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DEVELOPMENT OF EXPERTISE IN FERTILIZER PLANT OPERATIONS

INDIA

DP/IND/85/006/11-04

# Technical Report: Environmental Control Management at four Fertilizer Manufacturing Companies and Assistance with Environmental Problem Solving at four Others*

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

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Vienna

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## SUMMARY

This report describes the second visit to India paid by a consultant and made under the programme DP/IND/85/006/11.04. It involved a study of the environmental control management at four fertiliser factories and discussions with representatives of four others as well as briefing and debriefing by PDIL and UNDP at the beginning and end of the visit.

At each plant, the environmental protection and improvement measures were assessed and the conditions in the neighbourhood of the factory examined. Certain aspects of works safety and public safety were considered. Environmental protection was found, in general, to be good; a number of recommendations are made for further improvements.


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## INTRODUCTION

The Government of India accords high priority to the development of its fertiliser industry. A current project, managed by Project and Development India Ltd (PDIL) and supported by the UN Development Programme, is aimed at improving the performance of the industry by upgrading existing skills through training and by bringing consultants to India.

One area where improvement is sought is the environmental performance of the fertiliser production factories and a British consultant visited two factories (National Fertilizers Ltd, Nangal Unit and Madras Fertilizers Ltd, Madras) in 1986.

This report covers a second visit to Indian fertiliser factories by a British consultant as part of this project. During the period 4 October to 26 October, 1988, the consultant visited four factories, with briefing and debriefing meetings in New Delhi with PDIL and UNDP at the beginning and end of the assignment. The four factories were:

Krishak Bharati Cooperative Ltd, (KRIBHCO) - Hazira factory.

Zuari Agro Chemicals Limited, (ZAC) - Zuarinagar, Goa.

Mangalore Chemicals and Fertilizers Ltd, (MCF) - Panambur factory.

Southern Petrochemical Industries Corporation Ltd, (SPIC) - Spic Nagar, Tuticorin

In addition, PDIL had notified a number of other fertiliser companies of the consultant's itinerary and invited them to send representatives to meet him. Representatives of four companies met him for discussions at various times during his work at the four factories visited.

The representatives came from:

Rashtriya Chemicals and Fertilizers Limited, (RCF) - Chembur factory, Bombay

Gujarat Narmada Valley Fertilizers Co Ltd, (GNFC) - Bharuch, Gujarat State

The Fertilisers and Chemical Travancore Ltd, (FACT) - Udyogamandal factory, Kerala State

Hindustan Lever Limited - Haldia, West Bengal State

This report gives the consultant's general conclusions from the visit. It then briefly describes PDIL and the recent expansion of the fertiliser industry in India. The detailed report about the individual factories follows and notes about the discussions with the representatives of the four other companies.

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OVERALL CONCLUSIONS

1 The factories visited are all conscious of their environmental responsibilities and the older factories have made many improvements over the years.

2 The factories were in compliance with nearly all the requirements of the state Pollution Control Boards. The exceptions were the urea dust emitted from the urea prilling towers and one case where liquid effluent is heavily diluted with river water to reduce pollutant concentration pending the introduction of purification equipment.

3 The supply of fresh water presents problems at two of the factories. All four should continue to seek further ways of economising in the use of fresh water, if only during drought periods in the other two cases.

4 All factories are developing disaster plans which involve cooperation with other enterprises and with the emergency services. They all will contain plans for dealing with ammonia escapes and with spills of chemicals from pipelines or tanker trucks outside the factories.

5 All factories will arrange for professional assistance in the prediction of the movements of ammonia clouds following accidental releases under various conditions.

6 Two of the factories have DAP plants which use ammonia inside totally enclosed buildings. They will make arrangements for the safety of personnel in the event of leak of ammonia inside the buildings.

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**PROJECTS AND DEVELOPMENT INDIA LTD**

PDIL is a Government of India undertaking. It originated as the research and development arm of the fertilizer corporation of India (FCI) and became independent under its current name when the Government-owned FCI was divided into five independent companies including National Fertilizers Ltd Rashtriya Chemicals and Fertilizers Limited and an independent PDIL. A similar public sector consultancy company is FEDO which is part of the FACT fertilizer company,, owned by the Central Government.

PDIL and FEDO offer consultancy and design and engineering to the fertilizer industry. PDIL's services include procurement, inspection, monitoring, scheduling, construction, supervision, commissioning, trial runs and guarantee demonstrations, it has four main offices at Sindri, Baroda, Delhi and Calcutta. PDIL does not manufacture fertilizers but does manufacture catalysts (at Sindri, Bihar). It has intensive research and development facilities for fertilizer catalysts.

PDIL also prepares Environmental Impact Assessments for the fertilizer and other industries.

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## THE EXPANSION OF FERTILISER MANUFACTURE IN INDIA

Since the break up of FCI in 1979, demand for fertilisers has caused the setting up of many other fertilizer companies in various sectors:

a Two co-operatives, namely:

- Indian Farmers Fertilizer Corporative Ltd (IFFCO).
- Krishak Bharati Co-Operative Ltd. (KRIBHCO) which was originally a subsidiary of IFFCO but is now independent.

b Seven companies with a majority of private capital, including:

- Zuari Agrochemicals Ltd.
- Mangalore Chemicals and Fertilizers Ltd.
- Southern Petrochemicals Industries Corporation Ltd (SPIC).
- Gujarat Narmada Valley Fertilizers Co Ltd (GNFC)

Three companies owned by the Central or State Governments, including Madras Fertilizer Ltd and FACT.

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# S E C T I O N 1

## KRISHAK BHARATI COOPERATIVE LIMITED

## KRISHAK BHARATI COOPERATIVE LIMITED (KRIBHCO) - HAZIRA FACTORY

### INTRODUCTION

In the last 10 years, oil and natural gas finds in the Bombay area have led to the setting up of a number of fertiliser plants based on these feedstocks in Western and Northern India. The Indian Farmers' Fertiliser Cooperative Ltd (IFFCO) promoted another cooperative at Hazira near Surat on the South East coast of the State of Gujarat and this was formally set up as an independent company, KRIBHCO, on 17.4.80 and started manufacture in 1985.

The site chosen for the factory was a marshy, sparsely populated area on the Northern bank of the Tapi River estuary, about half way between Hazira on the Arabian Sea and Surat, some 25 Kms upstream. The 700 hectare site was raised to 5m above Mean Sea level. The company township was established on a 40 hectare site, 1 Km to the North of the factory beside the Surat-Hazira Road.

### FACILITIES

The main raw materials used are desulphurised natural gas, water and air and the sole product is urea.

The Ammonia Plant comprises 2 streams, each of 1350 tonnes/day nominal capacity, producing ammonia by the Kellogg High Pressure Reforming Process. The desulphurised natural gas, imported from the neighbouring refinery, must be further treated to remove the last traces of sulphur as the first step in the ammonia production process.

In the Urea Plant, ammonia and carbon dioxide from the Ammonia Plant are converted to urea in 4 streams, each of 110 tonnes/day nominal capacity, by the SNAM Ammonia - Stripping Process.

Steam and power are provided by three Foster Wheeler boilers (2 working, 1 spare), burning natural gas, and each of capacity 275 tonnes/hour of steam at 105 atmospheres pressure. There are two 15 MW generators, supplied by BHEL, and 2 auxiliary Diesel generators, each of 1.5 MW capacity, to supply power in emergencies only.

Some 40,000 $M^3$ water are drawn each day from an irrigation canal into the company reservoir and are clariflocculated in the Water Pre-treatment Plant for domestic and sanitary use and cooling water make-up.

The boilers require demineralised water, provided by the Demineralisation Plant which comprises four streams, each of 4000 $M^3$/day capacity.

There are two silos, each of 45,000 tonnes capacity, to store the urea product off season, and a Bagging Plant to pack the prilled urea into 50 kg bags for despatch. Some 10% goes out by road transport to local customers and 90% by rail transport.

There is a well equipped fire station and a pressurised (9 ats pressure) fire-water network.

The effluent treatment facilities are described in a subsequent section.

The plants came into operation in 1985 and 1986, and in 1988 are producing ammonia and urea at 20% more than design capacity. Kribhco have plans to build a Diammonium Phosphate (DAP) plant on the site.

