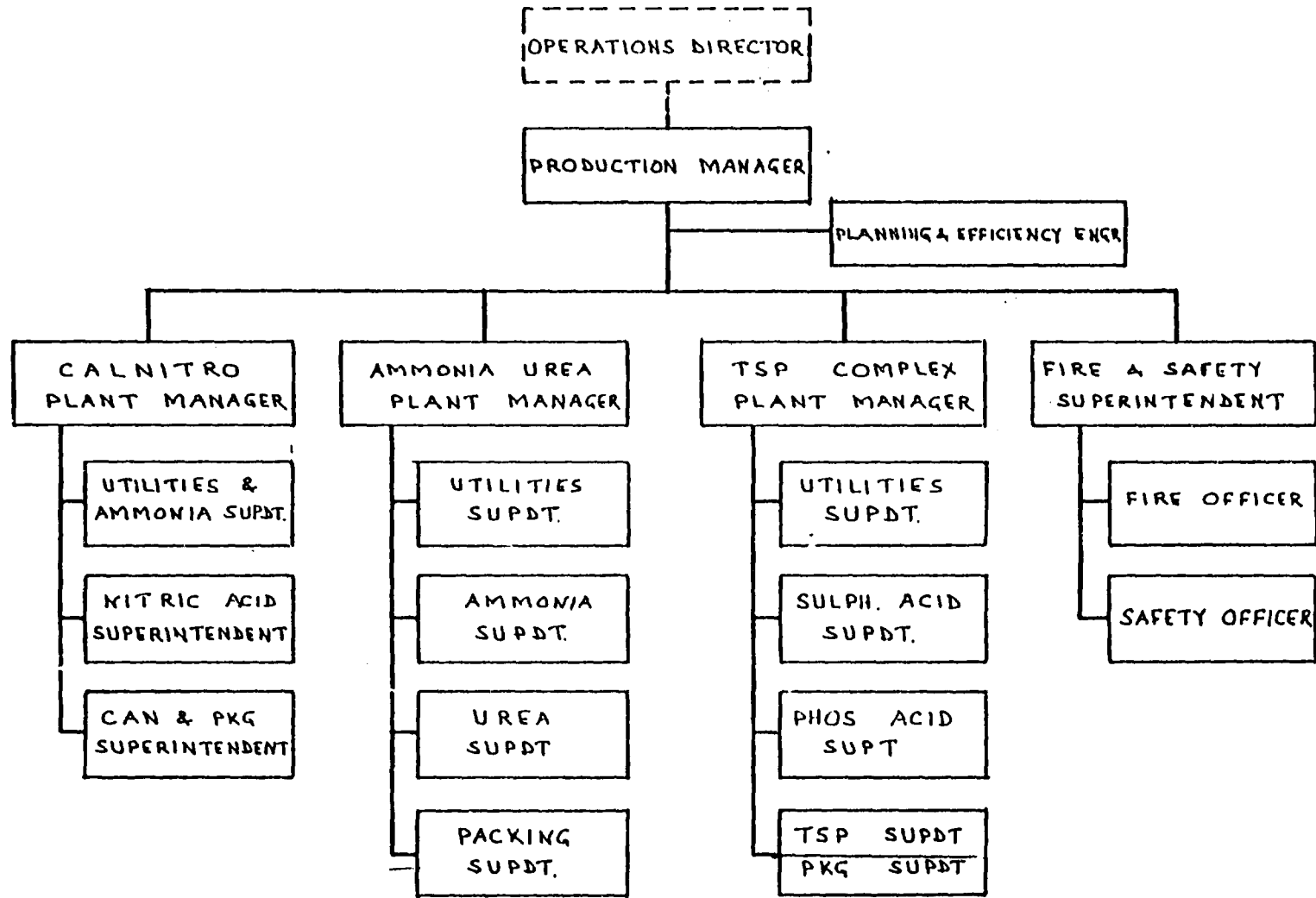


Figure V-1. Maintenance Manager: alternative 1

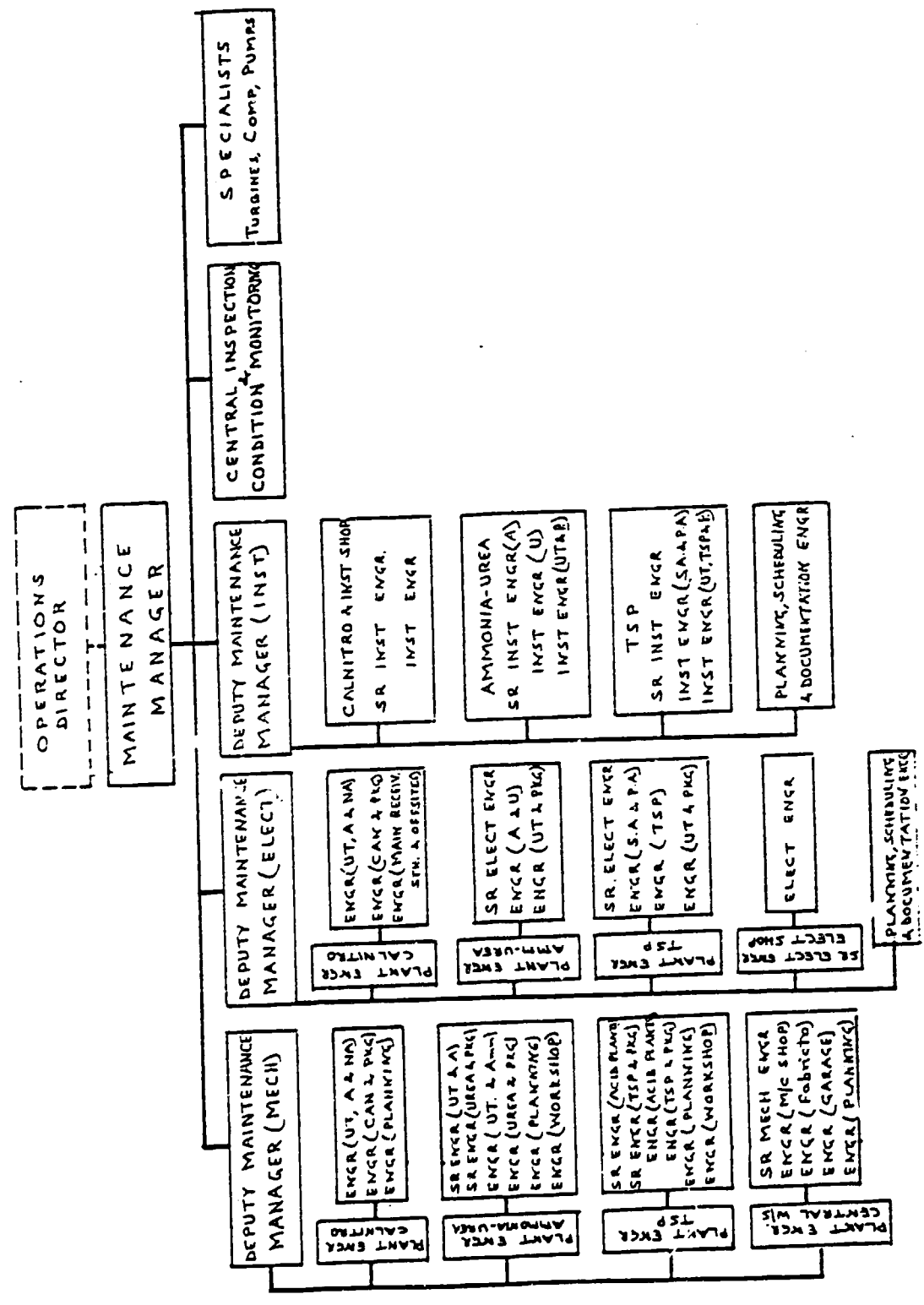


