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UPGRADE EXISTING SKILLS AT SELECTED FERTILIZER PLANTS

THROUGH THE PROVISION OF TRAINING AND CONSULTANCY

DP/IND/85/006/11-04/32.1.I.

Technical Report: Environmental Control Management at National Fertilizers Ltd (Nangal) and Madras Fertilizers Ltd (Madras)*

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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ABSTRACT

The Project (Number DP/IND/85/006/11-04/32.1.I) covers a study in environmental control management at the Nangal Plant of National Fertilizers Ltd and at the Madras Plant of Madras Fertilizers Ltd. The visit consisted of 20 working days in India divided between Nangal, Madras and Delhi.

At each plant assessment of the environmental conditions within the plant and surrounding neighbourhood was made and recommendations given on areas for improvement. Plant modifications to improve effluents were considered and recommendations on preferred solutions are given. Recommendations are also made on changes to the management structure and systems to assist in the achievement of better environmental performance at each plant.

CONTENTS

INTRODUCTION

The Government of India accords high priority to the development of its fertilizer industry. A current project, managed in India through Projects Development India Ltd, is aimed at improving the performance of the fertilizer industry. One area of improvement is aimed at environmental performance and this report covers a study in environmental control management at two fertilizer plants in India - National Fertilizers Ltd plant at Nangal, and Madras Fertilizers Ltd plant at Madras.

RECOMMENDATIONS

NATIONAL FERTILIZERS LTD, NANGAL UNIT

1 The function responsible for environment performance (Production) and environment advice (Technical Services) should respond to the same Deputy General Manager, and the reasons for this and the associated responsibilities should be clearly understood by all.

2 NOX emissions from the nitric acid plants should be reduced and the stacks fitted with continuous NOX analysers.

3 In view of what, from initial measurements, appears to be satisfactory SO_2 levels in the neighbourhood, NFL should attempt to get PPCB to agree that changes in SO_2 emissions are not required.

4 In view of the low level of urea emissions from the prill tower and the innocuous nature of the emissions, NFL should try to gain PPCB's acceptance of the status-quo.

5 Reductions in the discharge of particulates from the site should be made; improved cyclones and/or filters on the CAN plant stacks should be the first priority.

6 If chromium is separated from cooling water blow-down, then it should either be sold for recovery, or dumped in an area in which it is established that no seepage nor disturbance can occur.

7 As knowledge of the quality of the ambient atmosphere is established, monitoring should be concentrated on plant streams where control can be exercised, rather than on the ambient atmosphere, where it can not.

MADRAS FERTILIZERS LTD, MADRAS

1 MFL Should produce an environmental policy statement which includes a description of the organisation and systems which are in place to meet the policy objectives.

2 A detailed process design study of the NPK plants is required, aimed at making major reductions in the NPK effluent. Effluent treatment should be seen as a short-term palliative.

3 If the lagoon area, in which chromium is deposited, cannot be demonstrated to be completely contained on impervious land and with its future use absolutely controlled, then alternative means of chromium disposal must be developed.

4 Since ambient pollutant levels are already demonstrated to be satisfactory, capital would be better employed on equipment to monitor in-plant effluents at the point of control rather than on ambient monitoring equipment.

5 The urea plant prill tower effluent does not constitute a hazard to human or plant life. It is not a particularly noticable visual nuisance and it is considered that a cost/benefit analysis would reveal more worthy cases on which to spend a large amount of capital (£3-4M).

FURTHER INFORMATION

The writer will provide directly to the two companies visited further information as follows:

NATIONAL FERTILIZERS LTD:
Cyclones and filters for CAN plant
Fixed enzyme treatment of cyanide
Analysis of trace metal by atomic absorption
Technical feasibility of caustic scrubbing of NOX
NOX, SO_2 and (if possible) particulate continuous analysers

MADRAS FERTILIZERS LTD:
Experience on ambient monitoring for NOX, SO_2, CO, NH_3, F and particulates.

I NATIONAL FERTILIZERS LIMITED, 'NANGAL UNIT"

A FACILITIES

The main plant items are:

300 Te/day Ammonia Plant based on the electrolysis of water. (This plant is planned to be replaced by a new 200 Te/day unit based on naphtha).