ORGANISATION

The Joint General Manager (Production) and the Joint General Manager (Technical) respond to the Site General Manager. The Managers of the individual production plants, the Effluent Treatment Manager and the Laboratory Manager all respond to the JGM (Production). From the point of environmental protection, this is an effective arrangement. The production manuals lay down the environmental limits for each plant and the action to be taken by production staff and by the Effluent Treatment Plant in the case of upsets. Regular checks are carried out by the Central Laboratories and there is continuous monitoring of sensitive parameters. The Laboratory Manager alerts the production Managers to any deficiency in environmental performance but it is their responsibility to ensure compliance by their own plants at all times. They may seek assistance from the staff of the JGM (Technical).

The Laboratory Manager sends regular routine reports to the Gujarat Pollution Control Board (GPCB) whose inspectors visit Kribhco approximately monthly, at random intervals and at short notice, to carry out cross-checks on the main environmental parameters.

Differences which might arise between a Production Manager and the Effluent Treatment Manager or Laboratory Manager could be resolved at Joint General Manager level.

There is a written disaster plan and their planning ahead for emergencies involves the local authority emergency services and contacts with other industries in the area. In collaboration with the authorities, there will be discussion of emergency measures with the local population; the density being low at present.

EMISSIONS TO ATMOSPHERE

Stack Emissions

There are no toxic or unpleasant emissions to atmosphere under normal conditions.

The natural gas burnt in the Power Station is desulphurised before arrival at the site and thus $SO_2$ emission from the high stack is minimal. By modern design and by control of excess oxygen to the burners, the $NO_x$ concentration is kept very low. Routine checks of the stack gases show $SO_2$, $NO_x$, CO and dust always near to, or below, the limits of detection of the instruments.

Ammonia is sometimes detected in the area by its powerful smell. It escapes in small quantities from the Urea Prilling Towers and from the ammonia handling and storage area and from the Bagging Plant. Although it might be unpleasant to sensitive people, ammonia is not harmful at such low concentrations.

There is a light visible plume of urea dust from the tops of the natural draught Prilling Towers and routine measurements show the concentration of particulate matter to be usually between 10 and 50 $mg/M^3$ at the tower top. The GPBC have set a limit of 50 $mg/M^3$ for this emission and it is the only emission on the site which is close to the GPCB limit. About 10% of the readings are above the limit of 50 $mg/M^3$ but the GPBC are content with Kribhco's performance, probably because they recognise that it is rather a tight limit for such a harmless dust.

## Ambient Air Quality

Kribhco check ambient air quality twice per month at 5 locations, namely at the Bagging Plant and at the 4 villages nearest to the site. These include the Kribhco township and all four lie from 1 to 5 Kms from the factory in various directions.

The GPBC limit for $SO_2$ and $NO_x$ in ambient air near Kribhco is 80 $\mu g/M^3$ for each. Measured concentrations are negligible, averaging 3-5 $\mu g/M^3$ for $SO_2$ and 1-1.6 $\mu g/M^3$ for $NO_x$. CO is never detected.

Measurements of ammonia outside the factory average 4-8 $\mu g/M^3$ and at the Bagging Plant 35 $\mu g/M^3$. The GPBC have not set a limit and it is not usual to set a national or regional limit for ammonia in ambient air. One of the few published limits (in East Germany) is 100 $\mu g/M^3$.

Measurements by Kribhco of suspended particulate matter at the five locations average 144-211 $\mu g/M^3$. The national limit for industrial and mixed use zones is 500 $\mu g/M^3$ but the GPBC have imposed 250 $\mu g/M^3$ for the area around Kribhco. The current measured SPM concentrations are only a little higher than those found before the site was developed (120-155 $\mu g/M^3$) and most of the dust clearly arises from sources other than Kribhco.

## LIQUID EFFLUENTS

### Urea Plant

The main flow (2500 $M^3$/day), containing not more than 50 mg ammoniacal nitrogen and 200 mg urea per litre, is used partly for irrigation, the remainder going to its own Storage Pond in the final factory effluent Balancing Pond area and then into the Balancing Pond itself. The very much smaller quantity of Mixed Bed Polisher effluent, and occasional effluents arising from plant upsets, are neutralised and traces of ammonia removed in an air-stripping tower before the effluent goes forward to the urea effluent Storage Pond, which has a capacity similar to a days Urea Plant effluent arisings.

### Main Effluents Requiring Neutralisation

These are:

- 200 $M^3$/day from the Ammonia Plant mixed bed process water polishing unit.
- 350 $M^3$/day acidic effluent from the Demineralisation Plant.
- 950 $M^3$/day alkaline effluent from the DM Plant.

These three effluents go to the same neutralisation pit for mutual neutralisation and pH adjustment and thence to the final factory Balancing Pond.

Cooling Water Purges

Total cooling water purge from the cooling towers associated with various plants amounts to some 5000 $M^3$/day and is collected at the central Chromate Removal Plant. The purges contain up to 30 mg chromate/litre and this is reduced to Cr III and precipitated by addition of ferrous sulphate and then alkali. The brownish turbid effluent passes to a baffled settling pond (residence time about one half day) in the final Balancing Pond area and then into the final Balancing Pond itself.

Incoming Water Clariflocculators

The Clariflocculator Clarifier sludge (600 $M^3$/day) goes via the plant sludge pit to a Settlement Pond in the final Balancing Pond area, whose residence time is a few days, the the settled effluent passes to the Balancing Pond. Kribhco expect this Settlement pond, like the Urea effluent storage pond and the settlement pond for chromium sludge, to last for some years before it is filled with solid.

The Final Balancing Pond

This is a large, shallow pond covering some hectares, with a lot of vegetation growing on its banks and on islands and a large population of wild birds. Effluent residence time is about a week. The pond provides a safety buffer in case of effluent upsets, final effluent mixing and aeration and a visible demonstration of the wholesomeness of the treated effluent. Effluent flows from the Balancing Pond by gravity into a stream, which carries it about 1 Km to the Tapi River estuary.

Statutory Limits on Factory Effluents

The main limits set by the GPCB for liquid effluent from Kribhco, and the average Kribhco performance, are given in the following table:

| | | GPBC Limit | Kribhco Average Performance |
|---|---|---|---|
| Chromate Removal Plant Effluent | | | |
| Chromium as Cr VI | mg/l max | 0.1 | 0.02 |
| Total chromium | mg/l max | 2.0 | 0.05 |
| Balancing Pond Exit to the Estuary | | | |
| Temperature | ° Max | 40 | <40 |
| pH | | 6.5-8.5 | 6.5-7.5 |
| Total suspended solids | mg/l max | 50 | 40-48 |
| Total dissolved solids | mg/l max | 2700 | 2000 |
| B O D | mg/l max | 50 | 20-30 |
| C O D | mg/l max | 150 | 40-60 |
| Oil and Grease | mg/l max | 10 | <10 |
| Ammoniacal Nitrogen as N | mg/l max | 25 | 15-23 |

Domestic Effluent from the Company Township

This is the only Kribhco effluent stream containing substantial amounts of organic material. It is biologically aerated and clarified before discharge to a stream leading to the Tapi estuary. Biological sludge is discharged to drying beds.

OTHER NUISANCES

Noise

The factory is quiet and gives no noise nuisance.

Solid Waste

There is very little solid waste produced by the factory.

CONCLUSIONS

Kribhco's performance in environmental protection is satisfactory and no intractable problems are apparent or foreseen.

They are fortunate in operating relatively clean industrial processes and in being able to build in the latest technology at the design stage to satisfy the standards set by the GPBC. There has been no shortage of money for environmental protection and they have a substantial tree-planting programme.

The GPBC limits are unlikely to be further tightened because the area around the factory is not environmentally sensitive and the limits are already in line with international standards.

Kribhco appear to be well organised and properly motivated to protect the environment and no changes are recommended.

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## S E C T I O N  2

## ZUARI AGRO CHEMICALS LIMITED

## ZUARI AGRO CHEMICALS LIMITED (ZACL) - ZUARINAGAR, GOA

### INTRODUCTION

The Company was first registered in Bombay on 12 May 1967, with the objective of setting up a fertiliser plant in Goa. With the technical and financial collaboration of the the United States Steel Corporation, the contracts for design and construction of the production plants and of the auxiliary and ancillary items were granted to Toyo Engineering Corporation of Japan. Trial production of prilled urea started in May, 1973, and of complex fertilisers in March, 1975. An additional plant to produce diammonium phosphate was commissioned in December 1984.

The factory, offices and some residential accommodation were constructed on an estate of 550 hectares on a hill overlooking the Arabian Sea, near the port of Vasco-da-Gama. Goa was chosen for the factory because of its proximity to the fertiliser consuming areas of central and southern India and the site near the port of Vasco-da-Gama because of the need to import petroleum products and phosphoric acid.