Figure V-2. Maintenance Manager: alternative 2

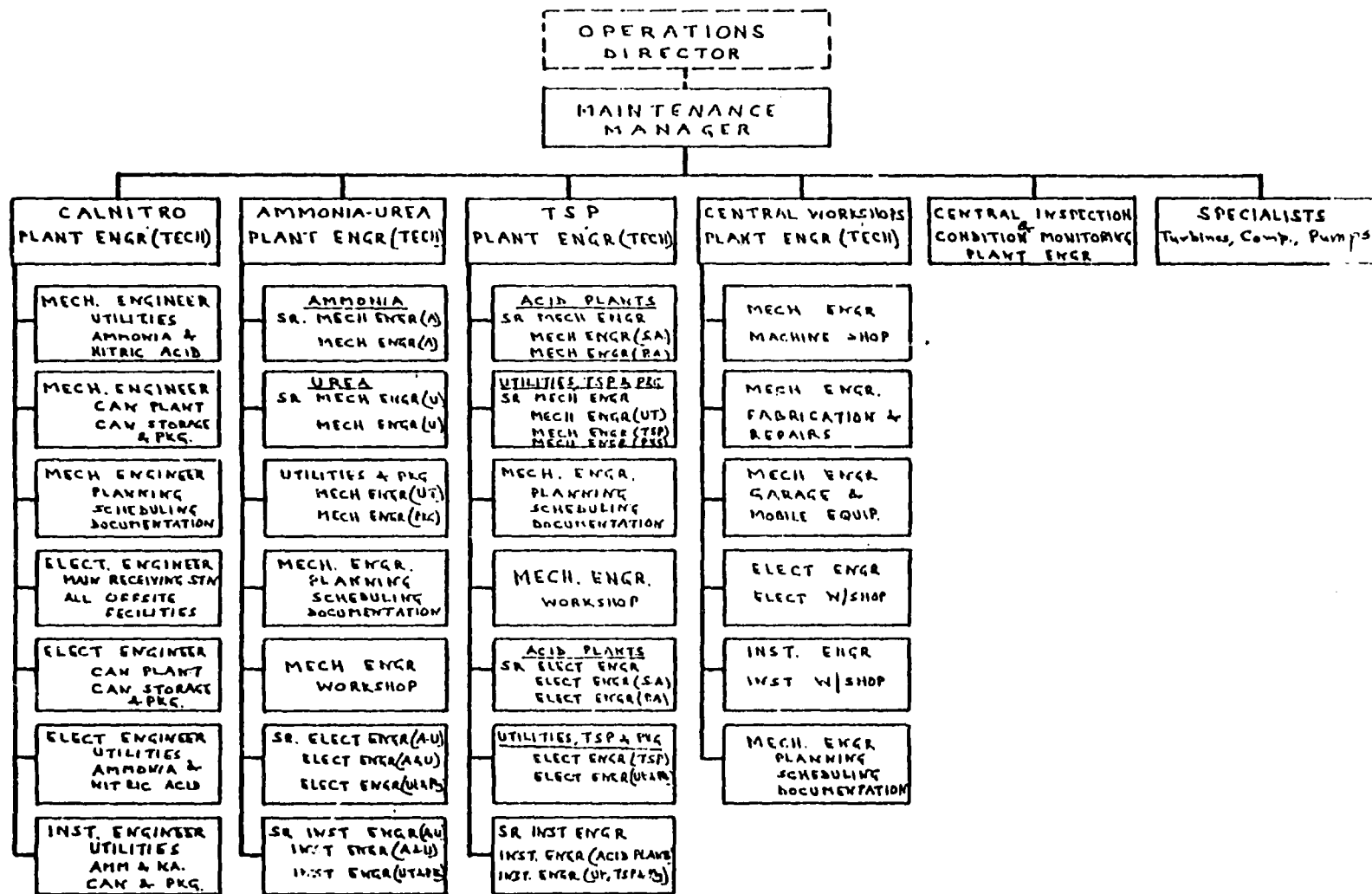


Figure V-3. Maintenance Manager: alternative 3

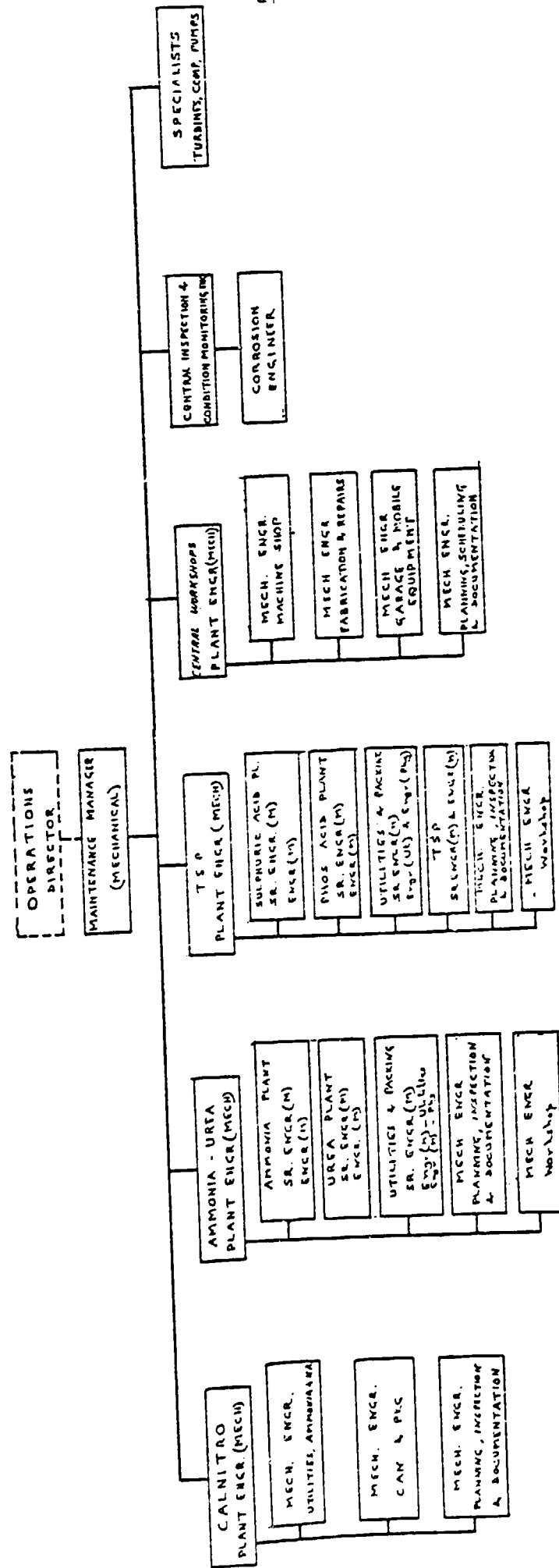