554 Te/day Nitric Acid Plant (expressed as 100% HNO_3) in two streams designed by Bemag and operating at 3.5 ata pressure.

964 Te/day CAN plant making 25%N product.

All of these plants were built in 1961.

In 1975-76 as a result of a major expansion the following plants were added:

900 Te/day ammonia plant based on partial oxidation of H.F.O. The main contractor was Udhe and the process employs Cryogenics air plant, Shell gasification, and Topsoe synthesis. (at 180-220 ata); the Rectisol process is used for CO_2 and H_2S removal.

1000 Te/day Montecatini total recycle urea plant.

Three 182 Te/hr. boilers producing steam at 91 ata and fired with coal and 2-2.5%S H.F.O. There is a single stack 80M high.

The area is essentially rural and is lightly populated in the form of small villages and a large NFL township. The Sutlej river is about 1 km. away from the site. This is a clean fact flowing river at Nangal with a minimum flow of about 200,000 M^3/hr; one irrigation canal leaves the river at Nangal and another is under construction.

B ORGANISATION

The operating managers (Production Group) are responsible for the environmental performance of their plants. The Chief Chemist (Tech. Services Group) is responsible for ensuring adequate monitoring facilities, providing environmental advice, and holding discussions with the Punjab Pollution Control Board (PPCB).

The production function reports through the production manager to a Deputy General Manager. The Chief Chemist reports through the Technical Services Manager to the General Manager as a result of recent organisational changes. This is not considered to be an ideal arrangement since any conflict between the advisory system (Technical Services) and the response system (Production) will only be resolved at the highest level on the site (General Manager). It would be better if both functions reported to no higher level than the Deputy General Manager, and the reasons for this and the associated responsibilities should be clearly understood by all.

C EMISSIONS TO ATMOSPHERE

General

In addition to plant stream and plant ambient monitoring carried out by NFL, a detailed survey has recently been carried out by PDIL in periods during February, July and September 1986 in the surrounding neighbourhood. Whilst these results have not been analysed in detail at this stage they provide a valuable guide to the ambient air quality around the site and form the basis of some of the comments below.

Oxides of Nitrogen

The main emission of NOX is from the two nitric acid streams each of which emits 1500-2000 ppm NOX from low level stacks. This is equivalent to about 5 kg/Te weak acid compared with a PPCB required of 3 kg/Te weak acid (ie 1100 ppm NOX). The PDIL survey indicates that maximum ground level concentrations of NOX are probably unacceptably high confirming that remedial action is required.

NFL would like to reduce the NOX emissions to a few hundred ppm and are considering a catalytic reduction unit using NH_3 (only ICB of Bombay are interested in tendering) or the addition of caustic scrubbing to produce sodium salts which would be marketed. The latter is the preferred economic solution for NFL and the process, designed by PDIL is in successful operation by RCF at Trombay. Significant additional absorption capacity may be required since the pressure is low. The writer will obtain a view on the likely technical feasibility of this option and communicate directly with NFL.

Sulphur Dioxide

The main sulphur dioxide emission is from the boiler stack at a level of about 1200 mg/M^3 (about 360 kg/hr) made up from about 260 kg/hr from the boilers and about 100 kg/hr from the Claus plant incinerator which also discharges to the boiler stack. The stack effluent is slightly in excess of the figure (1038 mg/M^3) permitted by the PPCB based on the boiler stack height (80M). The PDIL ambient survey indicates fairly low levels of SO_2 in the neighbourhood, averaging only 5 or 6 μg/M^3 compared with a PPCB limit of 30 μg/M^3 for an area which can be considered as sensitive eg schools, hospitals. In view of this it is considered that NFL should make the point that there is no justification in applying any corrective action.

Urea

The Monticatini urea prill tower is of natural draft design and the effluent air contains 80-90 mg/M^3 urea; the discharge is very innocuous and not persistent. The PPCB limit is 50 mg/M^3. However, since urea is harmless to animal and plant life and is non-corrosive, and since the effluent causes no visual nuisance it is considered that any modifications to reduce the emissions (which would be very costly) could not be justified. NFL should try to obtain the PPCB's acceptance of this view.