### FACILITIES

The current main raw materials are naphtha, phosphoric acid, water and air and the products for sale are prilled urea and complex fertilisers, of which 60% are despatched by rail and 40% by road.

Ammonia is manufactured in a single stream of nominal capacity 660 tonnes/day, employing Toyo technology, with synthesis at 135 atmospheres pressure. The naphtha raw material can contain up to 0.25% sulphur (normally 100-300 ppm) which is removed by IFP desulphurisation as a first step in the ammonia process.

The Urea Plant employs Toyo technology based on the Mitsui Toatsu total recycle process, with the synthesis reactor operating at 250 atmospheres pressure to convert ammonia and carbon dioxide from the Ammonia Plant into urea at a nominal rate of 1140 tonnes/day.

The NPK compound fertilisers are manufactured by neutralisation of imported phosphoric acid with ammonia and further ammoniation in an Ammoniator/Granulator where urea, potassium chloride and recycle solids are added to produce ratios of nitrogen, phosphorus and potassium appropriate to the grade.

Diammonium phosphate is produced similarly by using imported ammonia, since the full Zuari output of ammonia is used up in the manufacture of urea and NPK fertilisers.

Steam and power are produced by 3 boilers (2 working and 1 spare) burning heavy fuel oil and each of capacity 70 tonnes per hour of steam at 103 atmospheres pressure. The 7.5 MW electricity generator is driven by this high pressure steam with the simultaneous production of low pressure steam. Zuari also purchase electricity from the local electricity supplier.

The factory, offices and residential accommodation of the estate currently use a total of 11,000 $m^3$ of imported water per day, which flows into the factory's raw water pond from a variety of sources. 7,500 $m^3$ normally come from the Public Water Department but the PWD is short of water and now provide 5,000 $m^3$/day. Fortunately the company's own dam is full following the heavy monsoon rains but a long term solution is required urgently. About 3,500 $m^3$/day are recovered seepage water and another 1,000 $m^3$ comes from wells.

For most purposes the quality of this water is satisfactory but the boilers and Ammonia Plant require highly purified water, of which some 3,700 $m^3$/day is obtained by demineralising raw water in the Water Treatment Plant. There it undergoes chlorination, neutralisation, flocculation, sand filtration, carbon filtration and dimineralisation by Ion Exchange.

There is a group of three 7,500 tonne tanks in a company compound near the port for the large scale storage of imported phosphoric acid and a pump and pipeline starting from the same point to pump naphtha from the adjacent Indian Oil Corporation storage compound up to the factory. At the factory, there are working stocks of imported phosphoric acid and petroleum products. The phosphoric acid and heavy fuel oil are transferred from the port area to the factory stock tanks in road tankers.

There are facilities for bagging and storing the solid products for despatch (urea, DAP & NPK fertilisers). The company operates a siding alongside the main railway line near the factory for the despatch of products by rail.

There is a company fire station with fire tenders on the factory site and the factory fire water main is kept continuously pressurised at 7 atmospheres pressure.

The effluent treatment facilities are described in a subsequent section.

## ORGANISATION

Responsibility for compliance by the factory with all the effluent and emission standards set by the Controlling Authorities lies with the company's General Manager Manufacturing (GMM). The superintendents of the production plants and of the utilities (which include the Effluent Treatment Plant) report to the GMM via the Production Manager (PM) so that differences which might conceivably arise between the production plant superintendent and the Utilities Superintendent could be resolved at PM level. Under the written arrangements approved by the GMM, the production plant superintendents are each responsible for ensuring that their plants meet the environmental regulations at all times, both as regards liquid effluents and emissions to the atmosphere. In the case of upsets, the production Shift Officer concerned must contact the Shift Officer of the Effluent Treatment Plant, if possible in advance of the disturbance, and must take the action required of him by the Effluent Treatment staff, which in most cases will have been agreed in advance. This is a sound arrangement.

The production plant superintendents may seek the help of the Technical Services Department in making improvements to the environmental performance of their plants; the Technical Services and the Production functions both report to the Vice President Technical, who ensures that the optimum solution is adopted.

The Factory Laboratory reports to the Technical Services Manager. The Laboratory staff carry out regular sampling of plant liquid and gaseous effluents to check on plant environmental performance and the results are forwarded via the Production Manager to the General Manager manufacturing and from him to the Vice President Technical. The laboratory also reports the results to the Technical Services Manager who passes them to the Vice President Technical. If a measurement shows that a stream is not in compliance with the value set by the authorities, the Laboratory informs the Shift Officer concerned, who takes immediate corrective action and reports the incident to the Production Plant Superintendent. The Utilities Shift officer also takes corrective action and reports the matter to the Utilities Superintendent. In a serious case, the Technical Services Manager would report the matter immediately to the Controlling Authorities and via the Vice President Technical to the company Executive President but, fortunately, up to now such a serious incident has not occurred and the non-complying analyses concerned have been reported to the authorities in the routine weekly reports of the required measurements.

Without prior warning, the authorities visit the factory every day to collect final effluent liquid samples and at random frequency, effluent gaseous samples. The authorities concerned are the Environmental and Pollution Control Wing of the Directorate of Health Services, Goa Government.

Zuari are developing a disaster plan of which a draft is at present with the Government of Goa Chief Inspector of Factories. It will involve cooperation with the local emergency services and other organisations including the nearby airport and the naval base. Zuari agreed that it would be useful to seek professional assistance to calculate the movements of ammonia clouds arising from major leaks. They will include plans to deal with such leaks, and also with spills of phosphoric acid or fuel oil coming to this factory, in the disaster plan.

## EMISSIONS TO ATMOSPHERE

### Stack Emissions

Each two weeks measurements are taken for the Controlling Authorities of the components of emission from six stack and from the top of the Urea Prilling Tower. The figures are reported on a dry basis. The only legal limit laid down concerns the concentration of urea dust in the plume from the forced draught Urea Prilling Tower where the Control board require not more than 150 mg urea/$m^3$ in plants like Zuari which were commissioned before 1982. The averages recorded lie between 90-125 mg urea/$m^3$ (in plants commissioned since 1982, the maximum concentration allowed is only 50 mg urea/$m^3$).

Two other measurements of suspended matter (dust) are taken, namely from:

- Urea Plant dust Separator : 80 - 130 mg/$m^3$
- DAP Stack : 100 - 140 mg/$m^3$

The ammonia gas concentration is measured at 4 places with the following average results:

| | | |
|---|---|---|
| - Urea Plant Off-gas Absorber (only 250 $m^3$/m and vented at the top of Prilling Tower) | : | 10000 - 15000 $mg/m^3$ |
| - Urea Plant Ammonia Recovery Absorber | : | 30 - 60 " |
| - NPK Plant Dedusting Stack | : | 20 - 40 " |
| - DAP Plant Stack | : | 30 - 60 " |

The sulphur dioxide concentration at the top of the boiler stack is found to be 4000 - 5000 $mg/m^3$. This relatively high concentration is because the fuel oil used contains 3% sulphur. It will shortly be replaced by LSHS (Low Sulphur Heavy Stock) containing not more than 0.8% sulphur.

No measurements are taken of the concentration of the nitrogen oxides in the boiler stack. Many authorities apply limits to emissions of NOx and it would be advisable to make occasional measurements once the new fuel oil is being used so that the information is available if the authorities raise the subject.

Ambient Air Concentrations

Twice per week measurements are made at three points near the factory boundary, approved by the Pollution Control Board, of the concentrations of three polluting materials and the results are forwarded to the authorities. The results obtained are as follows:

| | | | | |
|---|---|---|---|---|
| $SO_2$ | : 0 - 5 | $\mu g/m^3$ | average | 2.5 |
| Ammonia | : 0 - 3000 | " | " | 1000 |
| Suspended Particulate Matter (dust) | : 30 - 80 | " | " | 40 |

These values are low enough to cause no concern. The authorities have given no guidelines about ambient air quality.

LIQUID EFFLUENTS

Company policy has been to minimise the production of water effluent by maximising re-cycling and re-use of water. One objective is to protect the environment but mainly this is done to conserve water since the amount available from the Public Water Department is diminishing. The current situation is set out below:

Ammonia Plant

There is normally no discharge of water effluent to the Effluent Treatment Plant. Dimineralised water is used on the plant in large quantities as feed to the Waste Heat Boilers and the naphtha-fired boiler. The steam so produced is used in the reforming process and for driving turbines on the Ammonia Plant.