Figure VI. Maintenance Manager (Electrical and Instruments)

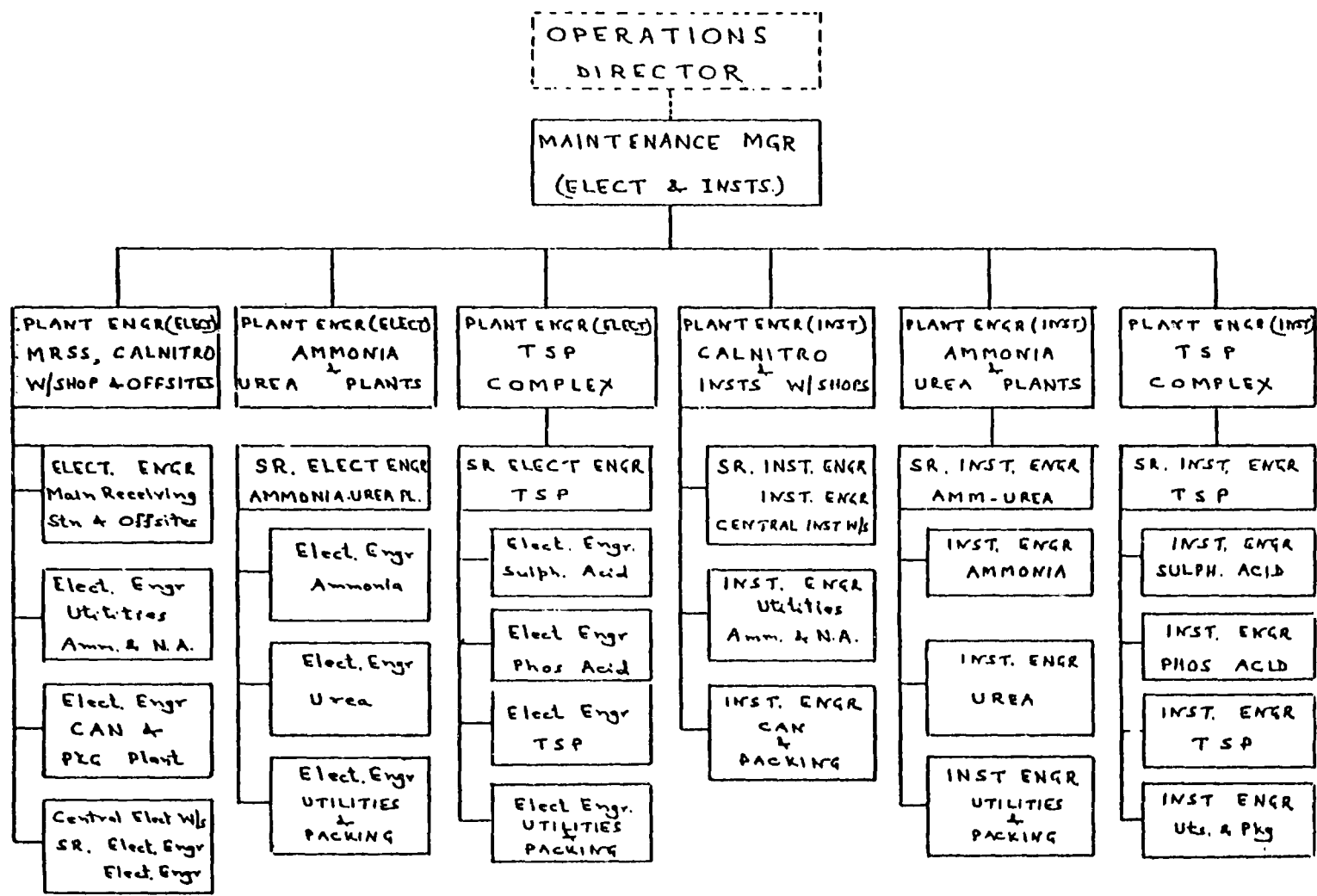
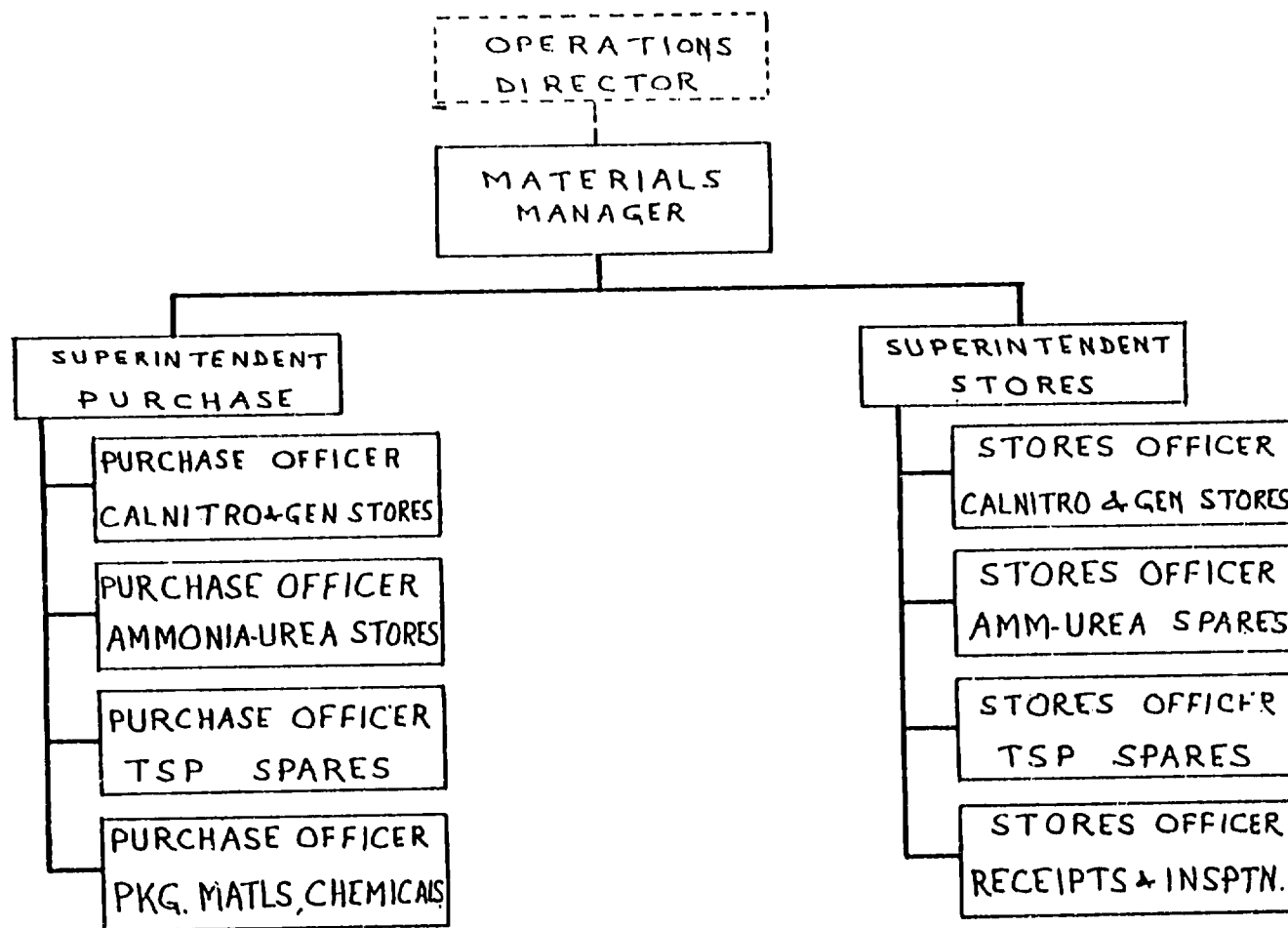