Other Particulates

The main sources of other particulate matter are the boiler stacks which operate at about the PPCB limit of 600 mg/M^3 for pre 1979 plants and the

CAN plant stacks which also operate at about the old PPCB limit of 6 kg/te product. (The limits for new plants are 150 mg/M^3 and 0.5 kg/te product respectively). The PDIL survey indicates that some particulate measurements in the area are above the PPCB ambient limits for both sensitive and residential areas.

The state of affairs indicates that improvements to the ambient atmosphere should be made. It would be interesting to establish what the 'background' dust measurements are by analysing remotely from the plant. Alternatively an assay could be made of particulates sampled in the neighbourhood to establish what proportion is of industrial origin, since under Indian conditions the background could be significant.

However, the evidence suggests that improvements may be necessary. The mass emission of particulates from the boiler stack is about the same as the total from the lower level stacks on the CAN plant. Improvements to the CAN plant stacks (whose particulate effluents are poor by present day standards) may be the most rewarding route, either by using high efficiency cyclones or cyclones in series with filters. The writer will supply any information he can obtain on most suitable cyclones or filters for the duties direct to NFL.

Ammonia

Ammonia concentrations in the surrounding neighbourhood are low - generally well less than 1 ppm. The PPCB has not yet set a limit for ambient ammonia concentrations, nor for ammonia emissions, but the ambient levels are not a cause for concern. However, ammonia is released at a level of about 1500 ppm in the vent gases from the ammonium nitrate neutralizer and this causes problems within the site from time to time. The neutralizer problem is discussed below under liquid effluents and a possible modification is suggested which would also reduce the ammonia concentration.

D LIQUID EFFLUENTS

Urea Plant Effluent

Solution from the base of the urea plant rectification column together with plant washings go to an effluent pit and then to an ammonia stripping tower designed to deal with 500 ppm NH_3 in about 20 M^3/hr water; the solution also contains about 1.5% urea. The stripped solution then goes to lagoons where it evaporates and seeps away. More concentrated solutions arising from start-up and shutdown are passed to storage vessels which are drained slowly to the effluent pit when they cannot be recycled. The effect of this is to grossly overload the stripping tower and the liquor leaving the tower for the lagoons can contain up to 1.5% NH_3. The PPCB will not accept seepage lagoons (although no effects on surrounding water quality have been observed) and NFL have proposed a modified system which would recover most of the NH_3. This system takes the effluent to a hydrolyser, the ammonia from which is fed back to the ammonia section of the urea plant rectification column. The bottoms from the hydrolyser would contain only 10 to 20 ppm NH_3 and would then be treated in a new stripper before going to a new guard tank prior to discharge to drain.

This scheme would not only avoid any possible effects from seepage, but would improve the urea plant material efficiencies.

Cyanide Effluent

The quench water (about 20 M^3/hr) from the gasification unit after carbon recovery is passed through a sand filter to remove residual carbon and then passed through an HCN stripper where it is stripped with tail gas (from the nitrogen wash system). The exit gases are burnt in the boiler furance, and the solution containing 2-5 ppm HCN, 170-180 ppm NH_3, up to 400 ppm methanol and 2 ppm H_2S is fed to the urea effluent seepage ponds. The PPCB require less than 0.1 g/l of cyanide at the exit of the plant.

NFL propose to take the liquid from the HCN Stripper and treat with chlorine in alkaline conditions to oxidise cyanide and then pass it to the new stripper on urea effluent duty for ammonia removal.

This system is in operation at the NFL plant at Panipat and should therefore be successful in eliminating cyanide from plant effluent.

ICI plc (U.K.) has recently developed a fixed enzyme process for the removal of cyanide from aqueous effluents. The writer will ascertain whether this process is suitable for the treatment of quench water and will communicate directly with NFL.

Cooling Water Blow-down

The cooling water blow-down (54 M^3/hr) containing 10-12 ppm chromate is currently put to drain together with 15,000 M^3/hr of once-through cooling water. The PPCB will no longer permit the dilution of pollutants by once-through cooling water and an alternative means of reducing total Cr. to <2 ppm and Cr^{+6} to <0.1 ppm in the blow-down is required.