Ammonia Plant process gas is cooled and thereby loses water which passes to the Hydrolyser Stripper. Ammonia is evolved and is recovered for use in the NPK plant, whilst the water recovered is fed to the Water Treatment Plant just before the Ion Exchange column. Part of the condensate from the turbines goes to No 1 Cooling Tower as make-up.

Urea Plant

Miscellaneous small quantities of effluent from the Urea and NPK plants (about 2 $m^3$/hr) are combined and flow to the holding ponds at the Effluent Treatment Plant and then to the DAP Plant for use in the scrubbers.

DAP Plant

Similar small quantities of effluent arising on the DAP Plant flow to the Sump Tank in the Plant and from there are recycled for use in the Pre-neutraliser.

Cooling Towers

There are 4 cooling towers varying in size from No 1, which has a circulation rate of 14,500 $m^3$/hr, down to the smallest, No 4 at 200 $m^3$/hr.

The purges from No 3 and No 4 Cooling Towers do not go to the Effluent Treatment Plant but instead are re-cycled for process use. As an example, the circulating cooling water in No 3 Cooling Tower contains significant amounts of ammonia and urea because the circulation goes via the barometric condenser in the Urea Plant where it condenses the steam in a vacuum ejector and is thus in direct contact with these two substances. It is otherwise pure and is therefore not discarded as effluent and, in addition, the ammonia and urea are recovered.

The purges from No 1 and No 2 Cooling Towers are also not discharged as effluent but are used as far as possible as make-up to the fire-water system. In future, they will be used instead to replace raw water in irrigation of gardens on the Estate.

Water Treatment Plant

This is currently the most important source of water effluent which arises in two ways:

- The first 5 minutes of the backwash of the Sand Filter go to the Effluent Treatment Plant but thereafter the backwash water goes to the Raw Water Pond for further use. The total quantity of backwash water discarded is small and irregular, amounting to between 10 - 100 $m^3$/month.

- The re-generation effluent from the ion Exchange columns amounts to 200 - 250 $m^3$/day with an average content of dissolved solids of 2700 ppm. No use has yet been found for this re-generation effluent and it is discarded via the Effluent Treatment Plant.

Effluent Treatment Plant

The function of the Effluent Treatment Plant is:

- To neutralise, settle and blend regular effluent from the Water Treatment Plant and semi treated factory domestic effluent.

- To provide emergency storage, treatment and re-cycling facilities in case of upsets. The capacity of the Effluent Treatment Plant is 1700 $m^3$ against a daily flow of 1000 $m^3$ effluent.

Effluent which meets the specifications is discharged through a HDPE pipeline and a submerged diffuser some 225 metres from the shore in the Arabian Sea. A continuous sample of the discharged effluent flows through a fish tank in the Effluent Treatment Plant Control Room to demonstrate the wholesomeness of the effluent.

A complete analysis of the effluent is sent weekly and monthly to the authorities and is normally well within the specifications.

Outside the monsoon season, the sea water is analysed once per week at 5 points around the Diffuser at a time which matches weekly samples taken at the Effluent Treatment Plant, that is, sea water samples are taken half an hour after the Effluent Treatment Plant samples by which time the effluent will have passed along the discharge pipeline and reached the Diffuser.

WATER SUPPLIES AND ECONOMY

As pointed out under the 'FACILITIES' section above, the question of water supplies is becoming more urgent despite the water economy measures already taken. The population in the region is increasing and the Public Water Department gives priority to the population which is not sympathetic to the factory.

Further measures are about to come into operation:

- The backwash from the Sand Filter will in future be used to replace raw water for gardening purposes on the estate.

- A plant for full biological treatment of the factory domestic effluent is under construction and should be complete by the end of the year. Thereafter, some 700 $m^3$/day of treated domestic effluent will be used as cooling tower make-up, replacing the raw water currently used.

Zuari are urgently seeking a way of using the Regeneration Effluent from the Water Treatment Plant to replace raw water. Possible techniques for reducing the total dissolved solids content of the Regeneration Effluent from its current 2700 ppm to the 50 ppm of raw water are:

- Reverse Osmosis
- Electrodyalisis
- Multi Effect Evaporation

With a TDS of 50 ppm the water would be useable for cooling tower make-up.

Another possible use for Regeneration Effluent as such would be as a replacement for raw water for garden irrigation.

The cost and effectiveness of these possibilities must be compared with alternative ways of obtaining increased water supplies. A serious waste of raw water occurs because of the unfavourable geology at the site of the Company Dam where seepage is serious and increasing. The company's main effort in improving water supplies should be directed towards minimising this waste of water because the seepage quantities are greater than could be obtained from effluent economies and even if the Public Water Department is able to provide larger quantities in the long run, the water will certainly become more costly. Minimisation of the seepage loss will involve geological studies and hydrological engineering. A public relations effort would possibly also be worthwhile in order to mobilise support for whatever technical solution is proposed.

OTHER NUISANCES

Noise

The factory gives no noise nuisance externally. Certain items of noisy equipment, such as the ammonia plant compressors, are not heard outside the factory.

Solid Waste

There is very little solid waste produced by the factory.

OTHER ITEMS

a Wind velocity and direction are continuously recorded at the factory as well as the temperature and humidity of the atmosphere.

b Sensors to detect the presence of ammonia fumes and naphtha vapour and to sound an alarm when such released materials reach the TLV levels have been in operation at chosen locations for several months.

c The consequences of a leak of ammonia in the enclosed DAP plant could be serious because of the ensuing panic. The most likely place for a leak to develop is at flanges near control valves and consideration should be given to surrounding such points by a simple hood connected by ducting to an extraction fan such that any leak of ammonia would not escape in quantity into the plant. Another safeguard would be escape doors in each floor leading to outside platforms.

RECOMMENDATIONS

1 Carry out preliminary checks of $NO_x$ concentrations in the boiler stack.

2 Study the hydrology of the Dam Site area and develop a proposal for eliminating water loss by seepage.

3 Consider a Public Relations campaign to mobilise opinion in favour of a Company solution to the problems of water supplies.

4 Study the alternative approaches to the recovery for re-use of the Regeneration Effluent from the Water Treatment Plant.

5 Take precautions against the consequences of any ammonia leak in the DAP plant.

6 Include in the disaster plan arrangements for dealing with large leaks of ammonia and with spills of acid or fuel oil from tanker trucks coming from the port to the factory.

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# S E C T I O N   3

## MANGALORE CHEMICALS AND FERTILIZERS LIMITED

## MANGALORE CHEMICALS & FERTILIZERS LIMITED (MCF)

### INTRODUCTION

MCF is a joint enterprise between private sponsors and the state Government of Karnataka. The Headquarters of the Company is in Bangalore and the factory is on a 200 acre site located 9 km from the centre of Mangalore on the North bank of the tidal Gurpur River. The factory is separated from the new port complex of Mangalore by the main West Coast Highway. A Company Township with a population of about 800 people lies some 2½ km to the east of the factory.

The Ammonia and Urea Plants started up in 1976 and plants for the manufacture of food grade ammonium bicarbonate and of diammoniumphospate started up in 1982 and 1986 respectively.

### FACILITIES

The single stream Ammonia Plant of nominal capacity 660 tonnes/day employs the ICI steam reforming process based on naphtha, which is hyrodesulphurised before the reforming step.

The Urea Plant has a single stream of nominal capacity 1030 tonnes/day and employs Stamicarbon technology.

The food grade Ammonium Bicarbonate Plant (12 tonnes/day capacity) employs Indian technology and know-how, which was obtained from PDIL.

A plant to produce diammonium phosphate was erected using novel Toyo technology involving fluidised granulation but was unsuccessful. A second plant using the traditional preliminary neutralisation of ammonia with phosphoric acid, followed by further ammoniation in an Ammoniator/Granulator where recycled solid are added, was built by Toyo Engineering India Ltd, free of charge. Nominal capacity is 500 tonnes/day.

Electricity is mostly obtained from the Karnataka Electricity Board but is plagued by frequent power dips and cuts. A Captive Power Plant came into operation in 1986 comprising 6 Diesel Generators (5 working, 1 spare) each of maximum 6.5 MW capacity. Normal combined output is around 25 MW and is used by the Ammonia Plant. The Generators use heavy fuel oil containing 2.5 to 3% sulphur, as do the 2 boilers (1 working, 1 spare) on the Ammonia Plant of nominal capacity 60 and 35 tonnes/hour steam at 75 and 72 atmospheres pressure respectively.