Figure VII. Materials Manager





G. Technical Director/Manager

Figure VIII gives the areas responsible to the technical director/manager.

A technical department is the technical brain of an organization and should therefore be saved from its day-to-day problems. Central workshops, garage and NDT inspection should therefore be transferred to the maintenance department where they rightfully belong.

In all cases the first alternatives are preferred as providing better co-ordination and organizational control. During discussions, the GFC General Director was also in favour of the first alternatives proposed, and for these reasons the final recommended organization structure is that illustrated in figure IX (General Director) and figure X (Operations Director).

Figure VIII. Technical Director/Manager

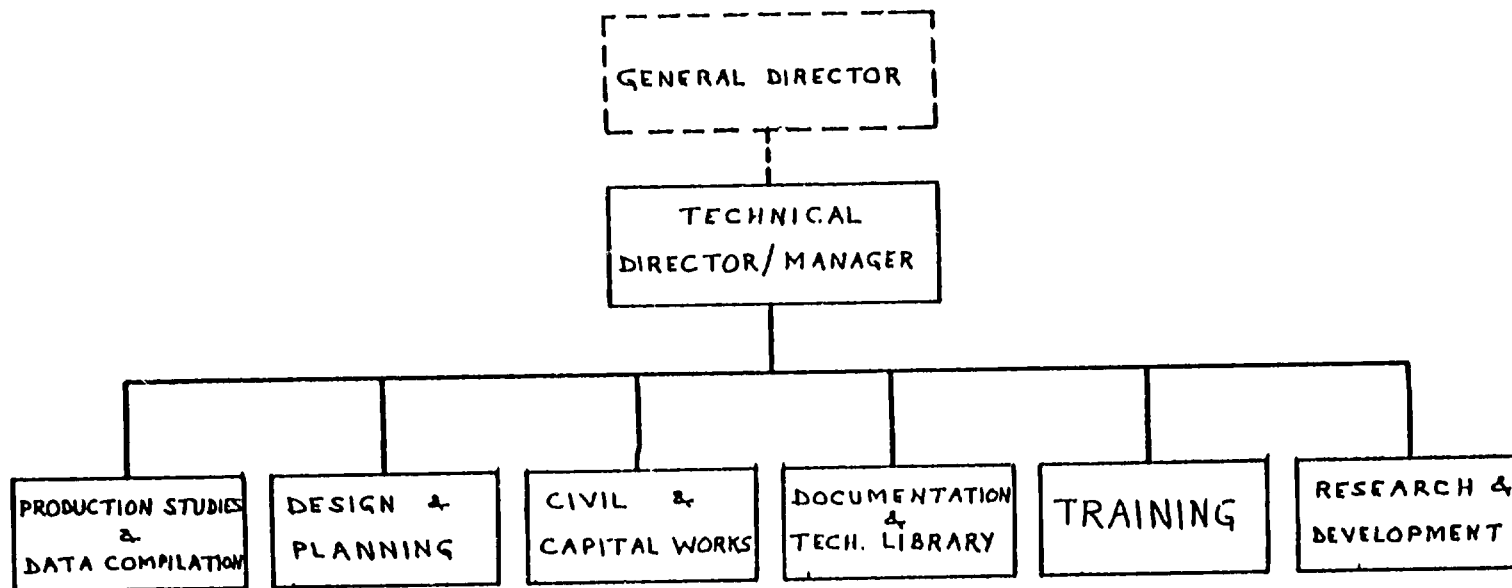


Figure IX. Recommended organization chart: General Director

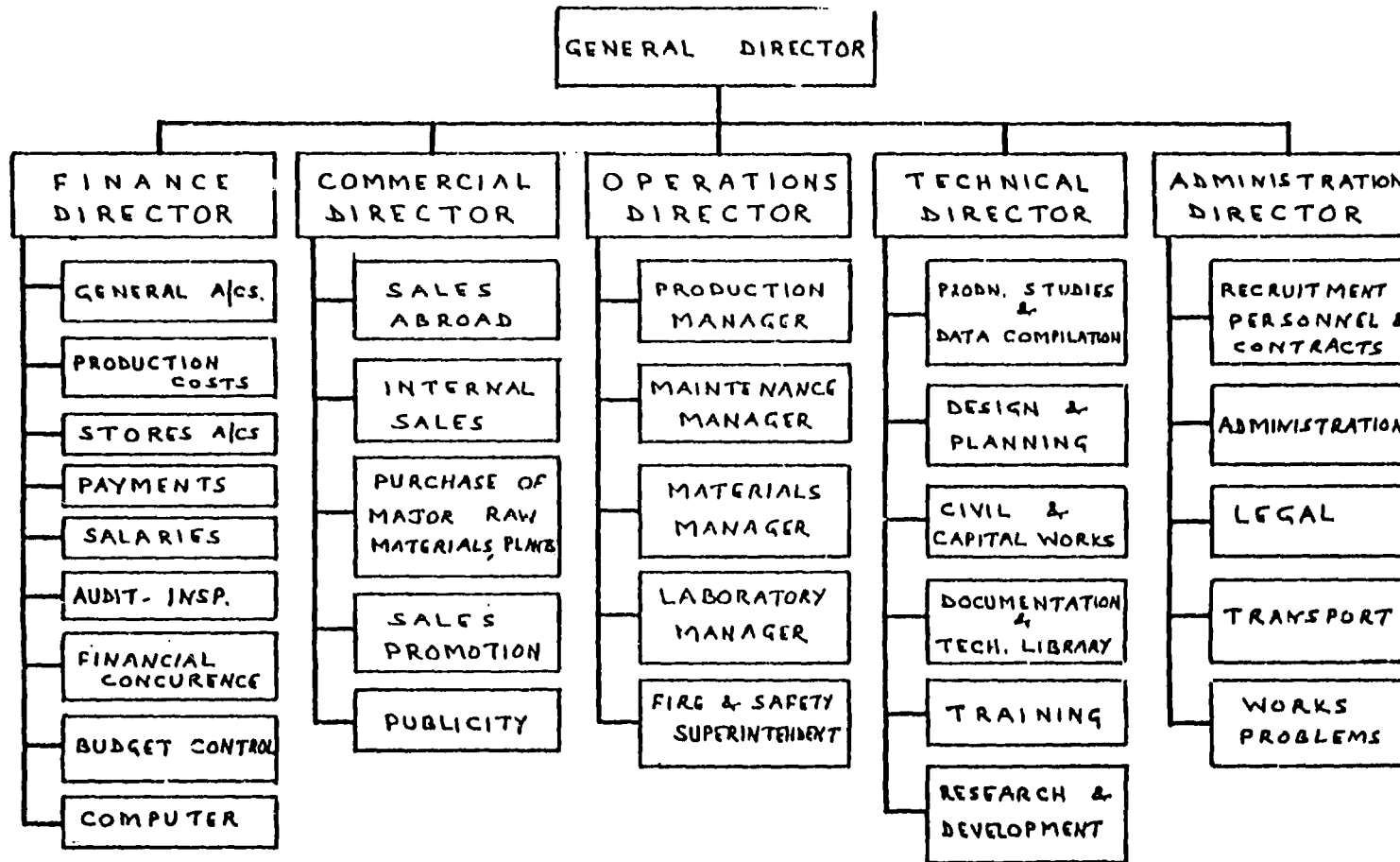
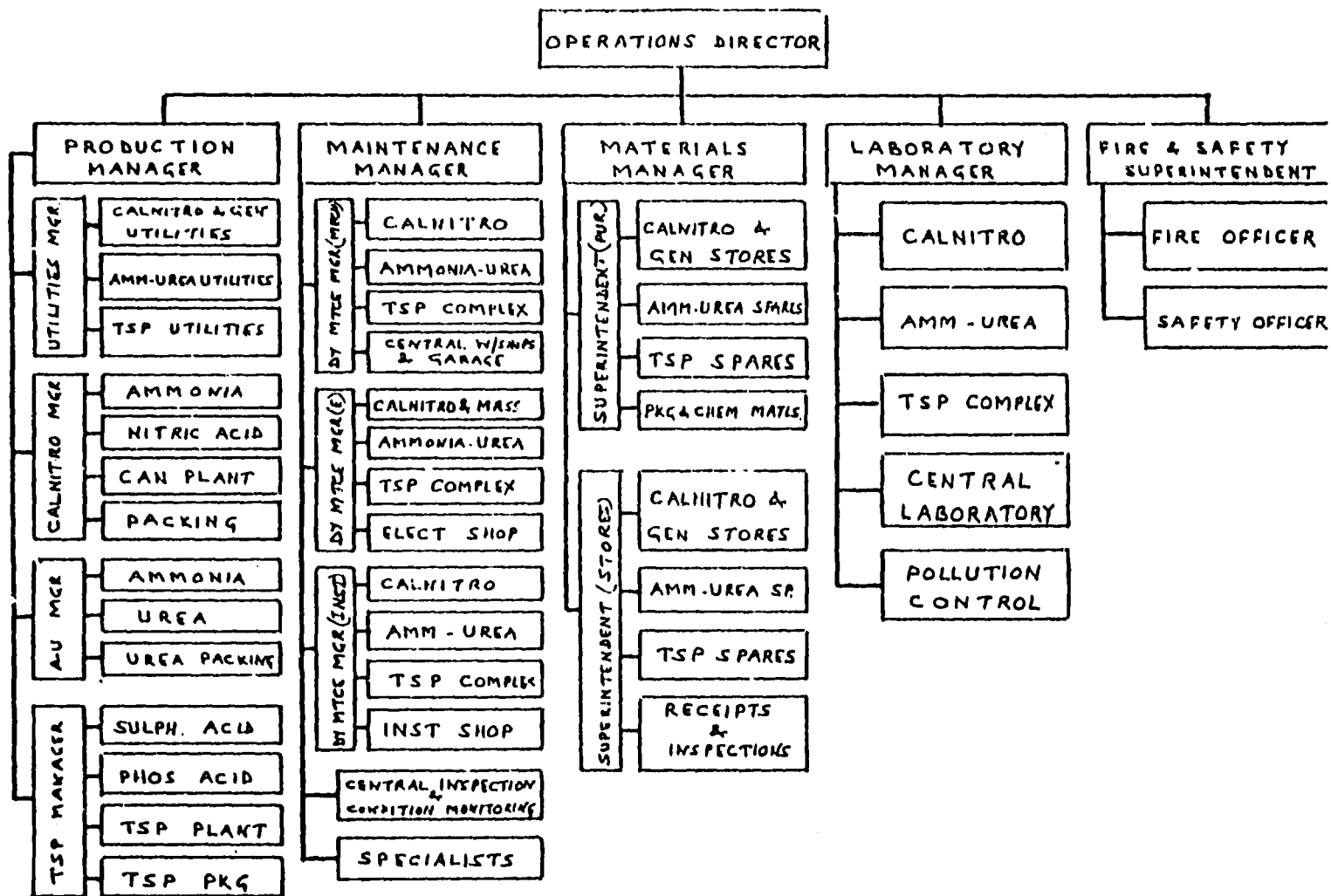


Figure X. Recommended organization chart: Operations Director



1  
2  
1

#### IV. MAINTENANCE DEPARTMENT

##### A. Organization

The maintenance department of the General Fertilizers Company at HOMS needs to be organized as a distinct entity, reporting to one head of maintenance, the maintenance manager who will be answerable to the operations director and maintain a close liaison with the production manager and materials manager as recommended in the organization chart. The following should be under his charge and control:

- CALNITRO plant maintenance
- Ammonia-urea plant maintenance
- TSP plant maintenance
- Central workshops and garage
- Central inspection and condition monitoring
- Specialists

It is recommended that the existing decentralized organization structure should be changed to a mixed organization structure, with a pool of workers and technicians available in the central workshops to be directed to any plant at the time of a major shut-down. Modern fertilizer plants are planned to be on stream for 330 days in each year, so that relatively few maintenance workers are needed to attend to day-to-day maintenance or minor interruptions. The annual turnaround, a planned shut-down, needs a large work-force because a great deal of equipment must be attended to simultaneously over a very short period of time. A good maintenance schedule and effective co-ordination in the replacement of catalysts, inspections etc. should complete the turnaround within 20 to 25 days. It is futile to maintain such a large workforce in each plant as happens in a decentralized system since they should be effectively deployed in the central workshops, which should handle major repairs and assemblies of such equipments as can be brought to the workshops. and for a range of construction work etc.

##### B. Maintenance system

Modern fertilizer plants are highly capital-intensive units in which down time is very costly. Their productivity is governed by their on-stream reliability and their operation at capacity level. New generation ammonia plants do not even start to produce an operating margin until an overall production of nearly 70% has been achieved. This is particularly relevant to the GFC ammonia plant which cannot be run at high loads even when the plant is fully available, because the plants capacity far exceeds consumption.

The maintenance function is categorized into the following:

- Breakdown
- Preventive
- Predictive
- Condition
- On-line

### Breakdown maintenance

The ancient practice of attending to maintenance requirements only when a machine actually breaks down must be discarded, especially in modern fertilizer plants. Tools, manpower and materials cannot be organized in advance of a breakdown, and the loss of production involved can prove much more costly than replacement of the equipment itself. Better maintenance systems must therefore be evolved.

### Preventive maintenance

Preventive maintenance aims at discovering and preventing faults from occurring by overhauling the key equipment at regular intervals. The appropriate interval is determined on the basis of local experience and the manufacturer's recommendations; and is thus empirical, even arbitrary. Maintenance scheduling engineers have a tendency to play safe and to fix less than optimum inspection schedules to avoid breakdown and machines are thus unnecessarily opened and overhauled. In this respect one must remember that the failure rate of a newly overhauled machine is many times greater than one which has been in operation for sometime, and that major preventive maintenance is often done when less would do. Correlating the timing of all preventive maintenance schedules within a continuous process industry like a fertilizer plant is a further problem, to be solved by compromise.

### Predictive maintenance

Unnecessary shutdown for programmed preventive maintenance can be avoided by planning maintenance work in the light of the requirements of the system and the equipment. By keeping a close watch on operational parameters and keeping track of the state of health of rotating and stationary equipment without stopping the equipment, a maintenance schedule can be predicted and planned. The use of NDT instruments is helpful in this regard. Thus when the preventive maintenance is carried out on the basis of condition of the equipment, forced outage hours are minimized and unnecessary maintenance is avoided. A preventive maintenance system based on inspection during operation and periodic replacement is likely to be more effective. Such a system of maintenance, which is termed as predictive maintenance, is recommended to be adopted for G.F.C. plants, will facilitate proper planning.

### Condition maintenance

Condition maintenance, though regarded as a recent concept is basically predictive maintenance, where maintenance is performed at irregular intervals, determined solely by the real condition of the equipment or its components. In order to establish these intervals, one must know the actual conditions of the machine at a given time and also the trend of its deterioration over a period of time. Ideally this should be done just before the machine or component is expected to breakdown thus eliminating unwanted overhauling etc. It is done only on machines requiring attention, and is achieved by a system of inspections called condition monitoring.

### On-line maintenance

Apart from inspection with help of NDT instruments while the plant is running, on-line maintenance repairs can be carried out on equipment which cannot be isolated, mainly in respect of leak sealing, isolation, by-pass (and therefore possible replacement), relief valve resetting, heat-exchanger cleaning, refractory failure, and local vessel thinning.

Isolation of equipment, especially primary reformer tubes, is achieved by hydraulically nipping the small-bore pipes (outlet pigtails). "Freezing plug" techniques are used for larger bore pipes. Needless to say these require great experience, careful control and safety checks.

Injecting balls upstream of the exchanger - which then pass through the tubes and clean them - clears fouled up condensers and exchanger tubes.

Falls of refractory materials in furnaces and flue ducts have been successfully dealt with by spraying an insulating coating over the affected area and then covering with an external steel plate.

Severe corrosion at a circumferential weld is successfully repaired on-line by welding steel plates over the weld to reinforce the area.

The sealing of leaks of process fluids (reformed gas, synthesis gas, ammonia, or high-pressure steam) is the most important of all on-line maintenance techniques. The method involves fitting a containment clamp around the joint or hole and injecting a sealant (thermosetting) to form a new gasket. A controlled alternative leak path is provided and the leak vented during the sealing process. Before attempting such an operation one must ensure that the:

- (a) Joint assembly is perfectly sound;
- (b) Bolts are of correct size;
- (c) Correct material is used;
- (d) Bolt stresses will be within design;
- (e) Strength of the remaining pipe is adequate for the sealing operation.

### Technical skills

For any maintenance system to be successful it is essential to improve the technical skills of the technicians. For this a rigorous on-job training is called for. Training manuals should be written in co-ordination with the training department and distributed to the staff. It should be ensured that the maintenance staff not only acquires the basic skills but improves upon them. For this purpose expatriate help from other countries is unavoidable, until the local staff is sufficiently trained. The present complement of expatriates in mechanical maintenance appears to be inadequate.

Choice of maintenance system

As recommended earlier, a predictive maintenance system based on NDT inspections (condition monitoring) is most suited to the needs of GFC. However certain other needs of the continuous chemical fertilizer industry must also be catered for, e.g. change of catalysts etc.

It is therefore recommended to plan annual turnarounds initially, even though plants elsewhere have turnarounds at 18 months or two years intervals. During the turnaround only such equipment should be opened as needs attention in the on-line continuous monitoring system. The frequency of such checks should be weekly, fortnightly, monthly or bi-monthly, depending upon the criticality of the equipment. Trend charts should be plotted to recognize and monitor the condition of the equipment.

Since GFC may be involved in turnaround this year, it is recommended that one or two senior maintenance engineers should shortly be sent to selected ammonia-urea plants during their annual turnaround and thus acquire some on-the-job training. Alternatively an expert from abroad may be brought in about one month in advance of the initial turnaround, in order to plan the event and ensure a minimum of down-time.