NFL propose to reduce the chromate to Cr^{+3}, precipitate the hydroxide and separate the precipitated chromium hydroxide, and pass the liquid to the new guard tank. This would still leave a disposal problem since chrome compounds should not be dumped on land unless it is established that the chromium can be completely contained and not allowed to enter any water courses. Sale of the chromium hydroxide for chrome recovery would be the best option, but if this cannot be done then formal agreement of the PPCB should be sought on a suitable dumping area (waste disposal legislation is not in place in India, but will inevitably emerge.)

New Guard Pond Effluent

The final effluent from the new guard pond to the river will be required to have <4 ppm free NH_3 (as N) and <50 ppm total NH_3 (as N). To meet this requirement NFL proposes to treat the effluent with sulphuric acid to reduce the free ammonia to the required level. This is quite unnecessary since the free ammonia in the river will be entirely controlled by the pH of the river, since the effluent flow is so small (about 130 M^3/hr) compared with the river flow (more than 200,000 M^3/hr).

Polluted Condensate from CAN Plant

In the CAN plant, steam from the ammonium nitrate neutraliser is used to preheat the inlet ammonia and 54% nitric acid; a condenser removes further steam and the excess passes to atmosphere through a Brink filter to remove ammonium nitrate fume. The effluent to atmosphere contains about 1500 ppm NH_3 and 1300 mg/M^3 of Ammonium Nitrate fume; it is a local nuisance on the site. The condensate from the preheater and condenser containing 2000-5000 ppm NH_3 and 350-900 ppm ammonium nitrate is fed to the last tower of the nitric acid plants to replace demineralised water. Sometimes there is a surplus of condensate and sometimes it is too acidic to use on the nitric acid plant and has to be put to a seepage pond. There are thus two problems - surplus condensate, and ammonia and fume discharge to atmosphere. The problem can probably only be resolved by a redesign of the system in such a way that less steam is condensed, and the steam which is then passed to atmosphere should be scrubbed to remove ammonia before going through a Brink-type filter to remove fume. The writer provided NFL with a copy of a paper which describes in detail how ICI have modified neutralisers to overcome similar problems.

E CONTROL AND MONITORING

The main site effluent into the river is analysed continuously for pH and ammonia and the results transmitted to the laboratory and the electrolysis plant control room. The main site effluent is also analysed at different points once/day for pH, total ammonia and urea. Shiftly analyses are carried out on polluted condensate, the cyanide effluent after stripping, and the urea effluent to the final stripper. Daily reports go to operational managers, but any abnormalities are reported immediately for corrective action once the pollution source is identified; monitoring frequencies are increased until any problem is resolved. Whilst this system may have been adequate to-date, better control over effluents would be obtained if appropriate continuous analysers (analysing key constitutents) were installed on individual plant streams; in this way effluent information is always continuously available to individual plants for in-plant control responsibility.

The river is periodically analysed 200 M downstream of the main site outfall for free and total ammonia, BOD, Cr^{+6} and TDS. After the effluent point from the ash slurry pond the river is also periodically analysed for metals at ppb levels. The writer will supply NFL directly with information on the atomic absorption system used by ICI for ppb levels of metals.

Ambient site - monitoring for SO_2, NOX, and NH_3 has been carried out periodically since 1981, but during the last year or so monitoring has been carried out daily. This is producing a good picture of site ambient conditions. The PDIL analysis of the neighbourhood is also providing external information. Once a picture of the ambient conditions has been established these conditions are not going to change significantly unless there are changes in plant effluents. For this reason, again, it is considered that the emphasis on atmospheric monitoring should move to plant effluent monitoring (where control can be exercised) rather than ambient monitoring (which identifies effect and not cause). In particular, a continuous NOX analyser and possibly a continuous SO_2 analyser would be desirable; a continuous particulate analyser would be desirable but these instruments are not very reliable on plant streams. The writer will supply NFL directly with information on NOX and SO_2 continuous analysers, and any information which may be available on continuous particulate analysis.

II MADRAS FERTILIZERS LIMITED

A FACILITIES

The facilities were constructed at the end of the sixties, Chemico being the main contractor. They consist of:

A 750 Tes/day ammonia plant using naphtha feedstock and incorporating a Topsoe reformer, Catacarb CO_2 removal, and a Chemico convertor operating at about 240 ata.

A 980 Tes/day Chemico total recycle urea plant.