The central factory cooling water system, with a circulation rate of 12,000 $m^3$/hour, serves the needs of the main plants. The Captive Power Plant has its own cooling water system.

Naphtha and heavy fuel oil are obtained through the Indian Oil Corporation depot in the port area and are pumped across the road to working stock tanks on the site.

Liquid ammonia and phosphoric acid are imported by sea and are stored in tanks belonging to MCF in the port area. Both these materials are pumped across the road as required, directly into the plant. Both are used in the Diammonium Phosphate Plant. There is a small cooling tower serving the liquid ammonia storage in the port area.

There are storage silos on the site for urea and for diammoniumphosphate and bagging facilities for both products. There is a rail spur for the export of bagged products but it is little used and most of the bagged materials leave the factory by road. The ammonia produced in the Ammonia Plant is used entirely by the Urea Plant. A buffer stock of ammonia is held under pressure in a Horton sphere.

The Karnataka Urban Water Supply and Drainage Board supplies filtered drinking water to the factory and township for domestic and sanitary purposes. It separately supplies 4 million gallons (18,000 $m^3$) per day of clarified water for factory use and there is a Company reservoir of 6 mill-gall capacity as a reserve stock. A second reservoir of 100 mill-gall is under construction to help in time of drought. The 6 mill-gall reservoir suffers from excessive growth of algae and the same problem will be met with the 100 mill-gall reservoir. The growth might be minimised by applying a surface film of long chain esters. Alternatively, a continuous circulation of water through the reservoir could be tried and the introduction of fish.

The Demineralisation Plant produces 180 $M^3$/hr of purified water for the boilers and for process use in the Ammonia Plant.

The effluent treatment facilities are described in a subsequent section.

There is a fire station, manned 24 hours per day, with one big engine and other water and foam pumping equipment. The fire water ring main is permanently pressured to 7 atmospheres.

ORGANISATION

The superintendents of all the production plants and of the Utilities, including Effluent Treatment, report through the production manager to the General Manger (Development and Technical Services). The plant operating instructions lay down the discharge limits for water effluent and for emissions to atmosphere for each plant. The Production operators must warn the Utilities operators, if possible in advance, of any plant upset and must play their part in ensuring that the final factory effluent does not exceed the set limits. Any difference which could arise between Production Management and Effluent Treatment management would be resolved at Production Manager level. There are effective arrangements.

Routine analyses of emissions to atmosphere and of water effluent are reported by the Superintendent (Chemical) through the Deputy Manager (Technical Services) both to the General Manager (D & TS) and to the Karnataka State Pollution Control Board (KSPCB).

Production staff can seek the assistance of Technical Services Department in developing technical means to improve environmental performance and the General Manager (D&TS) ensures the optimum course of action is adopted.

MCF are developing a Disaster Plan which has reached the final draft stage. It includes arrangements for meetings with neighbouring industries (particularly the management of the New Mangalore Port) and with the local authorities to arrange for mutual assistance. MCF will consider with the authorities how best to deal with the delicate matter of informing the local population about the risks from the factory, however remote, and the actions that the local population should take.

MCF agreed that it would be useful to seek professional assistance to carry out computer simulation of ammonia cloud movements. They foresee joint exercises with the local emergency services to optimise co-operation in case of ammonia leaks or other incidents, such as the spillage of phosphoric acid in transit from the Port to the factory.

## EMISSIONS TO ATMOSPHERE

### Emissions from Stacks and Vents

The emissions from 6 stacks and from the Urea Prilling Tower are analysed each month and the results reported to the KSPCB. The only emission limits sat by the Board are a maximum of 50 $mg/M^3$ of urea dust at the top of the Prilling Tower and 150 $mg/M^3$ for Suspended Particulate Matter (dust) from the DAP stack.

The content of urea dust actually measured in the emission from the Prilling Tower top averages about 60 $mg/M^3$ and this is accepted temporarily by the KSPCB. MCF believe they can reduce dust emission from its current level down to 30 - 40 $mg/M^3$ by making urea prills harder. They hope to achieve this by seeding and by reducing the moisture content of the prills. The KSPCB had suggested reducing the dust by adding scrubbers at the tower top but this is not technically feasible. The Central Government had decided that a suitable limit, for plants built before 1982, was 150 $mg/M^3$ but a number of State Pollution Boards are pressing for the limit of 50 $mg/M^3$ even from the older Plants.

For Suspended Particulate Matter, the achieved dust level in the DAP stack averages 42. In the other five stacks, burning heavy fuel oil or naphtha in boilers, the achieved level for SPM is 0 - 50 $mg/M^3$.

No limit is set for $SO_2$ in stack gases and, in any case, the amount of $SO_2$ is determined by the sulphur content of the fuel used. In MCF's case the $SO_2$ in boiler stacks varies from 800 to 1200 $mg/M^3$.

### Ambient Air

Measurements are carried out at 4 points approved by the KSPCB near to the boundary of the site. Samples are taken over 8 hour periods at 2 locations at a time over 3 days. To cover the whole 24 hours, samples are taken during a different 8 hour period on each of the 3 days. For the next 3 days sampling is carried out at the other 2 points on the site, so giving a 6 day monitoring cycle.

The limits set for SPM and $SO_2$ are those for industrial zones. The measured SPM averages 70 to 120 $\mu g/M^3$ against the legal limit of 500 $\mu g/M^3$ and the $SO_2$ averages 0 to 29 $\mu g/M^3$ against the legal limit of 120 $\mu g/M^3$.

Measured ammonia lies between 0 to 1000 $\mu g/M^3$, which is not detectable by smell; there is no set limit.

These measured concentrations are also sent monthly to the KSPCB.

Occasional $NO_x$ measurements have been made in stack gases and showed only very low concentrations. No limit is set by the authorities.

# LIQUID EFFLUENTS

## Ammonia and Urea Plants:

Ammonia is removed from process condensate by steam stripping and 30 $M^3$/hr stripped condensate, containing 15-20 ppm residual ammonia, is used as make-up to the main cooling tower.

Some 25 $M^3$/hr effluent at about 60$^{o}$C from the Urea Plant Desorber still contains about 300 ppm ammonia and 3000 ppm urea and can not be used as cooling water make-up. Some of it is used to dilute phosphoric acid in the DAP Plant but in the main it is sprayed, and further aerated by cascading, to remove some ammonia before lagooning in the Hot Pond where the Urea is partially hydrolysed.

Minor amounts of effluent from these and other plants (leaks, floor washings) are passed through oil separators (recovered oil is sold) and then go to the Hot Pond to reduce their ammonia and urea contents.

From the Hot Pond the effluents pass to the Cold Pond where they are diluted with controlled amounts of brackish water from the Gurpur river to reduce concentrations, particularly of urea and ammonia, to below the limits set by KSPCB.

## Demineralisation Plant

The acidic and alkaline regeneration effluents are mixed and the resulting acidic mixture (about 10 $M^3$/hr) passes to the Cold Pond where it helps to reduce the alkalinity in the pond.

## Cooling Water

The blow-down from the main factory cooling tower (about 15 $M^3$/hr) is treated with ferrous sulphate and then goes to the Cold Pond where the alkalinity precipitates the chromium.

Up to a year ago, cooling water was treated with 50 ppm chromate (as chromate). Now chromate treatment has been reduced to 10 ppm and, in addition, a proprietary mixture based on orthophosphate, zinc and polyelectrolyte is used as well. If the current arrangement continues to be satisfactory, chromate will be eliminated altogether within a year. The Cooling Towers at the CPP and at the tanks in the port area have used a polyphosphate treatment without chromate since installation.

## Domestic Effluent

Domestic effluent currently goes untreated to soakaways wherever it arises but a simple treatment unit is under construction. When domestic effluent has been treated in this new equipment it will be used for irrigation of a tree plantation and grass land next to the factory.

## Effluent Discharge

The various effluents arriving at the Cold Pond currently total about 100 $M^3$/hr and are there diluted with about 300 $M^3$/hr of water from the Gurpur river. The 400 $M^3$/hr of blended effluent is pumped continuously from the Cold Pond through a 4½ km pipe line and is discharged into the sea at the extreme low tide line. The choice of the discharge point was made in agreement with the Controlling Authorities following a detailed ecological and tidal study by the National Institute of Oceanography, Goa. Further studies have been carried out since the factory started operating to measure the dilution achieved and to demonstrate that marine flora and fauna have not suffered. Quarterly reports are prepared by the College of Fisheries of the University of Agricultural Science, Bangalore, based on the analysis of conditions near the discharge point.