## V. CONDITION MONITORING

In a maintenance system it is necessary to introduce a systematic examination of the equipment and its components, considering each machine as an individual with its own characteristics and life. Such a system, monitoring the health and condition of the equipment is called "condition monitoring" and is done with the help of a variety of instruments. Broadly it is classified into two categories:

- On-line (while equipment is running)
- Off-line (during stoppage or turnarounds)

Condition monitoring is the basis of condition maintenance as described in earlier chapters.

The GFC inspection department has a fairly large number of NDT instruments:

Ultrasonic thickness metre	Magnetic particle testing kit
Ultrasonic flaw detector	Magnetic dye penetrant kits
Gamma ray radiography equipment	Digital surface thermometer
Dye penetrant kits	Rockwell C portable hardness tester
Ferritoscope	Portable brinell hardness tester
Infra-red pyrometer	Thermal chalks
Shock pulse metre	Vibration and spike energy metre
Ultrasonic hardness tester	Material testing laboratory

The additional equipment described in the table should be procured for the department. It would also be desirable to procure a stroboscope, a metal spectroscopy and a vibrograph.

### Additional inspection equipment required

Equipment	Use	Approximate price (dollars)
Vibration analyser/dynamic balancer, with X-Y recorder	Measuring and analysing the vibration of rotary equipment	15 000
Vibration/sound-level meter	Measuring vibration and sound levels	1 500
Boroscope	Internal inspection of tubes	7 500
Reed tachometers: 600-6 000 rev/min 6 000-24 000 rev/min 1 500-7 500 rev/min	Measurement of rotational speed by contact	500
Balancing stand, 3 000 kg capacity	Dynamic balancing of rotors	10 000
Helium leak-detector	Detection of minute leaks in lined vessels; e.g. urea reactors	12 000

Metallurgical microscope	Metallographic studies	2 200
Portable magnetic crack- -detector, permanent-magnet type	Detection of cracks in ferrous metals	100
Mini molydetector	Checking ferrite contents of stainless steel	30
High-voltage, high-frequency spark-tester	Checking rubber and FRP linings	200
Elecometer	Measurement of coating and paint thickness	400
Shore hardness tester for both Shore A and Shore B	Measuring hardness of non-metals, rubber, FRP etc. <u>in situ</u>	120
Vibration analysis kit	Automatic analysis of machinery vibration	30 000
Viscometer	Measuring viscosity of oils <u>in situ</u>	140

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It is recommended that the NDT inspection team is subordinated to the maintenance manager in the reorganized set-up. The team also needs to become well acquainted with the use of various instruments and be confident of correct interpretation of the observations.

The techniques to be used for condition monitoring depend upon the construction of equipment, operating conditions and the parameters which are to be monitored. Some of the techniques not covered by the instruments available with GFC are described below.

#### Performance evaluation

The operating parameters maintained by the production department, e.g. pressure, pressure drop, temperature, flow, pH, quality of raw materials and utilities, are very useful in knowing the condition of the equipment. Good control of these parameters and steady operation will ensure good condition of the plant and reduce maintenance and downtime. Mal-operation and supply of poor quality of raw materials, such as naphtha with high aromatics, uncontrolled pH, and high silica in steam, are likely to cause serious damage to the equipment and increase avoidable maintenance.

#### Look, Listen, Feel (L.L.F.)

The L.L.F. technique is commonly used for all rotating machines, furnaces etc. Failures are mostly preceded by warning signals in the form of excessive vibration, abnormal noise, increased bearing temperatures etc. In the case of furnaces, many failures are caused by flame impingement on the furnace tubes. By use of L.L.F., such abnormal conditions can be recognized at the initial stage and necessary corrections made. One engineer tours the plant and carries out visual inspection of the relevant equipment. Any abnormality is intimated to the relative plant maintenance and production departments for correction. If done thoroughly and in time this can result in the elimination of major maintenance work and possible catastrophic failure.

### Vibration analysis

Vibration can be caused by unbalance, misalignment, a bent shaft, bad bearings, damaged gears, faulty coupling, looseness etc., and vibration analysis is used to determine which of these defects is causing the vibration. The vibration level at various frequencies related to the running speed is measured and from the result it is generally possible to predict the predominant defect present in the machine.

This needs a clear understanding of the construction of the machine and its operating condition, but with experience in interpreting the analysis data it is possible to pinpoint the defect.

### Boroscope inspection

Visual inspection of parts, especially pipes, tubes etc. is carried out to check for deposits, scaling, pitting etc. With the help of flexiscopes or fibroscopes, it is possible to inspect "U" bends and other areas difficult to approach a magnification facility to identify even very minute defects is available with these instruments.

### Leak detection

Leak-testing techniques using halogens, helium or Freon are used where very minute leaks are to be detected. These have higher sensitivity to leakage than does conventional hydraulic or pneumatic testing.

### Spark testing

Spark testing is very commonly used to locate damage to rubber lining in vessels and pipelines and even very minor pinholes can be detected. Non-metallic coatings are also checked for pinholes by spark testing.

The frequency of checking is based upon:

- Criticality of equipment
- Availability of stand-by
- Operating conditions
- Cost of repair work and preventive maintenance
- Total cost of maintenance and cost of production loss
- Mean time between failures
- Mean time to repair
- Personal safety

Severity limits should be established, to fix warning (alarm) limit and the maximum (emergency) limit for each parameter being measured under condition monitoring.

Regular monitoring, proper recording and continuous review are all of paramount importance. A conscientious team of fully trained and motivated engineers and technicians is a pre-requisite for this programme.

### VI. MANAGEMENT OF MATERIALS AND STOREKEEPING

Operations and maintenance to a very great extent are dependent upon proper purchase and storage of the optimum quantity and quality of spare parts and other general maintenance stores. In GFC, purchases are made through the commercial department while storage responsibility lies with the accounts department. It is necessary that both purchase and store functions are brought under one materials manager, who should report to the operations director. This step is very essential for improving maintenance in the fertilizer factory.

There are 14 stores as listed below:

- Chemicals required for production
- Chemical reagents (laboratory)
- Oil
- Spare parts
- Electrical and instruments
- Machines
- Sacks (bags)
- Scrap
- Stationery
- Building materials
- TSP
- Ammonia and urea
- Raw materials
- Tools

The spare parts and materials of the ammonia-urea and TSP complex have not been taken over, nor are they properly identified and codified. The 14 existing stores listed above are too many and need rationalization and consolidation. The existing codification of seven digits is not adequate and it is recommended to adopt an 11-digit code which may be worked out on the following basis:

1	2	3	4	5	6	7	8	9	10	11
<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
Plant		Main section		Material of		Type or			Size	
		or equipment		construction		classification				

At the time of receipt and allocation of a code number, gaps must be kept to allow for new code numbers according to size, so that for the future sizes reflect the ascending order of the code.