Three NPK compound fertilizer plants of Dorr Oliver design using urea, potash, and phosphoric acid as raw materials. The third stream was added in 1976 and the total capacity is nearly 2000 Tes/day consisting mainly of a 17:17:17 formulation.

There are two auxiliary boilers each of 58 Tes/hr capacity, originally using 4%S HFO, but over the last 3 years NFL containing 0.8-1%S has been used.

There are two 5000 Tes atmospheric pressure liquid ammonia storage tanks in a concrete bund designed to hold the contents of one tank.

The site is situated 16 Km NW of Madras. The area is essentially rural with a very low density of population. There is a thermal power station 3 Km NE of the site and several smaller chemical plants in the neighbourhood. The liquid outfall is into the Redhills Surplus Channel which then flows about 4 Km through rural areas into the Bay of Bengal.

B ORGANISATION

Responsibility for environmental performance is vested in the production line management, headed by the Plant Group General Manager. In addition, a senior member of the R & D Group acts as an Environmental Advisor to the line management. His responsibilities include making recommendations to improve site environmental performance, and holding discussions with the

Tamil Nadu Pollution Control Board (TNPCB); a further member of R & D is currently working full-time on the evaluation and development of schemes to improve environmental performance. The R & D Group reports through the Deputy General Manager (Technical) to the Plant Group General Manager. Thus, the production line management and the environmental advisory functions both report to a single General Manager. This is the usual structure embracing environmental management in production units and is considered to be entirely appropriate.

The management have not produced a written Environmental Policy. This is being increasingly carried out by chemical companies since it causes management to closely question their objectives and standards, and also the management structure and systems required to meet the objectives; the finished article provides a useful vehicle for promulgating the policy throughout the whole work-force. A copy of one such policy was left with MFL.

C EMISSIONS TO ATMOPSHERE

Sulphur Dioxide

SO_2 is emitted from the auxilliary boiler stacks and from the reformer furnace. The boiler stack height was originally designed for use in the 6%S HFO and 0.8-1.0%S oil is now used; the reformer furnace is fired with naphtha containing less than 0.2%S. Ambient SO_2 measurements by MFL and TNPCB meet the Board requirements ($120 \mu g/M^3$). The single boiler furnace stack is some 2 m less in height than required by the Board but in view of the satisfactory ambient levels of SO_2 any modifications would not seem to be justifiable.

Ammonia

The major gaseous ammonia effluent from the urea evaporator is now scrubbed with raw phosphoric and other discharges (eg drier stacks at 70 ppm v/v) are of a satisfactorily low level. Any ammonia vents and relief valves are vented to a flare stack and any vent which can contain liquid ammonia is passed via a knock-out pot to prevent entrainment of liquid ammonia into the atmosphere.

Oxides of Nitrogen

The only oxides of nitrogen emitted from the site will be in the reformer and boiler flue gases. The levels are probably less than 100 ppm and will make a negligible contribution to acidity in the surrounding atmosphere.

Particulates

The particulate effluent arousing most attention is urea from the prill tower. Measurements indicate that this varies from 50-350 mg/M^3, probably averaging about 150 ppm. The Central PCB has recently brought in a requirement for all plants to reduce urea discharges to less than 50 mg/M^3 by the end 1987; this figure is in line with that obtained on new plants using best available technology. The tower structure cannot take the load which would be produced by a scrubber at the tower top and the cost of building a ground level scrubber and returning the effluent to tower top level is estimated to be 5-6 crore Rs. (£3-4m). A PDIL proposal to reduce emissions by perhaps 70% by sonic agglomeration is to be carried out at the FCI Sindri plant and is likely to cost less.

This is a contentious subject since above about 100-150 ppm the emissions are fairly persistent and can be described as a visual nuisance. No adverse health effects have been associated with urea and any fall-out is not corrosive. During the writer's visit the effluent could not be considered to be a visual nuisance since there are few people living near enough to see it, it is not in any case in an area of natural beauty, and it is overshadowed in the area by the discharges from the 3 stacks at the thermal power station. I am sure that a cost/benefit analysis would produce more worthy cases on which to use a precious capital resource.

Particulate emissions from the NPK plant stacks are low (10 mg/M^3) since all the particle laden streams pass through cyclones followed by wet scrubbers.

D LIQUID EFFLUENTS

There are two main liquid effluents from the site.