Effluent Quality

The pH, temperature and flow rate of the effluent leaving the site are monitored by online instruments and a daily composite sample is analysed for urea, ammoniacal nitrogen, chromium, vanadium, oil and $CO_2$.

Each month a sample is taken for detailed analysis for comparison with the set limits. The main limits and corresponding typical measured values are as follows:

| | Tolerance Limit | Typical measured Value |
|---|---|---|
| pH | 6.0 - 8.5 | 8.0 |
| Temperature - $^{o}C$ Max | 45 | 30 |
| Oil and Grease - mg/lit max | 20 | Nil |
| Ammoniacal nitrogen (as N) - " " | 50 | 35 |
| Free ammonia (as $NH_3$) - " " | 5 | 3 |
| Urea (as Urea) - " " | 200 | 70 |
| Total Cr - " " | 2 | Nil |
| Total V - " " | 1 | Nil |

Once per week, the sea water 100 M. North and South of the discharge point, and the brackish water in the Gurpur River, are analysed for pH and free ammonia. All the analytical results discussed above are sent to the KSPCB monthly.

MCF are installing a Hydrolyser-Stripper which will start up in early 1990 and will be used to hydrolyse urea and strip ammonia from the Urea Plant Desorber effluent and other ammonia containing streams. The residual urea and ammonia in the stripped effluent will each be lower than 5 ppm making it eminently suitable as cooling water make-up and perhaps even useable as feed to the Demineralisation Plant.

The recovered ammonia will be recycled to the Urea Plant but total financial savings will not cover the cost of the equipment, which is being installed essentially to minimise the pollution of effluent and render dilution unnecessary to meet the effluent specification.

Dilution of effluent by Gurpur River water as a means of meeting the effluent specification has been agreed by the KSPCB as a temporary measure pending installation of the Hydrolyser-Stripper.

In general, MCF have no problem of water supply and thus no financial incentive to pursue recycling of effluent as a means of saving water. However, there are droughts from time to time and the minimisation of pure water consumption during those periods at least would help both the factory and the community. A discussion with a company such as ZAC, which has adopted a "zero effluent" objective could be useful.

OTHER NUISANCES

Noise

The factory gives no noise nuisance outside its boundaries.

Solid Waste

There is very little solid waste produced by the factory.

RECOMMENDATIONS

1 Discuss with another company such as ZAC, which has adopted a "zero effluent" objective, possible additional ways of saving fresh water at MCF for use in times of drought.

2 In order to minimise the algal growth in the 6 mill-gall fresh water reservoir, and with a view to protecting the new 100 mill-gall reservoir, MCF should try the effects of

a applying a surface film of a long chain ester

b maintaining a circulation of clean water through the reservoir

c introducing fish to the reservoir.

3 Retain the services of a consultant to calculate the movements of ammonia clouds arising from escapes under various conditions.

4 Develop plans to deal with large escapes of ammonia and with spills of phosphoric acid outside the factory.

5 Examine the feasibility of covering the sources of possible ammonia escapes in the enclosed DAP building with a hood attached to an extraction duct and of providing 2 escape doors to outside platforms on each floor.

6 Seek ways of sending out a bigger proportion of product by rail to relieve the pressure on the roads.

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## S E C T I O N  4

## SOUTHERN PETROCHEMICAL INDUSTRIES CORPORATION LIMITED

## SOUTHERN PETROCHEMICAL INDUSTRIES CORPORATION LTD - (SPIC)

### INTRODUCTION

SPIC is a joint enterprise between private sponsors and the State Government of Tamil Nadu. It was formed in 1969 in Madras with the objective of manufacturing and marketing urea and di-ammonium phosphate. The factory was set up on a 360 hectare site on the coast of the Gulf of Mannar, 10 Kms south of Tuticorin town and port. Next to the factory is its own company township of 120 hectares with a population of 4000 and nearby are townships belonging to other organisations such as the Tuticorin Alkali Chemicals and Fertilizers Ltd. These other townships have a population of some 2000 people. There are one or two small villages not far away so that the population within 5 Kms of the factory boundary is about 10,000.

The first plants started operating in 1975 and the factory now has several production units and is a more complex factory than the other three visited by the consultant. SPIC has an active research and development programme and has already installed three novel effluent treatment processes of its own design. Helped by its R and D Department, SPIC is diversifying into other products at other sites and into consultancy work like PDIL and FEDO. Expansion of production activities at Tuticorin is prevented by poor communications, a shortage of space but mainly by a shortage of water.

### FACILITIES

The current main raw materials for the factory are naphtha, low sulphur heavy stock (LSHS), heavy fuel oil, phosphoric acid, aluminium hydroxide, ammonia, sulphur and phosphate rock. Ammonia, naphtha and heavy fuel oil are pumped to the factory by pipeline from the port. Rock phosphate, phosphoric acid and sulphur come from the port by road and the LSHS and aluminium hydroxide come direct from the suppliers by road.

The products despatched from the factory are prilled urea, di-ammonium phosphate (DAP), aluminium triflouride, ammonia under pressure and gypsum. These products are despatched about 50:50 by road and rail.

The single stream Ammonia Plant has a nominal capacity of 1100 tonnes per day and uses the ICI steam reforming process. The raw material is naphtha containing about 1500 ppm of sulphur which is first removed in a hydro desulphurising unit. $CO_2$ removal is still carried out by the Vetocoke process rather than the Benfield process.

Prilled urea is manufactured by the improved Mitsui-Toatsu total recycle process using ammonia and $CO_2$ from the Ammonia Plant in a reactor at 250 atmospheres pressure. The single stream plant has a nominal capacity of 1600 tonnes per day prilled urea. There are two sets of cooling towers in the Urea Plant; one set has a circulation rate of 8000 $m^3$ per hour and the other 2200 $m^3$ per hour. The smaller cooling tower is used only to feed the barometric condenser and the cooling water thus becomes contaminated with ammonia and urea and is kept separate from the other cooling water.

470 tonnes per day of 98.5% sulphuric acid is manufactured by the Nissan process based on sulphur which is burnt to $SO_2$. Oxidation of $SO_2$ to $SO_3$ takes place in a single stage over a vanadium pentoxide catalyst.

Phosphoric acid is produced by the Nissan process involving the reaction of sulphuric acid with phosphate rock. The nominal capacity is 165 tonnes per day (as $P_2O_5$). A large amount of phosphogypsum is produced as a byproduct.

There are two Di-Ammonium Phosphate Plants and each originally had a nominal capacity of 500 tonnes per day using the traditional Tennessee Valley Authority process (preliminary neutralisation of ammonia with phosphoric acid, followed by further ammoniation in an Ammoniator/Granulator where recycle solids are added. The capacity of one DAP Plant has now been increased to 850 tonnes per day by retrofitting a small amount of additional equipment (a double gun pipe reactor). There is almost no risk of ammonia leaks inside the building because ammoniation mostly takes place outside and there are no valves inside the buildings.

Aluminium tri-fluoride (8 tonnes per day of crystal $AlF_3$) is manufactured by the Alusuisse process from purchased aluminium hydroxide and the hydrofluosilicic acid byproduct from the Phosphoric Acid Plant.

Electricity is obtained from the public supplier but suffers from many voltage dips and cuts in supply. For this reason, a Captive Power Plant (CPP) started up in December 1985. It consists of two steam turbogenerators of 5.4 and 13 MW respectively, which are operated as necessary to augment the power supply.

There are two offsite boilers, each of capacity 85 tes/hr steam at 45 atmospheres pressure and also burning LSHS or fuel oil. Their duty is to supply 150 tonnes of steam per hour to drive the Ammonia Plant synthesis gas compressor turbines.

25000 $m^3$ per day of water (of drinking water quality) is obtained from the Government public water supply (treated river water) and is stored temporarily in the raw water reservoir holding 8.2 million gallons (37000$m^3$, one and a half day's supply). There are two fresh water reservoirs, each of 90 million gallons capacity, for emergency purposes such as drought conditions (16 days supply each).

In the water treatment plant 250$m^3$ per hour of this raw water is dechlorinated, pressure filtered and then dimineralised to provide 170$m^3$ per hour feed water for the offsite boilers. The rest (75$m^3$ per hour) is polished in a mixed bed to make it suitable for the auxiliary boilers in the Ammonia Plant, which take returned condensate in addition.