Issuing procedure should be streamlined to avoid abnormal delays in issue of spare parts. It should not be necessary to seek the head of store's clearance on each issue note, and storekeepers should be authorized to issue the material on receipt of valid issue notes duly authorized by plant maintenance engineers.

The identification of raw materials and spare parts is of paramount importance. The following action should be taken immediately:

(a) Take samples of all unidentified materials and send them to the nearest reliable laboratory for chemical analysis. Care should be taken to allocate corresponding numbers or codes to the samples and original materials in order to avoid confusion and wrong marking after receipt;

(b) Instruct engineers at all plants to identify spare parts in the stores and update specifications;

(c) As a policy, eliminate damaged and unusable spares in the stores and inventories. Saleable scrap should be excluded from the stores without giving any credit as returning plant and it should be sold in accordance with the recognized sales procedure;

(d) Preserve spare parts and materials. Rubber materials, rubber-lined pipes and equipment, and conveyor belts must not be exposed to sun. Preservatives should be applied to parts which are subject to rust;

(e) Provide warm rooms for spare motors to avoid humidity. Similarly, air-conditioned storage is preferred for rubber jointing solutions and similar items;

(f) Weed out from the stores as much wood and combustible materials as possible to prevent any likelihood of fire. There should be no smoking in all stores and this rule should be strictly enforced.

## VII. FIRE AND SAFETY SERVICES

The fire and safety services possess the necessary equipment and seem to be fairly well-organized for fighting fires. A complement of three fire engines manned by a 16-man shift is considered adequate, although there is a proposal to increase the fire engines to four and staff to 20 per shift. Three persons per shift are responsible for safety. In common with other developing countries, the workers do not take safety seriously but safety is every day's and every body's business and it needs to be given high priority. In this regard the following suggestions are made:

(a) A record of each and every accident must be kept specifying the reason for the accident and remedial measures suggested or taken to prevent a recurrence;

(b) Every incident which could have resulted in a major accident should be treated as in (a) above;

(c) Pep-talks should be given to small groups of workers by safety staff and departmental engineers and supervisors on regular basis - say once a month - to inculcate safety consciousness;

(d) Safety slogans and posters should be displayed at prominent places throughout each factory;

(e) In order to utilize group pressures, prizes (about £S 30-40 each) should be awarded to all workers within a plant or section, when no accident takes place throughout the year. Personnel in administrative departments or those working in offices should be excluded from participation because they are not exposed to industrial risks and hazards. Drivers should be included in the scheme;

(f) Good housekeeping is an essential base for a good safety record. In order to introduce a competitive spirit, sections should compete in keeping the plant clean. Marks would be awarded by a committee which visits each plant every two or three months. Personnel of the best kept plant would be granted token awards (about £S 30-40 each) at the end of the year.

The cost of such awards is minimal when compared to cost of accidents which can cripple the human beings and damage equipment resulting in huge production losses.

As recommended in the organization chart, the fire and safety department should either come directly under the operations director or be subordinated to the production manager, on the grounds that it provides a service to the operational departments.

## VIII. TRAINING

The training director reports directly to the general director and is therefore independent of operations or technical departments. In the suggested reorganization, the training department is placed under the technical department. A two-year training course for school leavers chosen for the new projects was completed in 1982. So far there are no audio-visual aids or other training materials within the department, and formalized training programmes require to be worked out for all levels and implemented. Suggestions for improving training follow:

(a) Audio-visual training aids should be procured, especially the following:

- (i) A 16-mm movie projector and appropriate short training films;
- (ii) A slide-projector. Slides demonstrating a range of critical equipment should be prepared;
- (iii) A training projector with facility for handwritten additions to be made while image is projected on a screen;
- (iv) TV and video equipment with training films;
- (v) A public address system;

(b) In-plant and off-plant short-term training should be planned for various levels of employees starting with the critical sectors;

(c) Language courses should be initiated for those employees whom GFC anticipates sending abroad for training;

(d) To enrich the experience of engineers, visits to similar plants abroad, especially in the Arab States, should be organized.

(e) Outside experts, from within the Syrian Arab Republic where feasible, should be recruited to conduct short term training courses especially in general subjects e.g. management of materials, storekeeping, finance for non-specialist staff, and safety;

(f) GFC employees having expertise in particular fields should be encouraged to conduct training courses and classes. Where necessary volunteers can be given token financial remuneration;

(g) Training classes should be of two hours with two periods per diem. It is worthwhile to pay overtime for student employees who cannot be spared from shift operation etc.;

(h) Training manuals for personnel working in new plants should be prepared as a matter of urgency.

Annex

JOB DESCRIPTION

DP/RAB/78/021/11-53/32.1.F

Post title                    Consultant in the Maintenance of Nitrogen Fertilizer Plants

Duration                      One month

Date required                As soon as possible

Duty Station                 Home: Syria

Purpose of project            To provide the fertilizer industry with short-term consulting services, in order to improve technical skills, and to transfer managerial experience and specific expertise.

Duties                        The consultant will be assigned to the General Fertilizer Company and will specifically be expected to:

1. Study the existing maintenance system and services provided by the mechanical workshops of the two nitrogen fertilizer factories;
2. Assess the adequacy of the existing workshop equipment (machine tools, spare-parts storage, transport and lifting facilities);
3. Assess the organizational procedures relating to maintenance; e.g., reporting, staffing, procurement, engineering and manufacture of spare parts;
4. Recommend improved methods of maintenance planning and management, and advise on the establishment of a preventive maintenance system;
5. Make general recommendations for improving the maintenance workshop facilities and specify the specialized equipment necessary.

The consultant will also be expected to prepare a final report, setting out the findings of the mission and recommendations to the Government on further action which might be taken.

Qualifications              Mechanical Engineer, with extensive experience in the maintenance of machines and equipment of large-scale petrochemical or chemical fertilizer plants; experience in maintenance programming techniques and practices of preventive maintenance systems.

Language                     English; Arabic or French an asset.



Background  
Information

The nitrogen fertilizer industry in the country has recently increased its production capacity considerably. A large-scale ammonia and urea plant of 1,000 and 1,050 t/d capacity respectively has been put on stream. For many years, a relatively small nitrogen fertilizer plant has been in operation (ammonia, 150 t/d; nitric acid, 87,500 t/a; CAN 142,000 t/a).

Although certain experience has been accrued during the many years of operation and maintenance of the small plant, the company recognized the necessity of introducing an up-to-date maintenance management system. In connection with the new, large plant, transfer of experience is needed in order to organize the extensive maintenance work properly, thereby preventing machine breakdown and reduce recurrent, unforeseen costly repairs. In particular, maintenance of large centrifugal compressors and sophisticated high-pressure equipment is bound to become a problem area unless the management team of the maintenance services of the company is given the opportunity to benefit from the experience of a highly qualified consultant who would assist in the establishment of a well-conceived, mechanical maintenance system and related specialized service units.