Utilities Plant

This consists mainly of cooling water purge and also contains calcium carbonate sludge from the hydrotreater. The C.W. system uses chromate as a corrosion inhibitor. The CW purge is treated with boiler flue gas in scrubber; this reduces the chromium to the trivalent state and the liquid stream is then fed to large lagoons. In these lagoons, which are alkaline due to the associated presence of calcium carbonate in the effluent, the chromium precipitates and settles as the hydroxide. The final effluent from the lagoons to Redhills Surplus Channel is acceptable to the State Pollution Control Board, but the continual lay-down of chromium in the lagoons is not.

Certainly it is not good practice to dispose of chrome into an area unless the ground conditions are well-proven to be impervious and unless the site is registered in such a way that its possible use at any time in the future is absolutely controlled. If these points cannot be completely met then the Control Board's view is valid. MFL are exploring the possibility of controlled precipitation and separation of chromium hydroxide at the plant with possible disposal of the chrome to a chromium manufacturer.

There are alternatives to chrome-based C.W. systems; these are based on phosphate or zinc and generally give a higher level of fouling than chrome-based. The cheapest and most efficient alternative is likely to be the precipitation route if this can be developed.

N.P.K. Plants

The plants were designed on the basis of no liquids going to drain. In practice this has not proved possible. In order to control granulation all the scrubber liquors cannot be recycled and are put to drain. In addition, general plant washing and cleaning of equipment increases the problem.

As a result, an average 18 M^3/hr of liquid goes to drain and contains:

12500 ppm NH_3 (as N) equivalent to about 5 Te/day NH_3
5000 ppm urea (as N) equivalent to about 5 Te/day urea
12500 ppm phosphate (as P) equivalent to about 17 Te/day H_3PO_4
1-2% Solids (sand or dolomite filler) equivalent to about 6 Te/day

These represent significant losses in efficiency as well as causing considerable plant problems due to the settling of solids in drains. The liquid is drained to a lagoon on the site where solids deposit as the water evaporates. The situation is not acceptable to the Pollution Control Board.

This problem is not untypical of NPK plants. The real solution to an improvement in efficiencies, plant conditions and effluents lies in a detailed process design study of the plant. MFL are requesting Dorr Oliver to do this study and until this is completed, it is not possible to speculate on the best solution, but it could be that increased drying capacity will be required.

In the meantime, MFL propose to remove phosphate from the NPK effluent by precipitating as magnesium ammonium phosphate whilst considering further treatment to remove the remaining ammonia; other ammonia and urea streams will be treated in a separate hydrolyser stripper. These actions should be seen as short-term palliatives whilst the real problem of granulation control and drying is tackled by Dorr-Oliver.

E ANALYSIS

The site laboratory analyses the final liquid effluent once/week for NH_3, total N, P, hexavalent Cr, and pH. On a random basis, once/month, plant and ambient atmospheres have been tested for NH_3, SO_2, CO, and particulates. Copies of these results are passed to the production management up to Deputy General Manager. Abnormalities are followed up and repeat analyses carried out daily until the abnormality has been rectified. The Utilities Plant Manager has the responsibility of ensuring that the operational aspects causing an abnormality are corrected. In his absence (out of normal hours) the site General Superintendent carries the responsibility.

The weekly and monthly effluent figures are sent to the TNPCB.

Recently the Board has required the plant to carry out ambient analyses once/week for SO_2, NOX, CO, NH_3, F, and particulates at 5 points on the site and to retain weather conditions records. To meet this requirement MFL have ordered weather station equipment and are considering the purchase of appropriate instruments to carry out the analyses. (In this respect, the writer will check if there is any ICI experience on the instruments in question and reply directly to MFL).

The type of plants on the MFL site are not likely to give rise to significant variations in the ambient levels of polluting species, except in the event of an equipment failure or operational control failure. It would be fortuitous if ambient monitoring once/month picked-up such variations - they can best be observed by in-plant monitoring of effluent streams. Once it has been established that ambient conditions are satisfactory - and it appears that this is so at MFL - then only occasional confirmatory readings are necessary provided that there is sufficient monitoring at the point where control can be exercised, that is on the in-plant effluent streams. It is the writers opinion that the capital involved would be better spent on equipment for monitoring in-plant streams.