There is a 10,000 tonnes storage tank for liquid ammonia at Tuticorin Port, in a compound belonging to SPIC. This is equipped with a refrigeration unit having a small cooling tower. (The cooling water is not continuously treated but has chlorine shock treatment from time to time). The ammonia is pumped to the site in a 10 Km insulated pipeline as required. There is also a phosphoric acid stock tank at the port.

On the factory site there is a tank farm including two tanks for raw naphtha and one for sweet naphtha, each of 8800$m^3$ capacity. The raw naphtha tanks receive naphtha pumped from the IOC tank farm at Tuticorin port in a pipeline belonging to IOC. IOC also pump heavy fuel oil from the port to SPIC, where there are two fuel oil tanks each of 3750$m^3$ capacity and two tanks, each of 6150 tes capacity for high aromatic naphtha which will shortly be used as the fuel in the primary reformer in the Ammonia Plant.

There are silos and bagging facilities for urea prills and DAP and a railway siding for despatch of the 50% of factory output which goes by rail.

The factory fire station manned 24 hours per day, has two big engines with water and foam-pumping equipment. The fire water ring main is permanently pressured to 6 atmospheres.

The effluent treatment facilities are described in a later section.

## ORGANISATION

The managers of all the production plants and of the Cooling Water & Effluent Treatment plant report through the Chief manager (Operations) to the Joint General Manager (Works). The plant operating instructions lay down the discharge limits for water effluent and for emissions to atmosphere for each plant. The production operators must warn the effluent plant operators, if possible in advance, of any plant upsets and must ensure that the final factory effluent does not exceed the set limits. Any difference which could arise between a production manager and the effluent treatment manager would be resolved at the Chief Manager level. These are effective arrangements.

Routine analyses of emissions to atmosphere and of water effluent are reported by the effluent treatment manager through the Chief Manager (Operational) to the Joint General Manage (Works) and the Executive Director (Site) and to the Tamil Nadu Pollution Control Board (TNPCB).

The production staff can seek the assistance of the Technical Services Department in developing technical means to improve environmental performance and the Executive Director (Site) will ensure that the optimum solution is adopted.

SPIC are developing disaster plans for both onsite and offsite incidents. The onsite plan is the further developed. As far as the offsite plan is concerned, discussions have been held with other industries with a view to mutual assistance in the case of a disaster and one meeting has been held with the authorities and with the fire services. SPIC will consider how best to inform the local population about the risks from the factory, however remote, and the actions the local population should take in the case of an incident. They are fortunate in that most of the people who live close to the factory are the families of factory workers and therefore should understand the arrangements more easily than would people with no factory affiliations.

SPIC agreed that it would be useful to seek professional assistance to carry out computer simulation of ammonia cloud movements. They foresee joint exercises with the local emergency services to develop cooperation in the case of ammonia leaks or other incidents such as the spillage of phosphoric acid in transit from the port to the factory or of an escape of ammonia from a tanker under pressure being despatched from the factory. They recognise that the most likely cause of damage to pipelines from the port to the factory carrying ammonia (SPIC's responsibility) or fuel oil (IOC's responsibility) would be the damage caused by vehicle accidents and have already taken precautions against such accidents at vulnerable points.

# EMISSIONS TO ATMOSPHERE

## Emissions From Stacks and Vents

Emissions from nine stacks and from the top of the Urea prilling tower are analysed each month and the results reported to the Tamil Nadu Pollution Control Board (TNPCB). Certain emission limits are set by the Control Board as follows:

Sulphuric acid stack:

The limits are a maximum of 10 Kgs of $SO_2$ per tonne of 100% acid manufactured and a maximum of 50 mg of acid mist per $m^3$ of stack gases. The corresponding measured amounts in September 1988 were 4 - 6 Kgs of $SO_2$ per tonne of acid and 30 - 40 mg acid mist per $m^3$.

Phosphoric Acid Plant:

There is a limit of 25 mg of total fluoride per $m^3$ stack gases. The measured quantities in September 1988 were 0 - 3 mg/$m^3$.

DAP Plant stacks:

The set limit for suspended particulate matter is 150 mg/$m^3$ and the measured quantities were 20 - 40 mg/$m^3$.

The fluoride limit is the same (25 mg/$m^3$) as for the Phosphoric Acid Plant and the measured quantity was about 15 mg/$m^3$.

The waste gas stack of the $AlF_3$ Plant:

No limit is set for fluoride from this stack; the measured concentration was 15 - 20 mg/$m^3$, which is within the limits set in the other cases.

Urea Plant prilling tower:

The limit set by the TNPCB is a maximum of 50 mg/$m^3$ but the measured quantities are always about 120-150 mg/$m^3$. This is accepted temporarily by the TNPCB whilst SPIC are seeking a technical solution. A scrubbing mechanism is not possible on engineering grounds, but SPIC believe that an acoustic granulator (sonic vibration of the prill-forming nozzles) will be at least a partial answer.

The Central Pollution Control Board set no limit on $SO_2$ emissions from boiler stacks, but this is fixed in any case by the sulphur content of the fuel oil used and SPIC are using LSHS whenever supplies are available.

## Ambient air

Twice per week, SPIC analyse the atmosphere at three points near the factory boundary. The analysis is carried out on 24 hour samples and the results reported to the TNPCB once per month.

The limits set by the TNPCB are those proposed by the Central Pollution Control Board for industrial and mixed zones. The set limits and the measured quantities in September 1988 as follows:

| | Set Limit | $\mu g/m^3$ | Measured |
|---|---|---|---|
| 1 | Suspended particulate matter | 500 | 51 - 147 |
| 2 | $SO_2$ | 120 | 0 - 67 |
| 3 | $NO_2$ | 120 | NOx 5 - 42 |
| 4 | $NH_3$ - no set limit | | 37 - 309 |

The measured values are therefore well within the set limits and in the case of ammonia the concentration is below the level detectable by smell.

LIQUID EFFLUENTS

The effluent treatment arrangements have been conceived, developed and constructed entirely by SPIC themselves.

Phase I Plants

There are four main sources of effluent from the Phase I plants and these are treated as follows:

i Chromate Containing Effluents:

These effluents contain about 15 ppm of $Cr^{VI}$ and comprise cooling tower blowdown from the Ammonia Plant, the Urea Plant and the CPP and the process effluent from the Ammonia Plant which also contains some 20 ppm free ammonia. This combined effluent (120 - 150 $m^2$/hour) is treated in a novel elecrolytic chromate-removal plant (developed by SPIC R & D) where $Cr^{VI}$ is converted to $Cr^{III}$ by solution of a sacrificial iron anode with simultaneous formation of alkali which causes the precipitation of chromium as the hydroxide. This novel process requires no addition of acid or alkali and thus does not increase the dissolved solids in the effluent. The chromium sludge is deposited in two sludge ponds in series. The remaining chromium in the effluent is less than 1 mg/litre. A clarifier will shortly be installed and the sludge ponds will then become guard ponds. A means of recovering the chromium for re-use will be sought.

ii Urea Plant Process Effluent:

6 $m^3$/hour of this effluent containing about 5000 ppm of urea nitrogen and 3000 ppm of ammoniacal nitrogen are treated in an novel biohydrolysis unit, also developed by SPIC R & D. The urea is hydrolysed by a mixed culture and after treatment contains less than 50 ppm of urea nitrogen whereas the ammoniacal nitrogen has increased to 8000 ppm and the effluent contains dissolved $CO_2$. This effluent is mixed with the much larger quantity of effluent from i after chromium

removal. Alkaline regeneration effluent (effluent No iii) from the Demineralisation Plant and milk of lime are added to raise the pH level, thus converting all the ammoniacal nitrogen into free ammonia and precipitating the $CO_2$ as $CaCO_3$. After removing the precipitated carbonate in the clarifier, the effluent passes to a SPIC-designed ammonia stripper which discharges ammonia to the atmosphere.

The pH of the effluent is reduced by adding acidic regeneration effluent (effluent No iv) from the Demineralisation Plant and the pH adjusted to 8 by the addition of sulphuric acid. It is then acceptable for discharge to the sea or to a fresh water body like the bird sanctuary or for use in the Phase II plants (Sulphuric and phosphoric Acid and Aluminium Triflouride Plants). The new effluent treatment plants came on stream in early 1988.

The set limits for the key parameters and the corresponding typical measured values are as follows:

| No | Parameter | | Measured Values | TNPCB Standards |
|---|---|---|---|---|
| 1 | pH | | 8.4 | 5.5 - 9.0 |
| 2 | Temperature | $^oC$ | 31 | 40 |
| 3 | Total suspended solids | mg/l | 20 | 100 |
| 4 | Total dissolved solids | " | 2034 | 2100 |
| 5 | Chloride as Cl | " | 100 | 1000 |
| 6 | Sulphates as $SO_4$ | " | 913 | 1000 |
| 7 | Fluroides as F | " | Nil | 2 |
| 8 | Dissolved phosphates as P | " | 0.1 | 5 |
| 9 | Ammoniacal nitrogen as N | " | 43 | 50 |
| 10 | Total Kjeldahl nitrogen as N | " | 43 | 100 |
| 11 | Free ammonia as $NH_3$ | " | Nil | 5 |
| 12 | Oils and grease | " | 6 | 10 |
| 13 | Chromium hexavalent as Cr | " | 0.035 | 0.1 |
| 14 | Total chromium as Cr | " | 0.37 | 2 |

All these analyses are sent, together with analyses concerned with air emissions, to the TNPCB monthly and to the Central Pollution Control Board, New Delhi, quarterly.

Phase II Plants

The effluents from the Phase II plants (Sulphuric Acid and Phosphoric Acid and $AlF_3$) and occasionally a little effluent from DAP totals about 120 $m^3$/hr and contains fluoride and phosphate as the main unwanted pollutants. The total effluent is treated with milk of lime and settled in a settling tank.

The purified effluent is used to slurry the phosphogypsum byproduct from the phosphoric acid process and the slurry is dewatered and dried by evaporation in the Gypsum Dike. When dried, some of the gypsum is used in a pilot plant for the development of building products and further useful outlets are sought. Some is already used as a soil conditioner and in the cement industry.

Domestic Effluents

Domestic and sanitary effluent arising within the factory is disposed of in local septic tanks. Effluent from the main Works Canteen is pumped to the sewage treatment plant which serves the SPIC township and neighbouring townships and the treated sewage is used for irrigation of grass for fodder.

OTHER NUISANCES

Noise

The factory give no noise nuisance outside its boundaries

Solid Waste

There is very little solid waste produced by the factory.

RECOMMENDATIONS

1 Reduce the amount of urea dust discharged by the prilling towers. Accoustic granulation has already been proposed and other techniques, such as seeding, should be investigated.

2 Continue to seek ways to recylce more water eg by ceasing to evaporate the gypsum slurry in the Gypsum Dike.

3 Retain the services of a consultant to calculate the movement of ammonia clouds arising from escapes under various conditions.

4 Develop plans to deal with escapes of ammonia and with spills of phosphoric acid outside the factory.

5 Seek ways of sending out a bigger proportion of product by rail to relieve the pressure on the roads.

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# S E C T I O N   5

## VISITING REPRESENTATIVES

**RASHTRIYA CHEMICALS & FERTILIZERS LIMITED, BOMBAY - (RCF)**

The consultant had discussion with an RCF representative at Kribhco. RCF was built some 20 years ago and they are having difficulties particularly with liquid effluent, because of new standards which are being imposed upon them, coming into effect in 1989. I stressed that their attention must be focused on the production plants in the first place rather than on a more complex effluent treatment plant.

Several topics were discussed, the main one being as follows:

They have an underground sump which is used to trap occasional polluted spillages. When full, it contains about 100 tes of water with 10000 mg/l of ammoniacal nitrogen. When the sump is pumped out at 10 - 15 $m^3$/hr and mixed with the 250 - 300 $m^3$/hr factory effluent, the latter can reach 600 mg ammoniacal nitrogen per litre against their future limit of 50 mg/l. They cannot pump the contents of the sump to the Urea Plant Ammonia Stripping Tower since this is normally fully loaded at 25 $m^3$ effluent per hour. Urea production would be restricted if the additional effluent load were put through it. RCF will investigate whether they can treat the 100 tes effluent gradually when urea production is not at full plant capacity and thus when some capacity should be available in the Urea Plant Ammonia Stripper. A new Urea Plant is under construction, also equipped with an Ammonia Stripper and this, too, should be connected up for occasional use for treatment of the contents of the effluent sump.

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## GUJARAT NARMADA VALLEY FERTILIZERS CO LTD - (GNFC)

Two representatives of GNFC came to Kribhco and a meeting was arranged, including the consultant and a number of Kribhco staff. A number of topics were discussed, including the following:

1 GNFC are having difficulty in designing a biological purification system for their liquid effluent which will bring it into specification. They were recommended to consider a joint treatment plant, involving not only their industrial effluent but also domestic effluent from the nearby town, since biological purification of industrial effluent alone is notoriously difficult.

2 They have for disposal 400 tes/month of sludge containing 500 to 2500 ppm nickel. They enquired whether it was safe to use it for building purposes since they are having difficulty finding suitable sites to tip it. They were recommended to consider the leachability of the nickel in specific outlets case by case. European practice was discussed.

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**THE FERTILISERS AND CHEMICALS TRAVANCORE LTD - FACT**
(A Government of India Undertaking)

The consultant held discussions with their representative at Mangalore. FACT have two fertilizer manufacturing sites. Their Udyogamandal Plant was one of the first fertilizer plants in India and started up in 1946. The Plant now manufactures ammonia, sulphuric and phosphoric acids, ammonium sulphate, super phosphate and ammonium sulphate phosphate. The main topics of discussion were as follows:

1 Liquid Effluents

Calcium containing sludge from the clariflocculators is thickened by removal of water through sand filters and then proceeds to the sludge drying beds. In the monsoon there is not enough drying power in the sun and, in addition, the rain wets the sludge and the drying beds are over-loaded.

We considered several possible means of obtaining a thicker sludge to spread on the drying beds:

- thin the sand filters to speed up and make more complete the thickening process at the risk of leaving more particulate matter in the effluent coming through the filters.

- consider centrifuges and filter presses to improve the concentration of the sludge.

- install a second Dorr thickener in parallel.

A further refinement would be a roof over the drying beds to exclude rain while still allowing he wind to pass over.

2 FACT are disposing of gypsum slurry in a lagoon, but fear the effects of seepage of fluoride, phosphate and acidity. We proposed FACT should measure the concentrations of these pollutants at different points in the subsoil, over a period, to detect signs of the development of dangerous concentrations near wells or the river.

If such concentration appeared likely FACT would have to change their disposal method. The sludge should then be thickened and solidified before disposal to enable it to be discharged as a solid in an impervious tip with collection of drainings to be treated as effluent and with the covering up of the already tipped gypsum to prevent rain water percolation.

Another solution would be to barge the slurry out to sea.

3 There is an effluent spraying pond to remove ammonia. The spraying nozzles become rapidly blocked by calcium deposits.

Solution proposed for study were:

Injection of carbon dioxide to raise the solubility of calcium.

Use of an air stripping tower for ammonia removal to allow a different distribution system which would not be blocked by calcium deposits, perhaps after more intensive treatment with carbon dioxide.

**HINDUSTAN LEVEL LIMITED HALDIA, WEST BENGAL**

The consultant held a discussion with their representative at Tuticorin in the SPIC offices.

Hindustan Lever Limited manufacture sulphuric acid from sulphur and also phosphoric acid, tripolyphosphate for detergents, DAP and NPK fertilisers.

The two main topics of discussion were:

1 When Hindustan Lever Ltd (HLL) started operations some 15 years ago, they were in an area without any population but since then the area has become crowded with unofficial hutments. There is a significant but tolerable concentration of $SO_2$ in the ambient air from their Sulphuric Acid Plant and from an oil refinery and other industry in the area. Whenever HSL start up the Sulphuric Acid Plant, they emit a lot of $SO_2$ over a period of four hours from their 35 m stack which grounds 500 to 1000 m from the site, causing a severe smell among the hutments. We suggest three possible actions for study:

   i Blow more air into the bottom of the stack to raise the effective height of the $SO_2$ discharge and increase dispersion.

   ii Build a storage basin for cooling water to hold about a 1 week's supply (6000 $m^3$ at a circulation rate of 36 $m^3$/hr). At start up, divert the cooling water circulation through a scrubber for the flue gas containing the $SO_2$. Dope the cooling water with ammonia to increase $SO_2$ absorption. The $SO_2$ and ammonia will be evolved slowly from the cooling water.

   iii Dope river water with ammonia and use to scrub the $SO_2$ out of flue gas for the 4 hours. Store the used river water and discharge slowly to the river.

2 HLL have had risk analysis carried out and wish to determine what degree of safety for the local population now crowded around their factory and ammonia pipeline, would be appropriate. Names of consultancy firms were given.

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